REPORT ON LAND SURVEY FUND

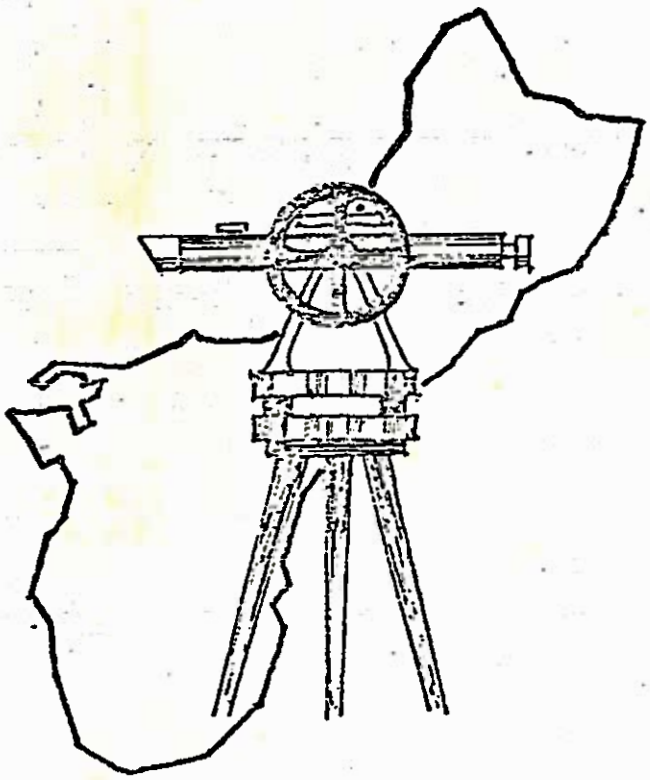
Prepared by: Department of Land Management, Survey Division
1978

GOVERNMENT OF GUAM

DEPARTMENT OF LAND MANAGEMENT

1978

SURVEY DIVISION



REPORT ON

LAND SURVEY FUND

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A GLIMPSE AT THE HISTORY OF SURVEYING IN GUAM

Land surveying is not generally recognized as the oldest profession even though in some minds, there seems to be a marked inability to separate the end results of those who practice Land Surveying and those who practice what is normally believed to be the "oldest profession".

Historically, land surveying antedates any other known learned profession and is the forerunner of our present day engineering profession. It is steeped in antiquities, the first written record of the necessity for the profession being found in Genesis 33:19 when Jacob was required to purchase a definite tract of land when he entered the land Canaan. No doubt some method of delineating property was then available, else, Jacob could not have acquired definite description.

The refinements of surveying as we know them today were not available to Jacob and since relocation surveys were not readily obtainable, property lines were defined by fixed monuments which usually carried some kind of an inscription to designate the owner. In some areas of the ancient world, such monuments became both the deed and the title to the land they enclosed. That such monumentation carried extreme importance was also indicated by many biblical references admonishing the people not to remove the ancient landmarks which marked their inheritances.

Today, many hundreds of years after the time of Jacob, land surveying has advanced in its antiquities but none of those techniques have eliminated the monument, a fixed and defined permanent marker, as the ultimate means by which land is controlled. To this date, practically all property surveys are dependent partly or totally on monuments previously fixed or established on the earth. Monuments are the backbone on which the framework of the land surveying system and techniques are based. Because of that one factor, monumentation is given the highest priority in establishing the intent of the property description and once they are established, the rights conveyed by them cannot be disturbed except by judicial action. Judicial records are replete with decisions that establish the seniority of monumentation and woe be to the land surveyor who ignores the oldest monumentation in favor of a later variety that is easier to find.

In the English Common Law, we find the beginnings of our property laws as we know them today. In the middle ages, human life was cheap and a man could be hanged for stealing a loaf of bread - another man's property. In the American West, a horse thief was meted summary justice from the end of a rope but murder in a "fair fight" was accorded all the dignities and forensics of a trial by "12 men tried and true".

The first and fourteenth amendments to the Federal Constitution protect the property rights of individuals, the first against invasion by the United States, the fourteenth against invasion by the individual state. Those amendments mean that when a man holds title to a parcel of land, that title cannot be taken away from him, nor can any part thereof be affected other than by "due process" of law. Thus, except in specific application of the "due process", a man cannot be forced to involuntarily part with any of his property.

Carrying this reasoning a little further, disputes between property owners can only be settled by court order or by agreement between the adjoiners, both of which have to be displayed in a system of public records before they can be made binding between the parties and/or their successors in interest. Also, amicable adjustments of property descriptions that vary from records are enforceable only if made by written agreement and the agreement is recorded in the appropriate public records.

* With this kind of a background, let us examine the distinctive problems of surveying and land title applicable to Guam for a better understanding of what we in the Survey Division, are trying to do.

Start

A little over a hundred years ago, Queen Isabella of Spain promulgated a set of laws applicable to the inscription of property titles. Just when those laws were first adopted in Guam is not known but property records as early as the 1880's are available in the Department of Land Management.

Most of these laws pertained to property held under written title, but they recognized the possibility that some property rights were acquired by adverse possession against unrecorded owners, essentially the Crown. Provisions were thus made to permit individuals to acquire "Possession by Information" titles, the effect of which was to bar the Crown from making any future claims against the particular parcel but which permitted third parties with better rights to exercise them. These titles

are somewhat analogous with "patents" granted by the Federal Government to Federally funded public lands. To this date, they are recognized as good titles and when properly described, they permit a clear distinction between adjoiners conveying these proper titles.

After the Treaty of Paris in 1898, the Naval Governor of Guam recognized the need for private individuals to obtain land titles against the Government. The Spanish "Possessory Title" methods had continued for a number of years without change. (It is interesting to note that those laws were voided by Spain in the late 1880's or early 1890's, but for some reason, the action apparently was never recognized by the Spanish Governors of Guam or by their American successors.)

Unfortunately in Guam in the 1880's, there were no methods of locating property lines or corners except by reference to adjacent ownerships or natural boundaries. Early in the American occupation of Guam, the need for property descriptions and survey methods became urgent since a system of taxation was imposed and the entries of possessory title were made mandatory. Consequently, a minimal triangulation control system (now known as the Butler 1913 surveys) was authorized and installed, but it was probably conducted to meet the survey standards of those days. Unfortunately, the original notes of those surveys are no longer available and they can never be reestablished.

Concurrent with the installation of those controls, Executive Order No. 153, issued by the then Naval Governor of Guam, decreed that thenceforth, in addition to all previous requirements for establishing and/or conveying title, a map had to be submitted with each such transaction. If a map was not filed with a conveyance, the recording was made but suspended, giving the action no legal recognition but merely recording the intent of the parties to the action.

A series of complicating elements then began to enter the picture with respect to surveys and titles which created conditions that still exist as a source of confusion today. One, only Naval Government forces could conduct land surveys which meant that the individual citizen was at the mercy and disposition of the authorities to provide approved land surveys. Thus, no new titles could be established and no

conveyances of property were legalized until the "official" surveyors got around to the task. Old records appear to indicate that several years would elapse between the request and the survey.

Two, basic 1913 surveys were totally inadequate to meet the needs of "working level" controls and every evidence appears to indicate that the triangulation system was greatly expanded by open traversing, a very poor method for establishing controls. This caused overlaps in some instances and created hiatuses in others. Apparently, the situation was so alarming that many pre-war annual reports of the Naval Government indicated their distress with the conditions being created. These conditions are still evident today.

Three, when consolidated cadastral maps were made by the Naval Governor surveyors, they failed to properly honor individual surveys and descriptons previously created. Incidentally, it is interesting to note that where the fact of the availability of the required maps is noted in many old documents, it has not been possible to find a single one of them. There is not even feasible theory as to how they all vanished so completely.

Four, many individual errors exist in the consolidated maps which made them utterly dependent on monumentation for resurveys. Regardless of the equipment then available, there was no excuse for failing to mathematically close every traverse but for some reason best known at the time, this basic requirement was ignored.

Other revisions to the means for establishing title came into being, first, with a system of Guaranteed Claims, and later, a system of land registration with the latter system continuing to be almost unchanged up to this period. Neither of these systems made any improvement on survey accuracies and they solved nothing except to forge the beginning and often times fragile link in a chain of titles.

Following World War II, the reestablishment of survey contracts became an absolute necessity resulting in the 1945 Naval Government Land and Claims Commission surveys. Inauspiciously, most original control monumentations (1913 Butler surveys) were not reoccupied or reestablished based on available information. Instead, new points were installed based on the theoretical values of the original, which resulted in two sets of monumentation. Then, on the basis of the theoretical values of those monuments and the

theoretical values of pre-war lot corners, a larger number of revised property maps and descriptions came into being. Nowhere is there any evidence that the preservation and use of pre-war monumentation of individual lot corners were made mandatory. Today, consequently, the variance between pre-war surveys and post-war surveys based on Land and Claim Commission data has been proven to be as high as 65 feet, or approximately 20 meters, with variance as much as 80 feet suspected in some areas. These variance can be proved on the basis of pre-war monumentation now being required to be recovered and upon which surveys must be based. It is surprising how many old monuments can be found if diligent effort is expended in searching for them.

LAND SURVEY FUND ANALYSIS

For detailed information of the Land Survey Fund, I will attempt to summarize the objective of the program and include my recommendations on the means to reach these objectives. This summary will barely scratch the surface of the program. Even so, due to the complexity of the program, it may still be rather long.

For the past four years, the Land Survey Fund Program, with the exception of the "Control and Government Land Survey", but relative to the Cadastral Mapping portion, has been a nearly complete failure. Much has been learned but actual accomplishments are practically nil. The only explanation I am able to arrive at is that the inherent confusion and weaknesses of the existing island cadastre are not being solved but rather, more data of questionable reliability has simply been added to the conglomeration. The addition of Subsection (5) to Section 13970 of the Government Code, by enactment of Public Law 12-3 in March, 1973, provided that an attempt at "systematic" progress must be made. This should have brought a halt to the addition of unquestionably unreliable data but due to various pressures of priority programs from various governmental agencies in addition to the Survey Division being way understaffed, the attempt to plot all recorded maps for the purpose of evolving an Island Cadastral Mapping System was severely retarded. (Please see Island Cadastral Mapping Program.)

In view of the above, the first part of this inquiry deals with a re-examination of the Land Survey Fund in relation to the other status relating to the functions of the Survey Division. This will hopefully, provide a better picture of what the primary duties and responsibilities of a surveying unit are within the most modern concepts of a "Cadastre" designed to provide a sound basis for land planning and management. The following part will outline in some detail the proposed systematic attainment of this cadastre.

In viewing Executive Order 15-59 which re-organized the Department of Land Management in October, 1959, the foresight in the priority of duties and responsibilities of the Survey Division was most comprehensive and intelligent.

It is sad, but true, that these priorities were so warped and ineffectively pursued during the following 16 years that the Division has not provided Guam with the service so well intended. There have been some very notable jumps forward, using hindsight, whereby the Survey Division deserves high praise in certain areas of operation. If further consideration of technologies of the time in respect to the current astounding rate of technological advancement would be taken, the evaluation would be general praise with a few exceptions. These exceptions do not refer to any incompetence on the part of the personnel, but rather the burden of having been overpowered by the great number of responsibilities and priorities of the Division unsustained and unsupported by enough personnel to administer these responsibilities.

To analyze the Survey Division, an abstract of Executive Order 15-59 with a parallel abstract of Section 13970 (Land Survey Fund) has been prepared and is shown on attachment. Items (1), (2) and (3) of Executive Order 15-59 closely parallel Items (1), (2) and (4) of Section 13970 and are prime ingredients of a modern and feasible cadastre.

The three basic ingredients of a good cadastre have been present since October, 1959. Each of these were further delineated, strengthened and hopefully accelerated by the Land Survey Fund enactment. The most advanced concept of a cadastre have (1) a highly accurate coordinate system of ground control, (2) a recording or a filing system for documents and plans which are

adaptable to computerization and, (3) a set of appropriate graphical presentation of the data for better understanding. These three basic ingredients closely interrelated and properly correlated can provide the foundation for a data bank of fantastic potential in the planning and management of Guam's future. Within any government structure, there must be one survey unit that has the prime responsibility of servicing the total cadastre structure. This survey unit, in close coordination with a records unit, shall be responsible for gathering cadastral data, assimilating the data in an orderly system and then disseminating the correlated data to all government and private agencies equally. Such a cadastre unit should work only as a general service department, but it can never truly serve humanity if it is under the control of any single interest re-· presented by a specialized administration department. For instance, a cadastre unit cannot function properly under a department whose prime interest is only government land or only highways, or only utilities. A cadastre unit can function properly only under a department whose prime function is service to all other departments and not unto itself.

GOVERNMENT OF GUAM
Office of the Governor
Agana, Guam

EXECUTIVE ORDER NO. 15-59

WHEREAS, Section 9(c) of the Organic Act of Guam provides that the Governor shall, from time to time, examine the organization of the Executive Branch of the Government of Guam, and shall determine and carry out such changes as are necessary to promote effective management; and

WHEREAS, Section 5107 of the Government Code of Guam establishes a Department of Land Management within the Executive Branch of the Government of Guam; and

WHEREAS, a more efficient administration and control of the prescribed functions and responsibilities of the Department of Land Management necessitate a reorganization of such department;

NOW THEREFORE, in view of the foregoing, the organization and functions of the Department of Land Management shall be as follows:

1. The Department of Land Management will consist of the Office of the Director, Division of Land Records, Division of Land Administration, Division of Planning, and Division of Survey.

2. FUNCTIONS:

The functions of each Division and the

duties and responsibilities of each chief official thereof, are;

a. Office of the Director

The Director of Land Management, as head of the Department of Land Management and Chief Official of the Office of the Director, is responsible for formulation of all policies affecting the Department of Land Management. He shall be charged with the overall administration of the Department of Land Management and shall have general supervision of all the personnel and operations of the Department. He shall have general cognizance of all Government of Guam real property (land). In this connection, all departments or agencies of the Government of Guam desiring to make any use of Government real property must first obtain the approval of the Director of Land Management covering the use of such real property. Ex Officio, the Director is the Executive Secretary of the Territorial Planning Commission, and Registrar of Titles.

b. Division of Land Records.

The Division of Land Records shall be responsible for the recording of instruments affecting titles of all land in Guam. The Chief Official of the Division shall be the Deputy Registrar of Titles who shall be charged with the supervision of the personnel and functions of the Division. As Deputy Registrar of Titles, he shall be charged with the duties and responsibilities of keeping and maintaining all official records relating to land titles and of discharging the functions and duties of the Registrar of Titles. He shall also be responsbile for such other related matters as shall be prescribed for him from time to time.

c. Division of Land Administration.

The Division of Land Administration shall be charged with the duties and responsibilities of keeping and maintaining a record of all government real property assigned or allocated to departments and agencies of the Government of Guam, as well as a record of all government real property leased to, or occupied under land

use permits by private individuals in accordance with the provisions of law All investigations and appraisals of Government real property to be dispos of by the government, and of private properties to be acquired by the Gove shall be the duties and responsibiliti the Division of Land Administration.

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The Chief Official of the Divisio Land Administration shall be the Chief Land Administration who shall have sup vision of the personnel and functions the Division. The Chief of Land Admin shall be the Executive Secretary of th Transfer Board, he is responsible for and processing all applications filed Land Transfer Board of purchase or leas of Government real property.

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d. Division of Planning.

The Division of Planning shall be charged with the duties and responsibilities of providing the Territorial Planning Commission with such technical and clerical personnel and office facilities as may be required or necessary to enable the Territorial Planning Commission to comply with its functions and duties in preparing and adopting a comprehensive, long-term general plan for the physical and economic development of the Territory of Guam.

The Chief Official of the Division of Planning shall be the Chief of Planning who shall have supervision of the personnel and functions of the Division. He shall also supervise the subdivision development of all Government of Guam real property. He shall also serve as the Executive Secretary of the Parks, Monuments and Museum Committee.

The Division of Planning is further charged with duty and responsibility of developing, maintaining and controlling all public parks, park nurseries, and monuments in Guam, and shall have cognizance of the Guam Museum.

e. Division of Survey.

The Division of Survey shall be charged with the duties and responsibilities relating to the maintenance and supplementing of a land square-plane grid system, a triangulation network and an Island-wide vertical control. The Division is further charged with the duties and responsibilities of maintaining all files relating to land surveys, i.e., complete technical descriptions and other information on all property on Guam including Military, Government of Guam, Federal Government and private, and the preparation and maintenance of a set of cadastral maps for the territory, and other related survey matters such as reconnaissance information, as-built, topographic and contour maps of all scales, etcetera.

The Chief Official of the Division of Survey shall be the Territorial Surveyor who shall have supervision of the personnel and functions of the Division. In addition to the above duties and responsibilities the Territorial Surveyor must approve or disapprove for accuracy and form, maps plats or surveys of private lands which are filed for recording with the Registrar of Titles, and further he must recommend for approval or disapproval on the basis of accuracy and form all final subdivision maps filed with the Territorial Planning Commission.

3. The appended Organizational Chart of the Department of Land Management is incorporated as an integral part of this Executive Order.

Dated at Agana, Guam, this 6th day of October, 1959.

/s/ R.B. LOWE

RICHARD BARRETT LOWE
Governor of Guam

COUNTERSIGNED:
(Seal)
/s/ Marc. Boss
MARCELLUS GRAEME BOSS
Secretary of Guam

Survey of government land: duty of Territorial Surveyor. All real property belonging to the government of Guam for which certificates of title have not been issued, shall be surveyed and mapped for appropriate government use, and in order to accomplish the registration of such property. The Territorial Surveyor shall carry out a program, on a continuing basis to so survey and register government owned land, and such program shall include, but not necessarily be limited to the following:

(1) Completing the calculation and field traverses necessary to establish the Guam Geodetic Triangulation Net, including the referencing of all markers, the integration of such system with those previously established on Guam, and the restoration of all monuments destroyed since the initiation of said system;

(2) Researching all existing survey records and plans, selecting those surveys that can be utilized, updating such surveys by connecting them to the Guam Geodetic Triangulation Net, verifying questionable boundaries, and completing registration proceedings for those lots for which such surveys already exist.

(3) Selecting from the remaining parcels of government land those parcels of highest value and proceeding to survey them in order of value, on a parcel by parcel basis, until all government of Guam land is surveyed;

(4) Putting all parcels of government of Guam land on the cadastral maps of the government.

There is hereby authorized to be appropriated the sum of not to exceed two hundred fifty thousand dollars ($250,000.00) to carry out the purposes of this Act. (Added by P.L.9-28, effective March 3, 1967).

GEOGRAPHIC, HISTORICAL AND ECONOMICAL CONDITIONS NECESSITATING A PROGRAM FOR DENSIFICATION OF THE GUAM GEODETIC TRIANGULATION NET AND GOVERNMENT LAND SURVEY

The disruption of agriculture poses a serious problem to Guam. Although wartime activities gave subsequent rise to the transition from agriculture as a way of life with the local inhabitants to accepting wage employment, there is still a great possibility in developing the agricultural industry. However, problems stemming from inadequate maps and records for the purpose of identification of lands encompass this development. A considerable acreage of agricultural land remains under military jurisdiction. Those returned, whether fit or unfit for agriculture, require surveying. Programs for soil conservation, general land rehabilitation to control the erosion which is strikingly increasing in capacity, reforestation, essential particularly in areas tributary to the island's water supply, technical inventory of public land areas suited to agriculture for setting up irrigation systems, are pressing needs which cannot be accomodated and carried out effectually without credible survey maps of government property completely registered and recorded. With this, programs requisite to raise agricultural production can be implemented beyond expectation to meet not only local but possibly extraterritorial demands. This would certainly be a boost to our not to stable economy.

With the ending of World War II, Guam witnessed the creation of a major military base. Both wartime activities and the military expansion contributed to the local inhabitant's loss of their homes and land.

To alleviate this situation, the United States Congress enacted several laws to relieve the sufferings undergone by the local people.

Public Law 224 of the 79th Congress authorized payment of claims for personal and real property loss or damage from injury and death. Adjudication of cases was assigned to a Land and Claims Commission appointed by the Secretary of the Navy. Settlement of claims under this Act has been virtually completed as reported on June 30, 1950.

Public Law 225 of the 79th Congress authorized the transfer of lands owned by the United States to the Naval Government of Guam for sale to residents for their rehabilitation and resettlement.

The continuation of this Act was transferred to the Government of Guam by the Judge Advocate General of the Navy.

It has been extremely laborious and practically impossible to identify land ownership. Prewar land records were not of the best. Much of these records were destroyed giving birth to confusion as to ownerships which was additionally intensified by a deficiency in dependable surveys and maps. Normal land utilization was inevitably besieged.

To date, no law has been promulgated for establishing a rehabilitation appropriation for the correction of records and of surveying done by the military which evidently effected the sum total chaos in present day surveying.

During the last few years, Guam has undergone quite significant changes in economic and social structure resulting in material expansion of industry and commerce. It has become a main way station of the Pacific area due to modern airfields, modern harbor, and modern communications linking it to the rest of the world. Population rise is significative. Employment is available not only to the local inhabitants but also to imported contractual workers and immigrants. Business, which used to be located mainly in Agana, has expanded into Tamuning, Piti, Route 4 and many other areas of the island. Foreign interest in investment in the island's industrial and commercial enterprises has mounted.

There is adequate land available for this very significant expansion in commerce and industry. The problem of local residents having a deepseated reluctance to alienate themselves from their landholdings whether temporarily or permanently is meager compared to the sizable essentiality for reliable surveying and mapping of considerable magnitude to meet these not merely local but also foreign land investment in our economy.

Another problem confronting our island with respect to the public land situation is exemplified in the case of non-military roads. Most of the island's major roads have been transferred to the Government of Guam but not all of it has been taken in fee simple. In most instances, monumentation of road controls were not well defined giving rise to inaccurate descriptions of how much land was absorbed

by the government for the right of way with respect to private property. Most severance maps prepared for the right-of-way delineations are unreliable because of differences in coordinate values thereby creating an end result in which the right-of-way as positioned on the map is not the same as its actual physical position. Determination of the size of tracts or parcels of lands absorbed for the perpetuation of these roads is impossible without competent surveying and mapping effectuating subsequent non-settlement with land owners.

Considerable criticism and dissatisfaction have evolved from the creeping pace at which this cases have been handled. Immediate cause for the dragging compensation process and non-exemption from taxation for lands taken through condemnation proceedings is due to insufficient land identification.

A similar case is the article that appeared in the Pacific Daily News edition of April 4, 1978 which headlined "Residents Paying Tax for Paved Property". Although this case was not under the direction of the Department of Land Management, its still reflects irresponsibility on the part of the government. Publicity of this nature is of course not as disturbing as the need to overcome the accumulated backlog of land matters which severely strains all government agencies charged with land matters combining to yield an administrative problem of the first magnitude. This can be curbed if the agencies involved were not incapacitated by limited operational funds to propagate surveying effectively.

The bulk of public lands, largely suburban, has neither been surveyed nor registered. Any problem for management of these lands will require that they be identified and registered.

Exact figure of the amount of public land is still not available. Included in these are lands acquired through non-payment of taxes, by purchase, land reclaimed by dredging and lands acquired largely due to numerous unsurveyed private lands. The existing amount of public lands cannot be determined until further surveys are made and claims to private ownership can be validated, adjudicated and registered. Claims of private ownership usually arise when some government use is to be made of supposedly government property.

The utilization and conservation of government land requires a program which cannot be fabricated until dependable information can be obtained from credible surveys, and mapping of such surveys. This aspect of our land situation is of paramount importance if we are to safeguard government lands from exploitation by private citizens. Initiation of measures to surmount this problem of public land loss to private owners and land speculators, especially water catchment areas that should be reserved for major water developments are mandatory. The only emendation is the intrusion of a program for expertise surveying and mapping with continued sustenance from sufficient funds.

Because the United States recognized that the program for management of Federally owned lands on Guam would be best implemented under the administrative direction of the local government, these public lands were officially transferred to the Government of Guam. The conveyance was filed at the Department of Land Management on March 30, 1953 under Instrument Number 25219.

Provisions were cited in the conveyance with respect to priorities in the sale or lease of government real property for residential or agricultural purposes - first, persons who have had all their land acquired by the United States, the Naval Government of Guam, or the Government of Guam and who have owned no other land since January 1, 1946; second, persons who have a substantial portion of their land acquired by the United States, the Naval Government of Guam, or the Government of Guam, since July 1, 1944, the remaining portion of whose land is not adequate or sufficient for reasonable agricultural or residential purposes. Provisions were also made for availing said persons of public lands for homesteads and allowing the Government of Guam to set aside sufficient areas of land for conservation, recreational and other long range public purposes for the best interest of the people of Guam.

PROPOSED RESURVEY OF THE ISLAND OF GUAM

Background

As an introduction to the proposed resurvey of Guam, it is important to give a brief synopsis of the surveying conditions on Guam, that is, a short history of the events which led to the present problems and how these events have affected any attempted solutions. It must also be realized that the conditions mentioned hereafter apply to all of Guam and not just to a particular area. For example, cumulative surveying errors resulting in gaps and encroachments magnified survey problems and produced a final event which is the failure of theoretical surveying.

Modern surveying was originated on Guam in 1913 by Butler. He initiated a fairly comprehensive control survey and established numerous monuments which were assigned, through mathematical calculation, a plane coordinate value. These surveys and coordinates, which appear from record to have been performed and calculated personally by Butler, indicate a generally high degree of accuracy and reliability. Consistently good surveying conditions existed up until the early 1930's. Apparently, good qualified work was done only under Butler's direct supervision and personal attention. However, Butler's successors, although sharing his knowledge of the theory and mechanics of plane coordinates, regretfully lacked Butler's apparent wisdom and foresight of the possible fallacies of plane coordinates in practical use.

During the latter 1930's up to the beginning of World War II, most of the remaining properties on Guam were surveyed and tied to the Butler 1913 control monuments. Many of these surveys were good, particularly within the specific group of lots completed under one project. Other surveys, some of which can be isolated, had errors in field survey and mistakes in mathematical calculations.

Generally speaking, the relative positions of property monuments to each other in the field, with no reference whatsoever to coordinates, have been found to be good with a few exceptions wherever original property monuments could be found.

On the other hand, the calculated ties to control monuments have not only normal mathematical inconsistency, but are subject to gross human errors which naturally occurred. This concept of relative position versus tied position is of extreme importance. However, let us proceed with further events before actually drawing conclusion.

After the War ended, military coordinate-oriented surveyors and young, inexperienced personnel tried to resurvey Guam. The control surveys are admittedly of lower accuracy than the Butler 1913 surveys. Also, the property surveys were often questionable. Military boundaries were well monumented and perimeter relative position is generally good. Road control line was described but never monumented.

In all these surveys of the post-war years, the concepts of coordinated tied position, and what could be summed up as theoretical plane coordinate surveying persisted. But due to inexperience, the personnel actually performing learned only the mechanics of coordinates and more had the opportunity to gain wisdom in random errors, blunders, mistakes, and normal human errors. They learned the magic of adjustment which came from textbooks and not the actual practical aspects of good surveying.

The next event on Guam was an attempt in about 1960 to arrive at a mathematical correlation of all previous control surveys. The U.S. Coast and Geodetic Survey states quite simply that the attempt was a complete failure which did us more harm than good. It was another three years before a new control network was started.

The 1963 GGTN has in it some isolated gross blunders, but it was highly accurate and a step in the right direction.

Added to the basic net has been nearly 1000 intermediate traverse stations. Of these, 85% have 1963 coordinate values during eleven years of surveys and of these, probably 90% have gross errors due to inexperienced personnel in performing geodetic work. Still, this was a step further in the right direction though plagued by inexperienced personnel and often incompetent leadership.

That brings us to the present technical aspects of surveying conditions on Guam and then only touching the highlights.

In many areas on Guam, the destruction of practically all of the comparatively accurate, original monuments by World War II and by people who actually repositioned monuments for profiteering purposes or other reasons, left only the reliance upon theoretical plane coordinate surveying system for reestablishment of property corners. These weaknesses are still present and surveying chaos is quite evident. To give a general background of present conditions, this is the synopsis.

Basic Problem:

The basic technical problem of Guam land surveys is the concept of coordinate tied position versus relative monument position. Especially during the past twelve years, many professional papers and discussions have been presented in nearly all of the mainland states on this very same subject. The emerging and rapidly expanding computerized technology is pressing for complete coordinate surveys for all lands. The more conservative title profession and conscientious property surveyors hold on to the concept of original monumentation and relative location of the properties. The development of land surveys here places Guam in the unique position of having more experience and examples of coordinate surveys than any mainland state. What has been held in check by conservation forces in the various states has been attempted on Guam by successive surveyors with the best of intentions, but regretfully, not to the best of results.

This is not to say that the concept and theory of coordinate surveys will not work. It is to say that the proper approach and combination of elements have not yet been achieved. The direct approach of coordinate surveys prescribes accurate and perfect mathematical correlation of all data, and does not allow for human error. The conservation approach developed over many centuries of law and cultures realizes the possibility of human error and provides safeguards. The idealistic coordinate survey is a near impossibility. The employment of coordinates in their proper perspective as a tool of the surveyor is practical and essential.

Definition of Elements:

The primary elements of a land survey are two:

1. The physical evidence of conditions on the ground; and

2. The title evidence of ownership in the records.

Between these two primary elements is the framework of technology which should provide an accurate, true, and complete correlation of one primary element to the other primary elements. This is the fundamental purpose of the land surveying profession and of all government and private factors connected with surveying. Surveying and records personnel require close cooperation of all operations at all times.

This requirement of correlation of records and survey is important. The specific name of the owner in the records is immaterial to the surveyor. A truly professional surveyor will consider the rights of adjoiners as well as the right of his client. The importance of records to land survey is a clear chain of title which is readily accessible.

Coordination of Existing Physical Evidence

The first problem of surveying at any particular area is to coordinate every recoverable item of physical evidence on one accurate coordinate system. This begins with a precise survey of all the 1963 Guam Geodetic Triangulation Net Stations around and in the area. The basic net is connected by control traverse criss-crossing the project area. The idea is to begin with a highly precise, large figure surrounding the project and work inwards in successively smaller figures to densify the control.

The primary control and densification is the very first task and responsibility of the government. The reverse procedure of working separate surveys and then trying to expand and join the various surveys will never succeed. This is usually the procedure of oceanic private surveyors to control land surveys exclusively. This is

natural. The private surveyor is only paid by his client for the immediate problem and simply does not have the time or money to concern himself with the total problem. The government is responsible for the total basic control so that all physical evidence can be coordinated into one system.

Once the basic random control is densified sufficiently, the tying of an existing property corner evidence to one control system is possible. This could be done by conventional ground surveys by government crews. It was tried and found to be too time consuming and expensive. The use of maps made and filed by private surveyors with property tied to the control is another approach. It was tried. It was found that the normal mathematical inconsistency and the occasional gross blunders resulted in a confusion of mass data which could not be satisfactorily correlated.

The Utopian concept of coordinates applied to surveys has thus far failed to produce the expected results. The principle is not contradicted but the full mechanics of its proper application has not been attained as yet. The limitation on the accuracies of the control net places conditions on the application to property surveys. The densification of control to good accuracy combined with the defining of perimeters of groups provides a relationship between the precisiveness of control surveys and the relative position factor so important to property surveys.

The integration of the records system to the group concept completes that land survey system. Records and surveys are so intimately related to each other that the technical solution must consider the two as being one. The survey depends on records for title evidence and records depend equally on survey for physical evidence. The two support each other completely.

Technology can perform miracles today but only in an atmoshpere of cooperation, understanding, and desire for the common good. The group concept for surveys and records is thus a reflection of the necessity of people to provide first for all, rather than for the individual. With the proper atmosphere, the technical problems of Guam land survey are soluble.

PROGRAM FOR THE IMPLEMENTATION OF THE GUAM GEODETIC TRIANGULATION NET, PUBLIC LAND SURVEY AND THE ISLANDWIDE CADASTRAL MAPPING SYSTEM

Intent:

It is the intent of the program to survey, delineate and map all real property belonging to the Government of Guam as prescribed in Section 13970, Title XIV, Chapter XII of the Government Code of Guam, thereby accomplishing registration and acquiring certificates of title to all such land.

Scope of the Program:

The program would cover the continuation of the Guam Geodetic Triangulation Net in an effort to establish approximately 5000 control points all over the island thereby densifying the triangulation system and replenishing with new monuments those which have been destroyed. Government land survey would be executed simultaneously to arrive at a successful end result of securing registration and titles to said government land and to complete plotting of such land on the island cadastral maps for convenient reference and easy accessibility of records by both the governmental agencies and the private sector.

Methodology

Guam Geodetic Triangulation Net

I. Technical Specifications for Guam

A. General: The following specifications cover geodetic control updating, and densification of the 1963 triangulation. Three phases will be performed.

1st Phase -- Primary Stations 1/100,000.

The 1963 basic geodetic triangulation net shall be utilized as the framework for the establishment of additional primary stations to first order accuracy or a minimum accuracy of 1 part in 100,000. Laser electronic meter should be utilized to check for scale errors and/or movement of our 1963 primary stations. Any of these stations that may have been destroyed should be reestablished.

2nd - Phase -- Secondary stations 1/50,000 with stations spaced about 1 mile apart.

Second order traverse stations shall be established between the primary stations at approximately 800 meters to 1609.35 meters or 1 mile to second order accuracy or a minimum accuracy of 1 part in 50,000.

3rd - Phase -- Secondary stations 1/25,000 with stations spaced about 1/2 mile apart.

Additional stations shall be established from 200 meters to 400 meters or 800 meters between second order accuracy stations to third order accuracy or a minimum accuracy of 1 part in 25,000.

From these three phases, all land parcels should be surveyed with monumented corners to a minimum accuracy of 1 part in 25,000.

B. Procedure - To derive efficient and accurate surveys, this system of procedures must be adhered to:

a. Specified standards must be established.

b. Reconnaisance is next for site location.

c. Set monuments.

d. Schedule field work to begin with a starting check angle and end with a check angle.

e. After observation of horizontal and vertical angles, the field notes shall be checked for possible errors.

f. Abstracts of field notes for both horizontal and vertical angles shall be finalized.

g. EDMI (Electronic Distance Measuring Instrumer measurements shall be checked and computed tc slope. For those stations with known elevati sea level distances between stations may be obtained.

h. Elevations for each station shall be computed utilizing either the slope or horizontal distance and zenith distances.

i. Slope distances may now be reduced to sea level.

j. Traverse loop will be laid out to determine if angular closure is within limits.

k. Traverse loop formed must be computed using horizontal angles and reduced distances ensuring that angle and length projection is within limits.

l. Station coordinates may now be computed using the coordinate traverse adjustment program.

m. Proceed with undertaking computation of plane coordinates to geographic positions.

n. Compute grid bearing between stations.

o. Prepare data sheet for each station exhibiting plane coordinates, geographic positions, bearings to other stations and description of station.

p. Have data sheet typewritten.

q. Key punch all data for future adjustment by NGS.

r. Leveling shall be scheduled where ties to other 1963 bench marks will be made.

s. Check leveling notes and prepare abstracts for these.

t. Adjust leveling line or loop distributing errors on closure proportionately to the distance of the line or loop.

C. Monuments: All 1st, 2nd and 3rd phase stations shall be doubled (underground station disk). Reference marks will not be set, but where possible, chisel crosses or nails or blazed tree, etc., shall be observed and measured.

BM ties shall be made as shown in the reconnaissance sketch. All BM's under 30-meters shall be traversed with two 30-meter standardized tapes and shall also be observed, taking 3 positions. BM's over

30-meters will be leveled by using the theodolite with rod or tape, or level and level rod.

G.G.T.N. monuments shall be tied in by traverse using standardized tapes, (under 30-meters) or DI-10 (over 30-meters) and observations will be 4 positions, 5 second rejection limit.

Old triangulation stations that are not used in traverses, but are near a traverse station must be tied in with traverse. Wheresoever possible, other NGS methods will be utilized depending on conditions of the area involved.

Observers/recorders shall draw a sketch in the volume and show all reference measurements, stamping of disk, etc. Reconnaissance is responsible for writing a "To Reach" for all new stations and corrections for recovery.

D. Angulation: All primary (1st Phase) stations shall be observed with a Wild T-3 Theodolite, taking 16 positions with a rejection limit of ±4 seconds.

Secondary (2nd Phase) stations shall be observed with a 1.0 second Theodolite, (Wild T-2 or equal) or a Wild T-3, taking 4 positions with a rejection limit of ±5 seconds.

Third (3rd Phase) Phase stations shall be observed with a 1.0 second or better Theodolite, taking 4 positions with a rejection limit of ±5 seconds.

All 2nd and 3rd phase stations shall change initials on the last positions to eliminate blunders. The last positions shall agree with the other positions within 5 seconds after converting the angle values back to the first initial.

The attached plate settings shall be used for all angulation and umbrellas shall be used to shade the instruments at all stations.

If optical plummets are used, they must be checked and adjusted prior to beginning of field work and checked weekly thereafter or anytime they are dropped or abused.

Observers shall check and initial all entries in the volume and abstracts (daily) and turn them into the office. Recorders must double check and initial any corrections to volumes and/or abstracts; also, instructor's initials shall be entered.

*8-Positions

Position		Circle		Micrometer
* 1	D	0°	00'	10"
	R	180°	00'	10"
2	D	11°	00'	25"
	R	191°	00'	25"
* 3	D	22°	00'	35"
	R	202°	00'	35"
4	D	33°	00'	50"
	R	213°	00'	50"
* 5	D	45°	00'	10"
	R	225°	00'	10"
6	D	56°	00'	25"
	R	236°	00'	25"
* 7	D	67°	00'	35"
	R	247°	00'	35"
8	D	78°	00'	50"
	R	258°	00'	50"
* 9	D	90°	00'	10"
	R	270°	00'	10"
10	D	101°	00'	25"
	R	281°	00'	25"
*11	D	112°	00'	35"
	R	292°	00'	35"
12	D	123°	00'	50"
	R	303°	00'	50"
*13	D	135°	00'	10"
	R	135°	00'	10"
14	D	146°	00'	25"
	R	326°	00'	25"
*15	D	157°	00'	35"
	R	337°	00'	35"
16	D	168°	00'	50"
	R	348°	00'	50"

8-Positions (T-2)

Position		Circle		Micrometer
1	D	0°	00'	10"
	R	180°	00'	10"
3	D	22°	01'	25"
	R	202°	01'	25"
5	D	45°	02'	40"
	R	225°	02'	40"
7	D	67°	03'	55"
	R	247°	03'	55"
9	D	90°	05'	10"
	R	270°	05'	10"
11	D	112°	06'	25"
	R	292°	06'	25"
13	D	135°	07'	40"
	R	315°	07'	40"
15	D	157°	08'	55"
	R	337°	08'	55"

4-Positions (T-2)

1	D	0°	00'	10"
	R	180°	00'	10"
5	D	45°	02'	40"
	R	225°	02'	40"
9	D	90°	05'	10"
	R	270°	05'	10"
13	D	135°	07'	40"
	R	315°	07'	40"

4-Positions (T-3)

1	D	0°	00'	10"
	R	180°	00'	10"
5	D	45°	00'	25"
	R	225°	00'	25"
9	D	90°	00'	35"
	R	270°	00'	35"
13	D	135°	00'	50"
	R	315°	00'	50"

Micrometer settings to be within ± 5 units

E. Measurements: For the various phases the following procedures will be used:

1st Phase - (1/100,000) one measurement with the RANGER III shall consist of 5 readings in meters and 5 readings in feet. A conversion of feet to meters shall be made while at the station site. If the readings do not agree within 1.5 cm., then another measurement must be taken. Conversion of feet to meters shall be feet X 0.304800609 63 or feet ÷ 3.28083333, rounding off the readings to millimeters.

2nd and 3rd phases shall consist of taking one measurement from each station whereby measurements are made in both directions on every course. Readings in meters and feet shall be the same as 1st phase, these also applies to conversion except they should agree within 1 cm.

Instruments and prism constants shall be dialed into the instrument with the recording sheet so noted. Atmospheric corrections must not be dialed as they will be taken at each station where the correction is computed. On a traverse line 1,000 meters or less, the temperature and pressure shall both be taken at the instrument station only; lines in excess of 1,000 meters shall have temperature and pressure readings at both ends of the line.

Thermometers and barometers must be shaded with an umbrella. The Navy will be asked for dry and wet bulb temperature readings on a daily basis to correct for humidity, (normal would be about 1.1 PPM correction).

For a discussion on tapes and EDMI's, please see Section G of III, (Technical Specifications for Public Land Survey), under the program for Public Land Survey.

II. Technical Specifications for Geodetic Leveling

First Order Leveling - is to be used for developing the main level net. Lines shall be placed so that eventually no point on the island shall be more than 50 miles from a bench mark established by this order of leveling. Lines shall be divided into sections one to two miles in length, each section to be run forward and backward, the runnings not to differ by more than $4 \text{ mm } \sqrt{K^*}$ or $0.017 \text{ foot } \sqrt{M^*}$.

Second Order Leveling - is to be used in subdividing loops of first order leveling until there is no point within the area that is more than 12½ miles from a first or second order mark. Second-order leveling shall include lines run by first order methods but in only one direction, between bench marks previously established by first-order leveling, and all double lines of leveling whose sections are run in a backward and forward direction to check within the limits of 8.4 mm $\sqrt{K^*}$ or 0.35 $\sqrt{M^*}$.

Third Order Leveling - may be used in subdividing loops of first or second order leveling in areas where additional control may be required. Lines of this order shall not extend more than 30 miles from lines of first or second order and they may be single run lines but shall always be loops or circuits closed upon lines of equal or higher order. Closing checks shall not exceed 12 mm $\sqrt{Km}$ in circuit or 0.05 foot $\sqrt{\text{miles}}$ in circuit.

*K is the length of a section in kilometers.
*M is the length of a section in miles.

For methods and other general instruction for geodetic leveling, please see Manual of Geodetic Leveling Special Publication Number 239 prepared by the U.S. Department of Commerce Coast and Geodetic Survey printed in 1948.

For computations and adjustment of geodetic leveling, please see Manual of Leveling Computation and Adjustment, Special Publication No. 240 prepared by the U.S. Department of Commerce Coast and Geodetic Survey printed in 1948.

Public Land Survey

These procedures have been formulated for the implementation of the program objective with respect to public lands.

I. The survey of public lands belonging to the Government of Guam shall be divided into three sections.

   a) Survey of government land occurring in the northern section.

   b) Survey of government land occurring in the central section.

   c) Survey of government land occurring in the southern section.

II. Public land survey shall commence at the northern section. The selection of this section for our priority survey is based on these factors.

a) Land values in this area have soared immensely these last few years.

b) There is concrete evidence of massive development progressing in this area. Our records also reflect a definite increase in land registration cases in this locality.

To safeguard government real property, measures must be initiated to implement surveying, mapping, registration and acquiring of certificates of title to government parcels in this locale where there is maximum potentiality of government land loss especially in areas tributary to the island's water supply and its vicinities, and to preserve these land and guard them against private land speculators.

III. Technical Specifications for Public Land Survey

A. Procedure

a) Perform thorough research on subject area and all adjacent lots.

b) Prepare preliminary sketch for field reconnaissance crew.

c) Set P.O.T.'s, monuments, etc.

d) Schedule field traverse work.

e) As the horizontal and vertical angles are observed, and field notes are turned into the office, they shall be checked for errors. Traverse loop shall be laid out, angular error shall be determined.

Minimum allowable error on angular closure is $10'' \sqrt{n}$ where n is the number of stations occupied. Preliminary bearings shall be computed from these angles.

f) EDMI measurements received from the field crew shall be computed to slope.

Distances under 30 meters shall be chained rather than measured with an EDMI.

g) Minute checks of vertical angles shall be made and elevations shall be computed utilizing slope or horizontal distances.

h) EDMI measurements shall be reduced to sea level.

i) Traverse computations shall be performed ensuring that specifications are met..

j) Metes and bounds description shall be finalized.

k) Final map shall be prepared for review of Chief of Cadastre and submission for approval.

l) Follow up until completion - until necessary signatures are obtained.

B. Survey is to comply with regulations prescribed in Section 13802, Chapter 9 of Title XIV, Government Code of Guam and the supplement provisions of that Chapter.

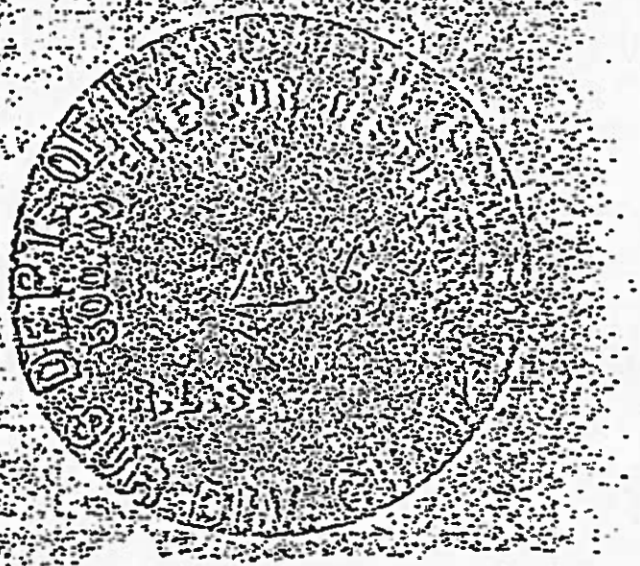
C. Basis of Survey - A minimum of one corner, physically referenced to the Guam Geodetic Triangulation Net shall be utilized as the basis of survey.

D. Monumentation - An identifying marker must be set in every change of direction of the boundary.

Reference monuments shall be set only when it is physically impossible to set the true corner or when destruction of corner is imminent due to construction.

Corners shall be identified by a 6"x6"x18" concrete monument with a standard metal disk upon which is inscribed:

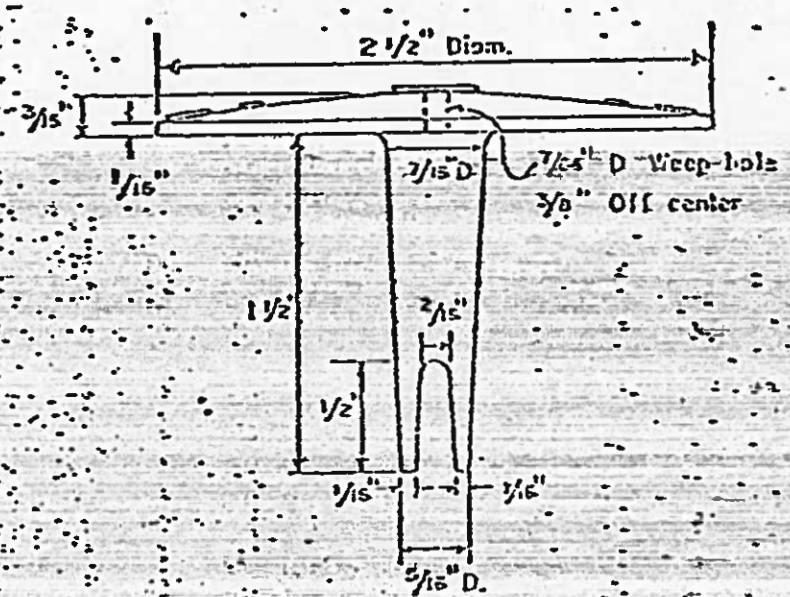
DEPARTMENT OF LAND MANAGEMENT
$500.00 Fine for Disturbing
( )
RLS ( )
SURVEY DIVISION, GUAM



NOTE

ALL LETTERS
CENTER TRIA
TO BE EMBO
1/32" APPROXI

SCALE = FULL SIZE



All points of traverse shall be denoted with #2 or #4 rebar with plastic caps marked LAND MANAGEMENT.

E. Angulation: Allowable error is not to exceed $10'' \sqrt{n}$ where n is the number of stations involved in the traverse.

F. Measurements - The minimum accuracy of surveys shall be no less than one part in 25,000 or th third order accuracy on all property lines of boundary or interior survey.

Reconnaissance surveys shall maintain an accuracy of not less than 1 part in 5,000 except in cases where only general monumentation is to be obtained and no precise monumented corners are to be created.

G. Equipment

1) Utilization of Electronic Distance Measuring Instruments

These distance measuring devices better accuracy and increase production at a minimum cost of time and labor. The Wild DI-10 utilizes infrared invisible light while the Ranger utilizes visible light to measure distances. Operation of these instruments is simple and straightforward with a minimum training course. Plumbing instruments and prisms being precisely over the point and proper alignment to the prisms are extremely important. Instrument constants should be checked frequently. Refractive index corrections are small and can be attained. Precise distances can be measured by one employee at a very minimal period of time and eliminates the numerous tape lengths which can naturally have error resulting from improper tension, improper inclination, improper catenary corrections, and human error with each tape length.

Training in the operation of EDMI's can be completed in a few hours. Proficiency and capability of overcoming problems related to day-to-day encounters with blocked lines passing traffic, eccentric set-ups, etc., require weeks, months and even years in experience.

a) Distomat DI-10 - An excellent instrument for stake-out and subdivision projects with respect to speed and accuracy, it has been used very successfully on control survey projects.

It is necessary to recharge the battery after 2 to 4 hours of continuous use. For extended operation, the unit is equipped with an external battery hookup.

The atmospheric correction graph supplied with the instrument is adequate for the range of the instrument and can be easily used in the field.

A test in 1968 showed that distance readings would change when connecting cables were moved but the fact that the cable movements had no effect on the readout was established in 1969. A change in the reading is only imminent when the cable is crimped sharply, but upon release, the correct reading is once again displayed.

Interruptions in readings may be experienced when a moving object crosses the measured path, however, the proper readout will be displayed as soon as the obstruction passes.

A different CAL value must be determine when using retro-reflective prisms other than those supplied with the instrument.

The readout will not stabilize with more than ten divisions of light return and the same is true when measuring with only one division of light return.

Measurement exceeding 1,000 meters must be known to the nearest 100 meters as the reading for a 1,095.50 line will be displayed as 95.50 at which case, 1,000 meters must be added. In cases where the readouts of measurements in excess of 1,000 meters does not stabilize, the high and low readings are meaned to determin the distance.

b) Ranger - Intensity control knob should be turned completely clockwi as this opens the aperture for maximum light in the counterclockwi position. At the completion of measurements for a line, the intensity control knob should be turned completely clockwise. If the next line to be measured is very short, you will not overload the photodiod

Panel light knob should be turned completely counterclockwise instead of clockwise.

Battery must be fully charged.

An error of a few millimeters will occur if the needle is set in the midst of the green area when adjust the intensity control knob.

Touching the instrument while takin the distance should be completely avoided because this action changes the signal light at times.

A filter should be placed over the transmitting optics to diffuse the outgoing light.

Instrument Evaluation - Simplicity of operations, speed in obtaining preliminary data and accuracy of measurements even in heavy traffic are features of the Ranger. An average of nine measurements per minute can be obtained at ease.

SUMMATION: The advantages of utilizing EDMI's far outnumber the disadvantages of taping. Larger product and increased accuracy can be expected if personnel are trained and familiarized with the proper field methods and procedures using proper related equipment.

2) Theodolites

Introduction: Many surveyors avoid using t even becoming familiar with theodolites because they fear the name "theodolites" and its inference to control surveys. This fea is unjustified as the following definitions will illustrate.

THEODOLITE: A precise surveying instrument consisting of an alidade with telescope, mounted on an accurately graduated circle, equipped with necessary levels and reading devices. On most instruments, the alidade carries a graduated vertical circle. The two types of theodolites are direction instruments and repeating instruments.

TRANSIT: A surveying instrument composed of a horizontal circle graduated in circular measure and an alidade with a telescope which can be reversed in its supports without being lifted therefrom.

Based on these definitions it can be stated that a theodolite is nothing more than a glorified transit. Putting aside these definitions and getting to the point, theodolites provide the means for obtaining reliable and very precise horizontal and vertical observations with a minimum of effort.

This chapter is designed to familiarize the reader with theodolites in general and to emphasize major principles in their operations. As most theodolites are similar, to avoid repetition, small differences will not be explained. However, to maintain continuity, all aspects of one type theodolite, the Wild T-2, will be discussed with other types being referenced whenever necessary. Specific information on various instruments will be found in the manual which accompany these instruments. Read this manual prior to operating the theodolite.

Directions are measured with the theodolite to two or more points, together with the inclinations of these directions, all referred to the horizontal plane passing through the observation point. From these measurements, horizontal and vertical angles are obtained.

BASIC PRINCIPLES: From what has been written already, it follows that theodolites need to be made for two different types of work. Triangulation needs instruments giving the highest possible accuracy in angle measurement, in other words, theodolites reading at least to single seconds. For traversing and detail survey, instruments reading to 1/10' are often sufficient, although they must be capable of providing a highly accurate optical distance measurement In both cases, the attainable accuracy depends mainly on three factors, namely: the instrument, the survey technique, and the error adjustment. So, before progressing to practical examples of angle measurement, a closer look must be taken at the effect of these influences.

The theodolite consists of the following main parts: a fixed base with tribrach movable upper part and a telescope. The base, with the tribrach, is screwed securely to the tripod head and is levelled up by means of its three foot-screws. In simple theodolites of older construction, the horizontal circle is fixed rigidly to this base. In modern instruments, the circle can be rotated independently by means of a milled knob or some other device. On the upper part (the alidade) which is rotatable about the standing (vertical) axis, are fixed bearing the telescope (with the sighting axis) and the vertical circle. The alidade also contains the reading index for the horizontal circle. For rough levelling-up, the base has a circular bubble fitted but for more accurate levelling-up, the more sensitive alidade tubular level (the plate level) is used. The instrument is centered over the station point by means of a plumb-bob or a built-in optical plummet. The vertical circle usually has an index level so that it can be oriented correctly, in relation to the horizontal, before a vertical angle is read. The telescope may be aimed

in any desired direction in space, by means of rotations about its standing and tilting axes. Fine pointing to a particular target is achieved accurately by means of clamping and slow motion (drive) screws.

In a Repetition Theodolite, the horizontal circle can be rotated independently about the standing axis, which, as a result, is made as a double axis. In this way, when sighting a target, any required reading can be set on the circle, e.g. the initial reading to R.O. (Reference Object) can be made zero.

OBSERVING PROCEDURES: Observations should be made following procedures which remove or minimize the collimation error of the instrument and range over the complete circle and micrometers.

To illustrate this technique, let us say several signals are to be observed from a point. One signal, usually the one furthermost to the left is selected as the initial. The circle and micrometer are set for a particular position. It is not necessary to set the seconds (or units for the older Wild T-3 model) on the micrometer exactly as specified, but every effort should be made to have the setting within 10' (or 5 units for the T-3). Each signal is then observed in a clockwise order and the results recorded. At the last target the telescope is reversed (counterclockwise order). The observed seconds are meaned and the initial direction is subtracted from each observation, thus referencing the measurements to the initial.

For more detailed information on theodolites, please see manual on "The Theodolite and its Application" which may be found at the Department of Land Management, Survey Division.

3) Tapes

Taping Procedures -

To obtain proper measured lengths with steel or invar tapes, corrections must be taken into consideration regardless of the amount of experience personnel has had.

a) All tapes must be standardized or compared to a standardized tape or base.

b) Improper tension results in incorrect lengths as tension appli affects the amount of a sag in each tape length.

c) Proper temperature readings are necessary for thermal expansion correction.

d) Elevation differences between tape ends must be computed and lengths corrected.

e) Care must be taken in aligning tape.

f) Sag corrections, temperature correction, thermal expansion correction and grade and alignment corrections must be made.

Islandwide Cadastral Mapping System

The Survey Division is additionally charged with putting all government parcels on the island's cadastral maps. This function has been initiated by the Division including in the process, plotting of approved private survey maps. However, investigation revealed that progress has not been gratifying. Work has been extremely time-consuming and laborious. For this reason procedures were formulated and survey was made of equipment relative to establishing a more stable and well-founded cadastral mapping system.

I. Program Procedure

a) Research every recorded land parcel from period as early as the year 1880.

b) Verify mathematical accuracy of each map.

c) Perform preliminary plotting into cadastral maps for comparison.

d) Finalize map for islandwide cadastral mapping system.

II. Equipment

We delved into the performance efficiency and costs of different programs and equipment for cadastral mapping and finally, was apprised of the feature qualities possessed by a CalComp drafting system best suited to our purpose.

The CalComp 7000 High Performance Drafting System is developed for graphic applications which require line quality comparable to a skilled draftsman but equipped with maximum drafting throughput and a full line of accessories. It consists of a read only magnetic tape unit, a stored program controller a read/write cartridge, and a high performance flatbed plotter.

Capabilities of the CalComp 7000 High Performance Drafting System

The principal advantage of this model is it provides usable throughput by producing high quality reliable artwork at maximum plotting speeds. It features a revolutionary four-pen pressurized inking system that gives quality liquid-on-mylar-lines at speeds up to 42 inches/second (107 cm/second). This four program-selectable liquid ink pens provide different range of color and linewidth selections. Inking may be done on linen or synthetic materials as well as on paper.

The 7000 system provides the system operator the flexibility of selecting from a wide range of performance without additional computer runs to generate new plot tapes. If the draftsman has a new plot tape and wants to verify that it is correct, he can load the tape onto the read only magnetic tape unit, set the plotter performance parameters for maximum throughput and see the data plotted in minimum time at accelerations up to 1.4G and speeds up to 42 inches/second (107 cm/second) diagonally.

If the draftsman has an error-free tape, he can select the system performance most suitable for

the accessory and drafting material. He can choose the performance parameters which assures him of line quality as good as that done by hand. A simple cartridge load is all that is necessary to change plotter performance parameters.

Plot scale is another variable that can be manipulated at the controller. By using these control options, it is possible to do extremely fast, scaled-down verification plots, then cut an integrated circuit mask or scribe a map plate from the same verified tape at full size and maximum quality.

The operator can scale the plot up or down by factors of 2, 1, 1/2, or 1/4.

Verification plots can typically be done twice as fast as final quality plots. One plotting system does both jobs; there is no need for additional computer runs unless data must be changed

If it is ever necessary to interrupt plotting and put the 7000 under manual control, a "Return" button on the plotter makes it possible to send the plothead back to where it left off to resume plotting.

The plotter's "Origin" control sets an exact point of origin and can return the plothead to that point at any time. This is particularly valuable when producing overlays and when it is desirable to redo part of a plot.

Changes do not require generating a new plot tape in a host computer; coding is in unique sentences, all of which are referenced to an absolute origin, making it easy not only to add or delete data, but also to replot any portion of a drawing by simply returning to the appropriate sentence; annotation, as well as graphic data, can be added, deleted or altered through a teletypewriter; linear, circular, dashed-line and spline fit interpolation are done in the controller plotting data may be independently scaled in X and Y, mirrored and rotated -- all these are more additional features of the 7000 CalComp system.

To sum this up, with a CalComp 7000 High Performance Drafting System, we obtain line work at a minimum cost of labor and time.

Comparison

We have made a close study of the advantages of purchasing this equipment and scrutinized every possible disadvantage. This is our analysis.

If the Survey Division were to employ ten (10) draftsmen, assuming each draftsman could plot (including metes and bounds descriptions) five (5) maps in one day, at 260 working days per annum, they should complete 13,000 maps per annum.

Taking into consideration that approximately 600 documents are recorded at the Department of Land Management each month, 80% of which have map attachments, this would give the draftsman 5,760 maps per annum to plot in addition to approximately 200,000 already recorded but not yet plotted. With these figures, it would take approximately 27.6 years to update the cadastral maps. (Note that this has been calculated without considering important aspects such as employee work performance, absences, and human errors.)

The CalComp 7000 High Performance Drafting System is capable of plotting (complete with metes and bounds descriptions) 132 maps per day and at 260 working days per annum, it should finish plotting 34,320 maps per annum. At this speed, the Cadastral maps should be brought up to date in seven (7) years which is one-fourth of the time consumed if the Division were to employ ten (10) draftsmen.

In terms of expenditures, it has been proven to be more economical with the CalComp system. Employing ten (10) draftsmen at approximately $7,770/annum (includes employee wages and benefits) for 27.6 years would amount to $2,144,520. This figure does not include drafting equipment, materials and supplies.

The estimated cost of the CalComp 7000 Drafting System including shipping and insurance charges is $90,000. Since CalComp does not have maintenance service capability in Guam, we would have to send one of our technicians to attend maintenance training in the United States for a period of approximately one month. This is estimated to amount to $2,000. Normally, monthly maintenance charge is $693.75, charge per annum would be $8,325. So as you can see, sending our own technician for maintenance training would prove to be wiser.

Also, a recommended level of spare parts have to be purchased along with the drafting system since we are located outside the continental U.S. At approximately $4,000 cost of spare parts/annum, in 7 years, cost would be approximately $28,000.

All these brings us to this conclusion. By utilizing a CalComp 7000 Drafting System, the total estimate of expenditures for updating our cadastral maps in seven years would be $199,400, this figure already including personnel service and benefits of $79,400 for 7 years.

Virtually, I am totally convinced of how the advantages of purchasing a CalComp Drafting System far outnumber the disadvantages of utilizing more manpower with respect to cost of time and labor, and expense to the Government of Guam. If we are to permanently eliminate further surveying quandaries as to the boundary of every parcel of land on the island, then updating our cadastral maps at the earliest possible time should be our very <u>first</u> concern.

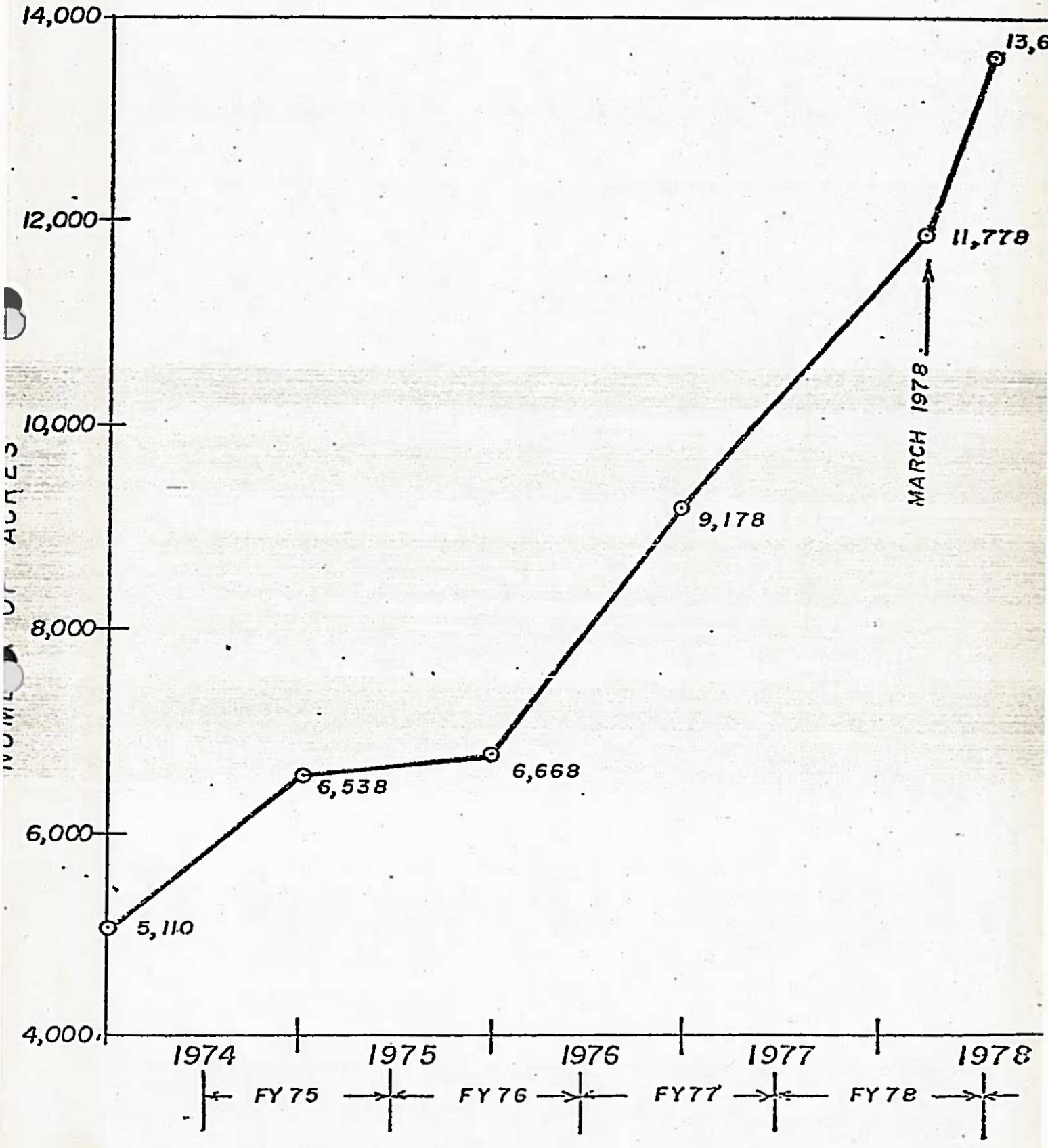
To outline its purpose and function - it is utilized for different types of surveys, mainly triangulation surveys where stations are not intervisible from the ground because of trees, buildings and other obstruction in the lines of sight between adjacent points. Therefore, the tower is utilized to elevate the observing instruments for sighting the targets above the intervening obstructions.

Another 37' tower was constructed to act as a mobile tower for whenever and wherever needed.

To further elaborate on our accomplishments, we have undertaken updating of cadastral maps by plotting not only approved maps of government land but also approved private survey maps.

For the aforementioned charts on our accomplishments, please turn to pages 45 to 52 .

PUBLIC LAND SURVEY
FOR LAND REGISTRATION

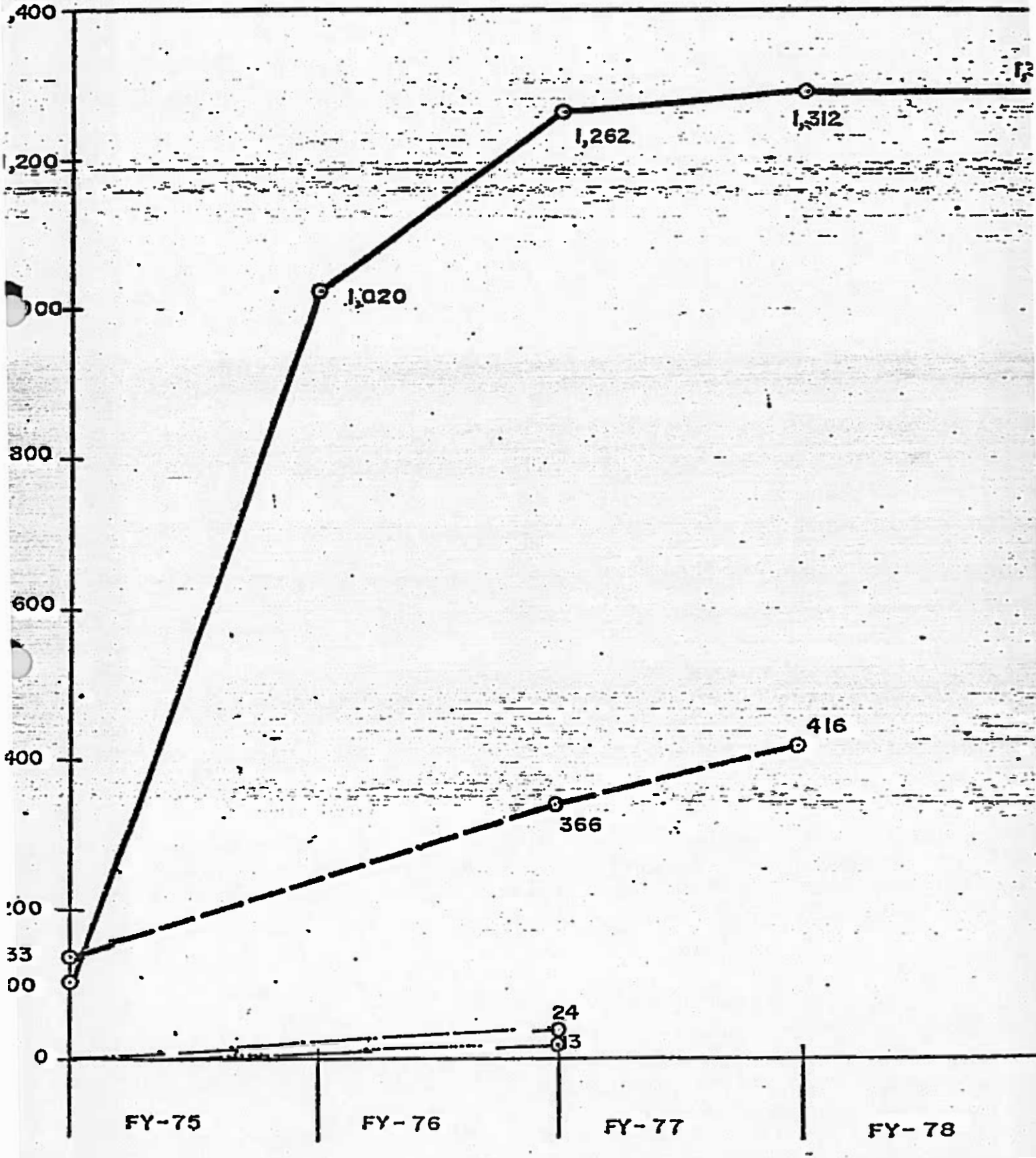


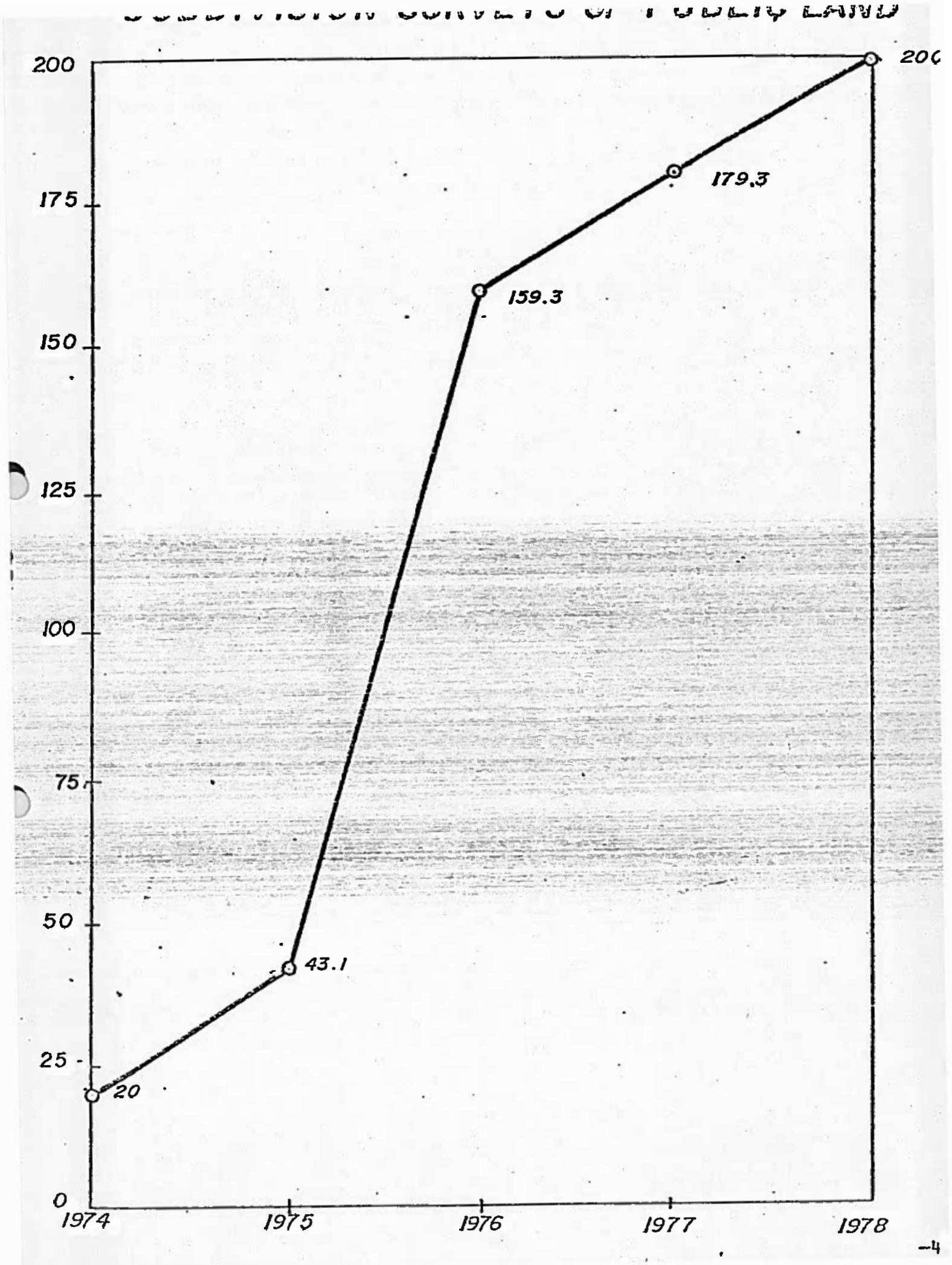
GUAM GEODETIC TRIANGULATION NETWORK

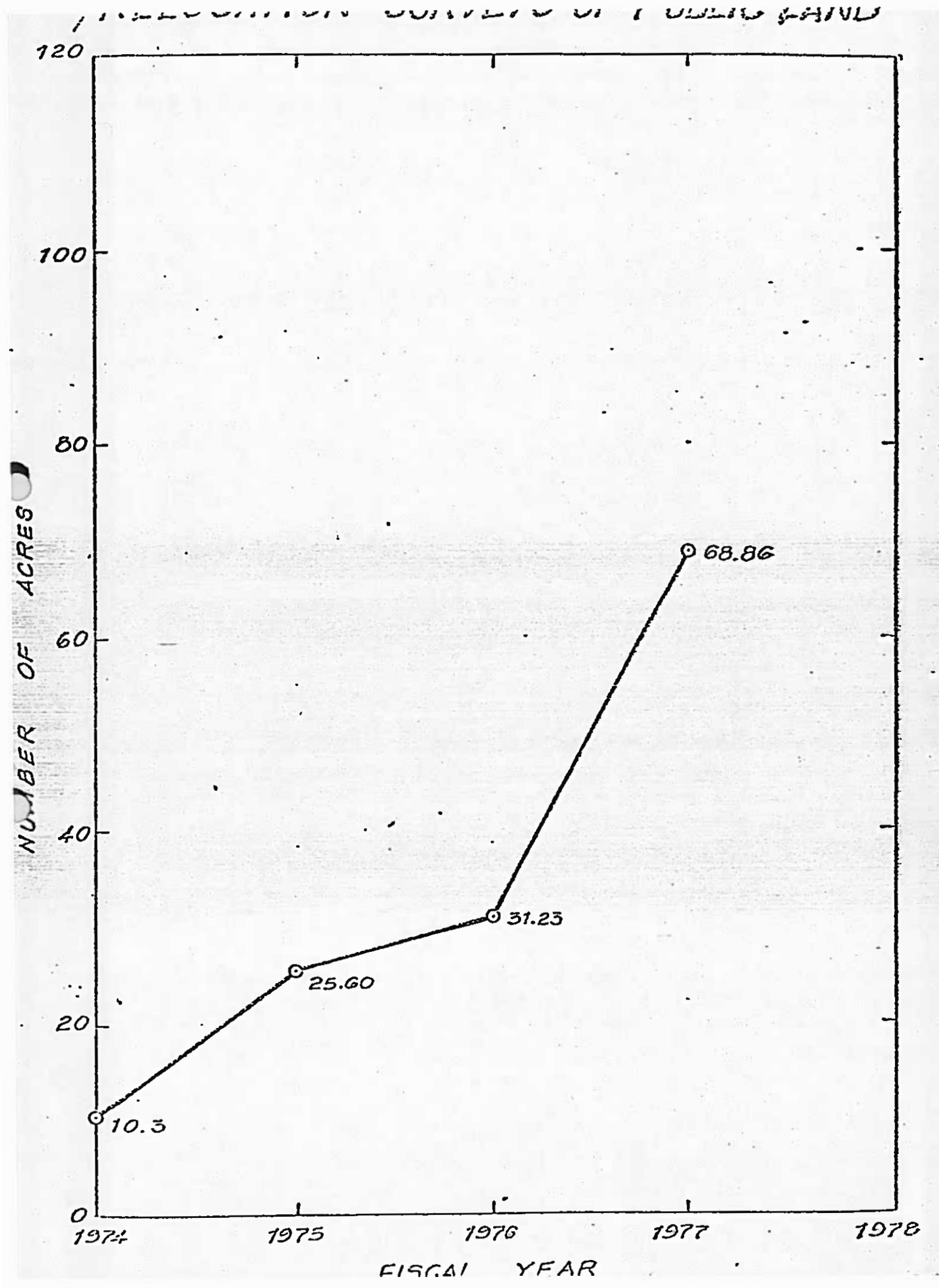
HORIZONTAL CONTROL
VERTICAL CONTROL

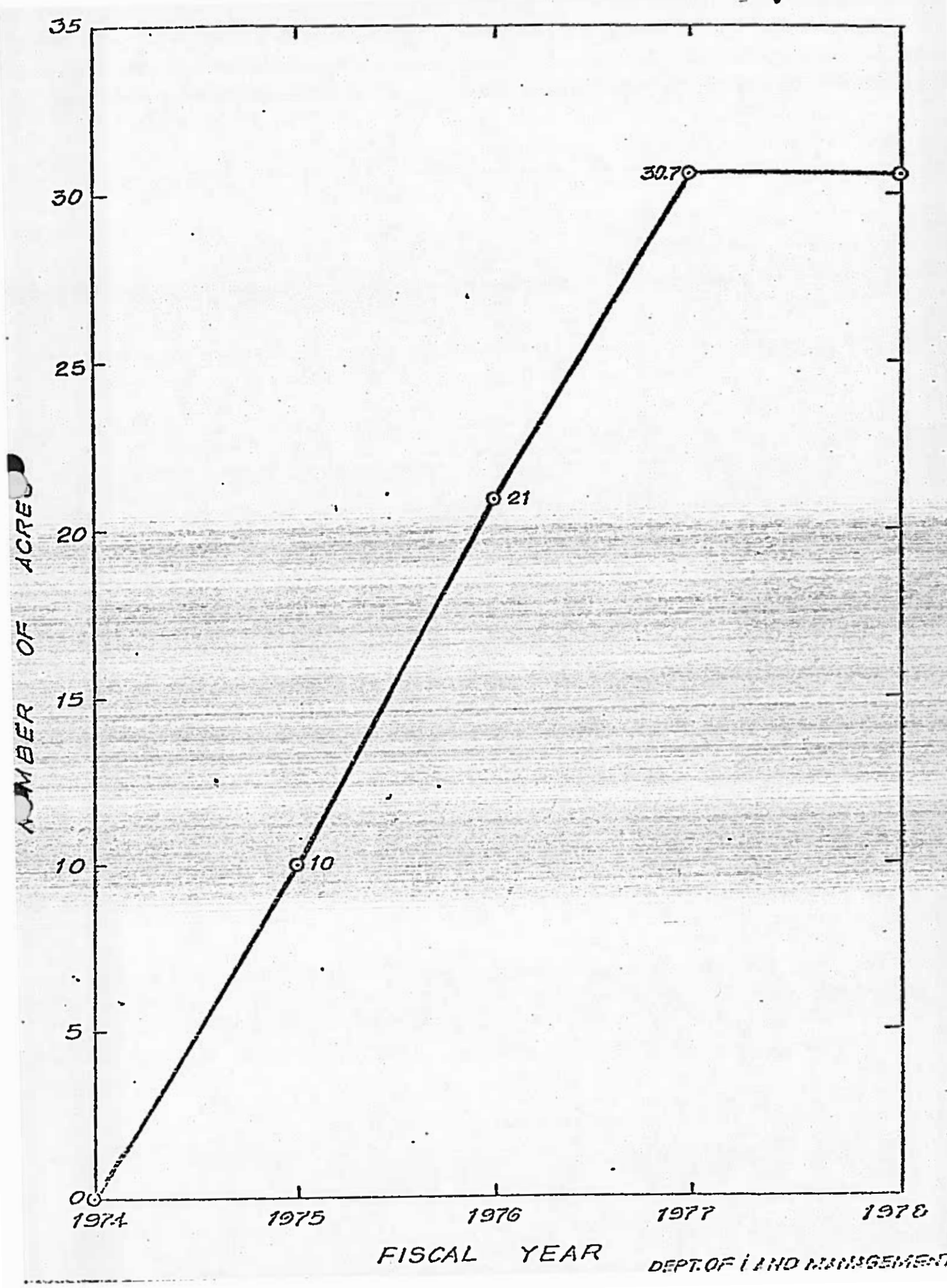
(DUE TO HWY. CONSTRUCTION RESURFACING & WIDENING)

HORIZONTAL MON. DESTROYED
VERTICAL MON. DESTROYED

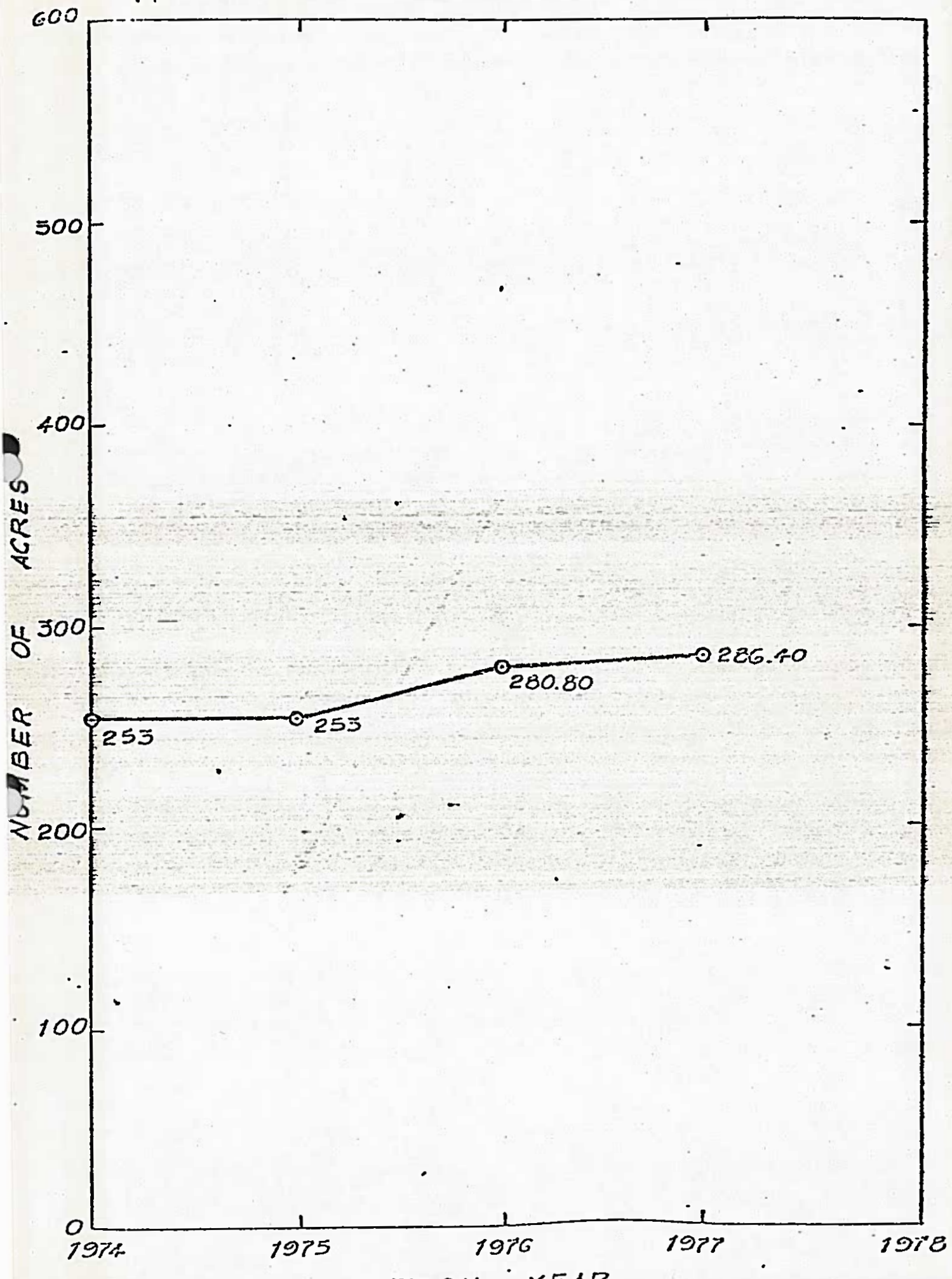


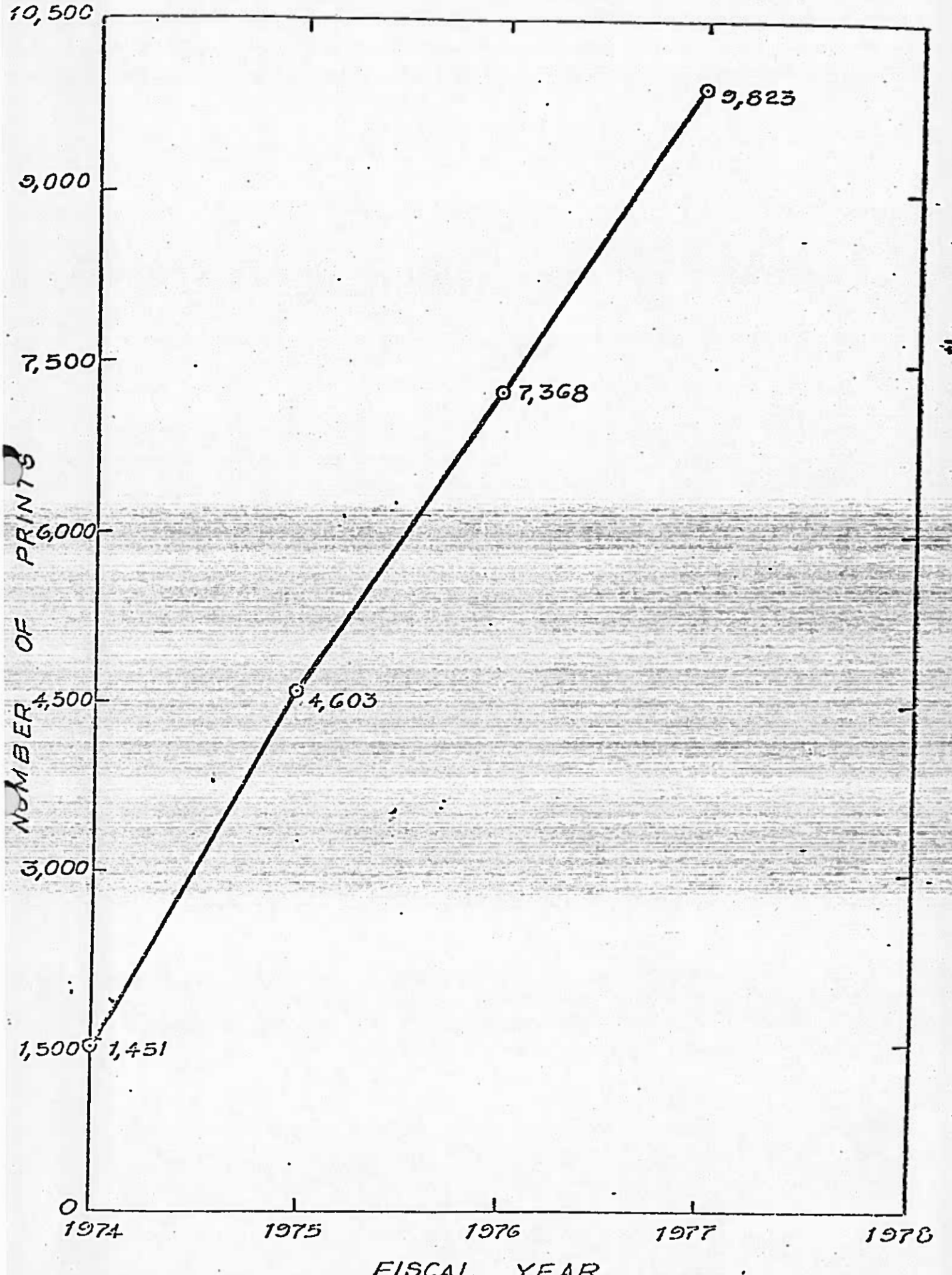

200
175
150
125
100
75
50
25
0
1974
1975
1976
1977
1978
20
43.1
159.3
179.3
200


120
100
80
60
40
20
0
NUMBER OF ACRES
10.3
25.60
31.23
68.86
1974
1975
1976
1977
1978
FISCAL YEAR


35
30
25
20
15
10
5
0
NUMBER OF ACRES
30.7
21
10
1974
1975
1976
1977
1978
FISCAL YEAR
DEPT. OF LAND MANAGEMENT

REQUESTED BY OTHER AGENCIES)




10,500
9,000
7,500
6,000
4,500
3,000
1,500
0
NUMBER OF PRINTS
9,823
7,368
4,603
1,451
1974
1975
1976
1977
1978
FISCAL YEAR

COMPARISON OF ACCOMPLISHMENTS

	FISCAL YEAR 1967- 1974	FISCAL YEAR 1975-1978
PUBLIC LAND SURVEYED	5,110 ACRES	8,537 ACRES
GGTN STATIONS ESTABLISHED	100 STATIONS	1,212 STATIONS
CADASTRAL MAPS AREA PLOTTED	1 LS SECTION	3 LS SECTIONS

NOTE

PROJECTION

This is our projection from the present thru FY 85.

Approximate acreage of public land completely surveyed, mapped and ready for land registration proceedings by the end of FY 78 - - - - - - - - - - - - - - - - 13,647 acres

Approximate acreage of public land completely surveyed, mapped and ready for land registration proceedings by the end of FY 85 (3,500 acres/annum) - - - 36,000 acres

Approximate additional GGTN stations (vertical and horizontal control) established by the end of FY 85 (300 stations/annum) - - - - - - - - - - - 2,100 stations

We anticipate completion of the public land survey program in seven (7) fiscal years. Densification of the Guam Geodetic Triangulation Net with an approximate additional 4,500 stations is projected for completion in ten (10) fiscal years.

RECOMMENDATIONS

Continuance of the Geodetic Control initiated in 1975 should be undertaken. The area which was covered in 1975 should be reviewed and all stations that were destroyed should be reestablished. Leveling should be continued and traverse stations should be utilized as bench marks. Property corners should be tied to third order stations that are established along with automated retrieval system for property surveys. Work should progress towards the northern section of the island where surveys of government land are already in progress in order to tie these surveys to the 1975 control.

In order to achieve our objectives and meet our projection, the following are recommended:

1. Revamping of our understaffed division by employing additional personnel required for automation of program.

   a) Creation of six survey crews -

      Two (2) crews, each crew consisting of five (5) personnel, to pursue continuance

of the 1975 geodetic triangulation network. These crews are to be charged with reconnaissance, monumentation, observing horizontal angles and zenith distances and measuring distances.

One (1) leveling crew consisting of six (6) personnel to deal mainly in geodetic leveling.

Three (3) survey crews, each crew consisting of 5 personnel, to take charge of public land surveys.

b) One (1) full-time geodetic advisor/consultan knowledgeable in every phase of geodesy (office and field procedures) to ensure that all specifics of the island's triangulation program are met and satisfied.

c) One (1) computer technician equipped with a knowledge of geodetic triangulation computations.

2. Program related work should be executed under the direct control of the Chief of Cadastre aided by immediate supervision of the geodetic advisor/consultant.

On the following page is a presentation of the funding necessary for implementation of the programs. Following the funding presentation are our projection charts.

LAND SURVEY PROGRAM

PROJECTION --FY 79 -- FY 85

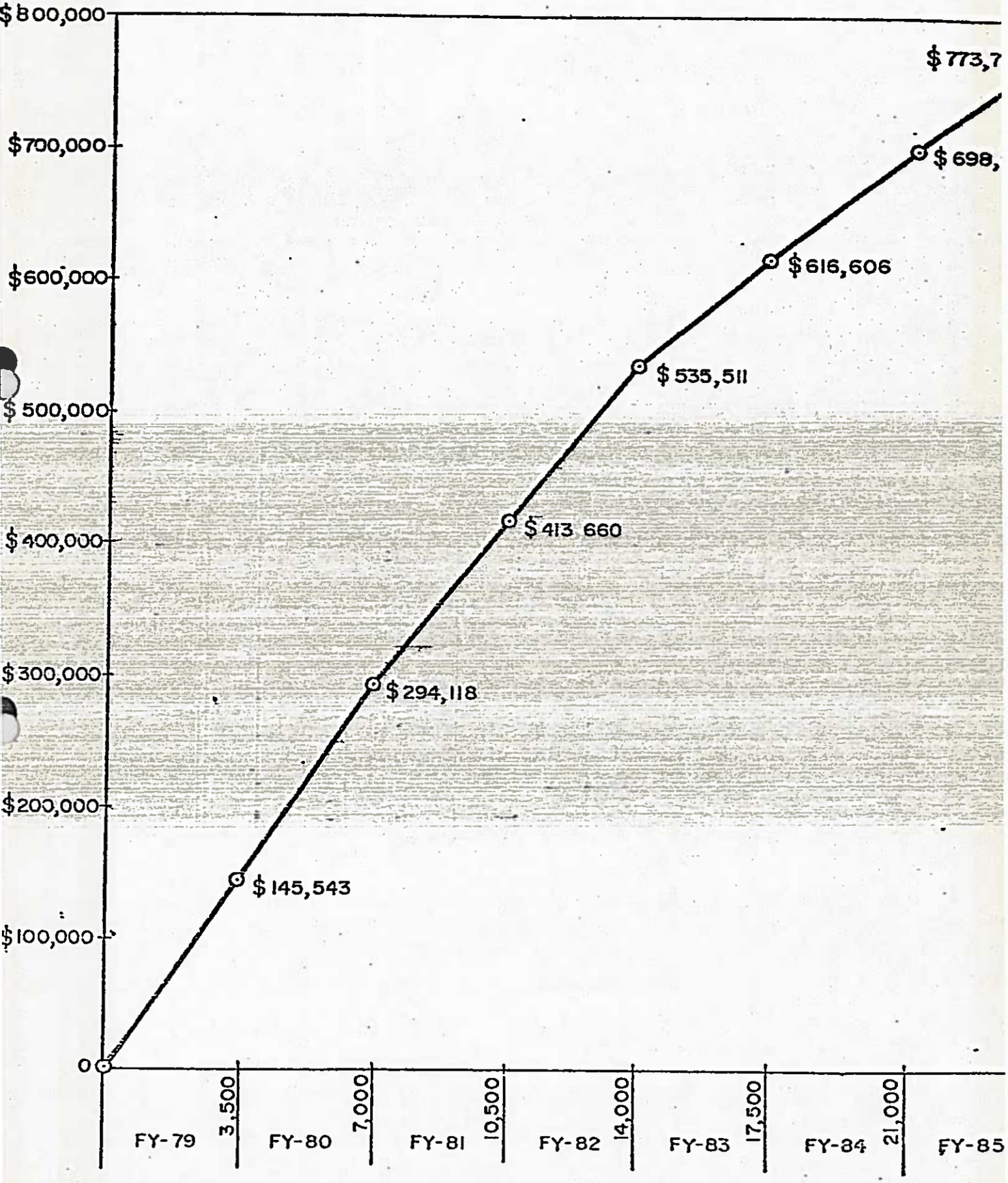
	1979	1980	1981	1982
1. GUAM GEODETIC TRIANGULATION NET				
(a) Systematic extension of triangulation and traverse net. (In-house and Contract)	107,492	109,640	85,176	61,476
(b) Extension of Island-wide vertical control net. (In-house and Contract)	48,696	49,963	51,284	53,047
2. PARCEL BY PARCEL SURVEY				
(a) Approximately 3,500 acres per year (In-house and Contract)	101,812	104,397	100,540	61,477
3. CADASTRAL MAPPING				
(a) In-house Expense	98,500	2,500	3,000	4,000
T O T A L	$356,500	$266,500	$240,000	$180,000

LAND SURVEY PROGRAM

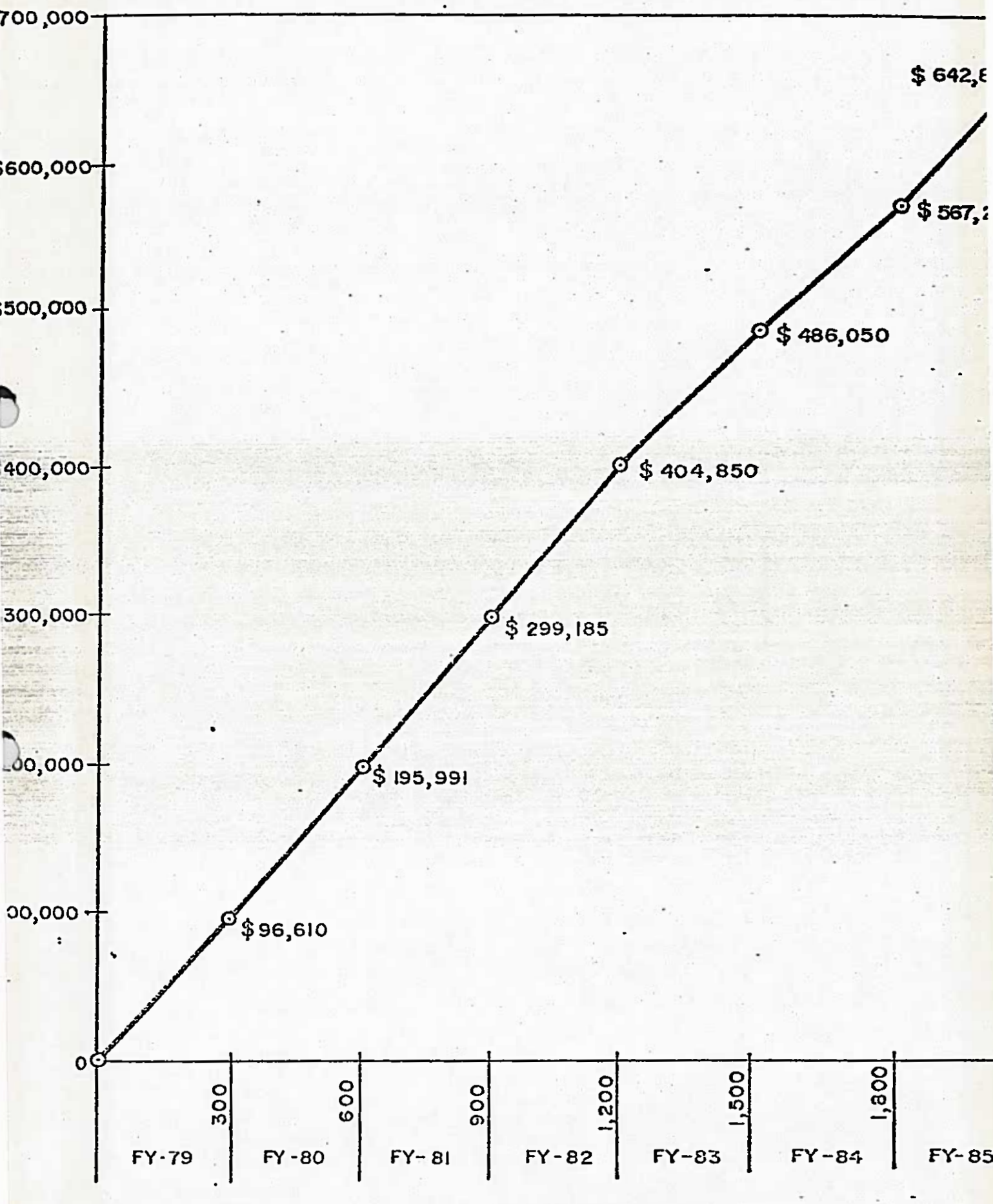
PROJECTION -- FY 79 -- FY 85

	1983	1984	1985	
1. GUAM GEODETIC TRIANGULATION NET				
(a) Systematic extension of triangulation and traverse net. (In-house and Contract)	62,504	64,145	66,030	
(b) Extension of Island-wide vertical control net. (In-house and Contract)	53,854	55,275	56,940	
2. PARCEL BY PARCEL SURVEY				
(a) Approximately 3,500 acres per year (In-house and Contract)	62,504	64,145	66,030	
3. CADASTRAL MAPPING				
(a) In-house Expense	1,138	1,435	3,000	
T O T A L	$180,000	$185,000		GRAND TOTAL $ 1,600,000

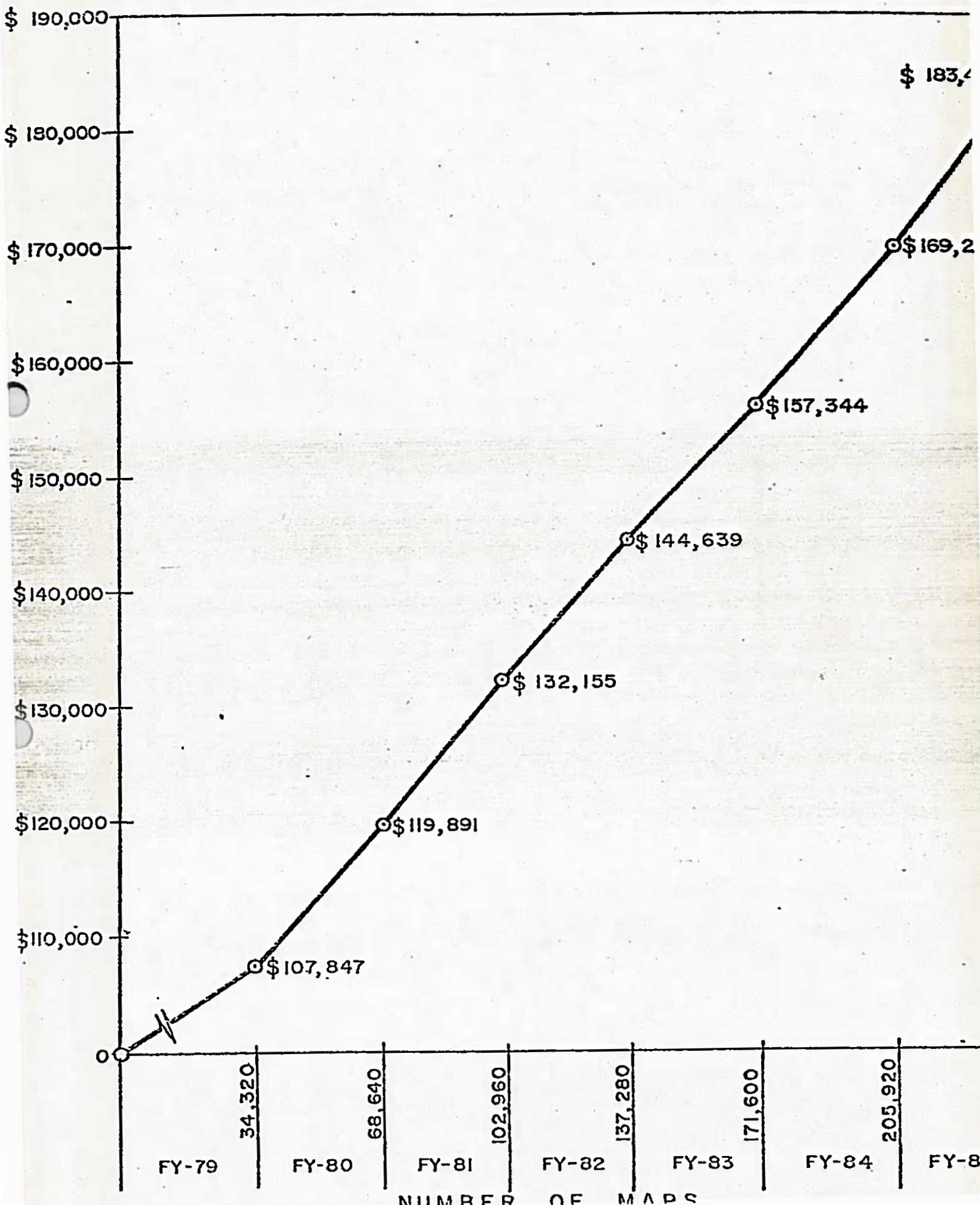
PUBLIC LAND SURVEY



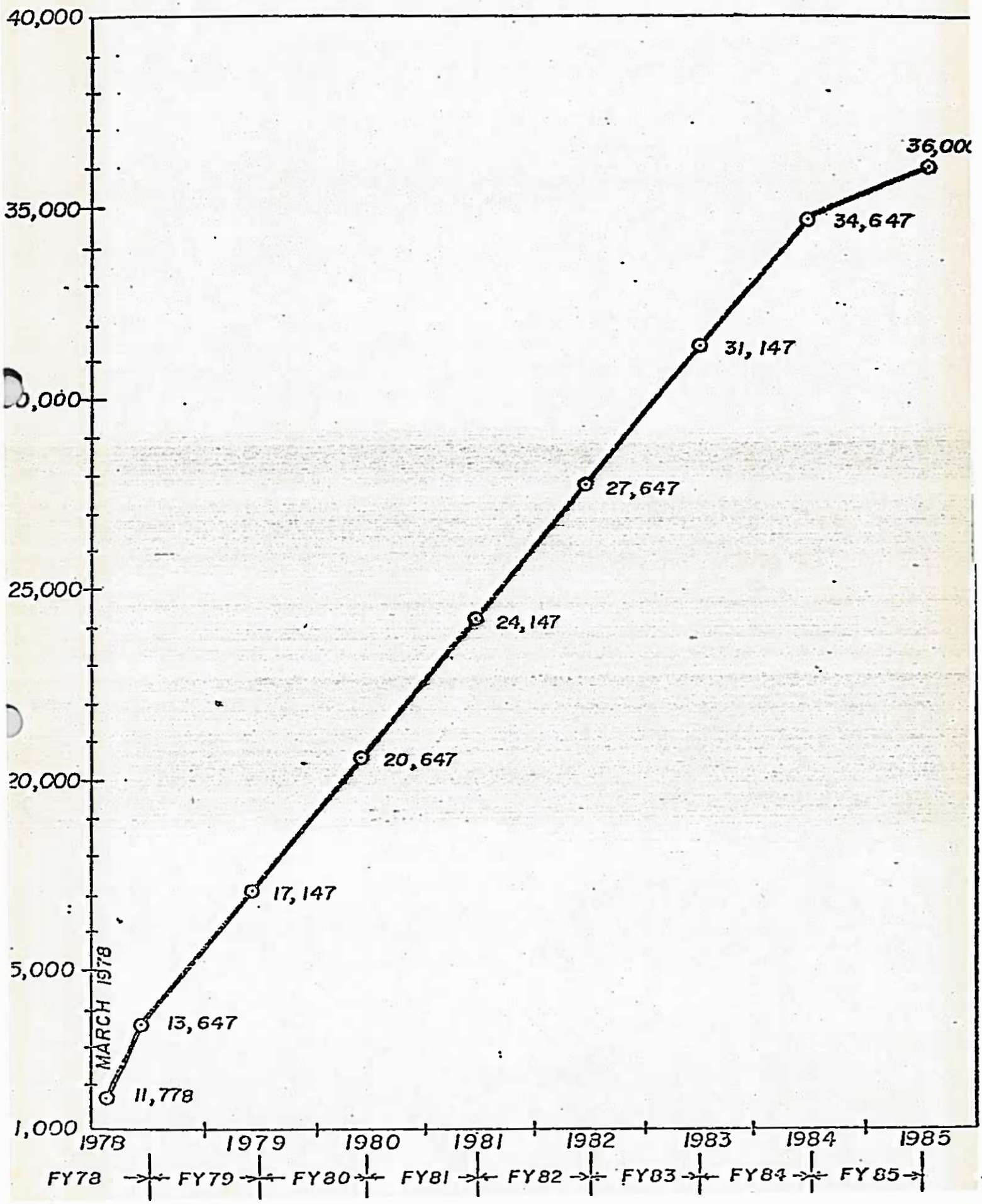
GUAM GEODETIC TRIANGULATION NETWORK



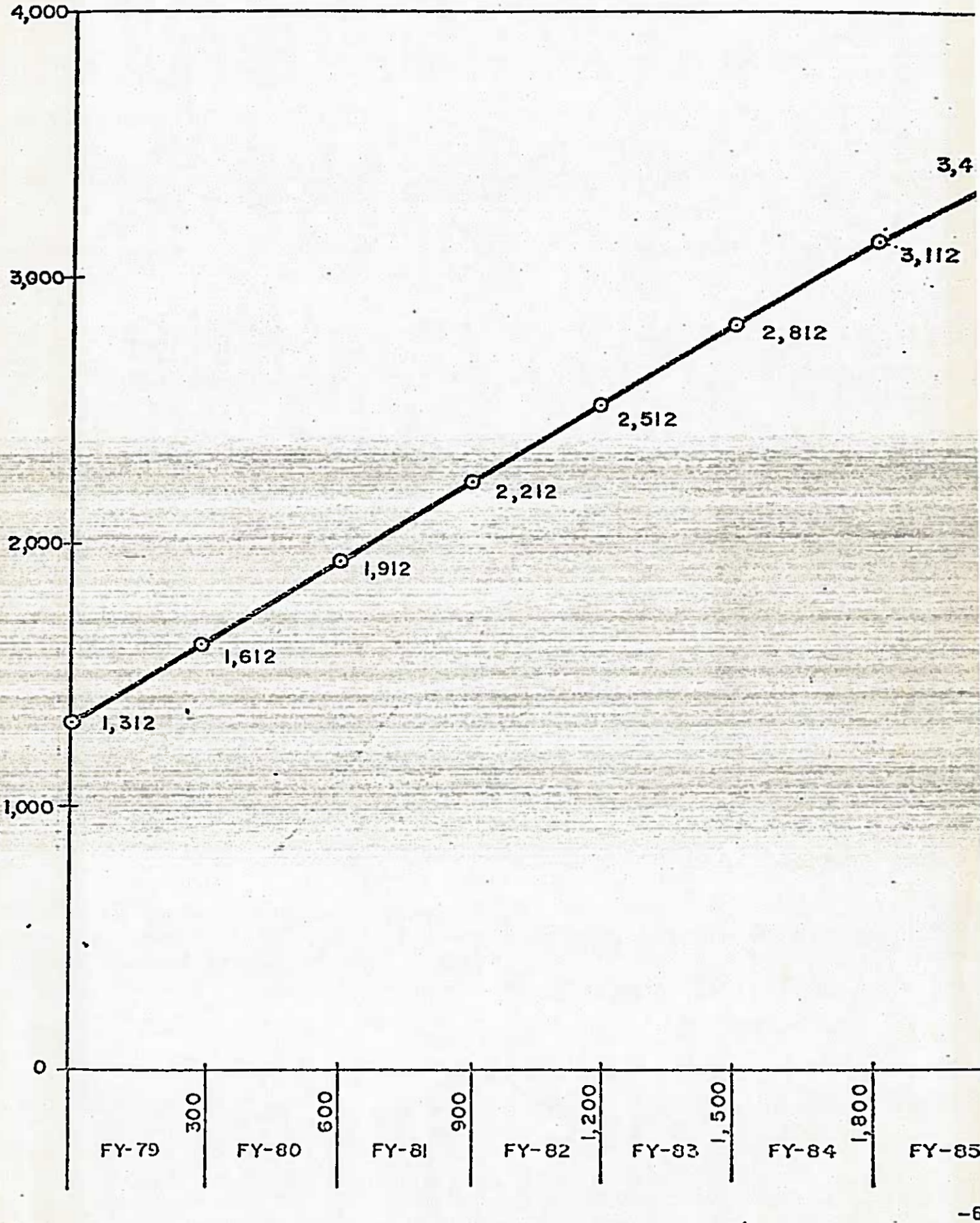
CADASTRAL MAP



PROJECTION FOR
PUBLIC LAND SURVEY PROGRAM



GUAM GEODETIC TRIANGULATION NETWORK
HORIZONTAL CONTROL



SUMMATION

The key to the successful management of Guam's future with respect to land surveying lies in a better understanding of the duties and responsibilities of a cadastre unit. Adequate surveys and adequate maps are of equal importance in this regard. Be it known that they are only producible if sustained by a cadastre unit that is not overpowered by responsibilities beyond its working capacity. This is precisely the condition of the present Survey Division. It is astonishing how the Division has continued to function and survive in its crippled state and still manage to carry on a program of this magnitude. To the members of the Survey Division, praise is in order for their unfeigned devotion to their duties. But the Division cannot survive eternally on praise. Channels have to be opened for amelioration of the condition the Division is experiencing.

The success of a program of this magnitude is hinged on soliciting maximized funds for the acquisition of sufficient technical personnel and properly related equipment to end the continuing threats and impediments to the working progress of the Survey Division. This is the substance of our presentation, and on this depends the triumph of our program.

Deliberate thought, extensive research and wide-ranging experience in surveying have been invested in the preparation of this program in the fervent desire to gain the understanding of all concerned as to what ingredients are imperative for insurance of the island's surveying future. If it shall prove to even partially meet the aims of the program, or most hopefully, overcome all the obstacles in the pathway of Guam's destiny in surveying and so shall smooth the way for surveyors of the morrow, the arduous labors purveyed shall not have been in vain.

Dometro R. Pablo

DOMETRO R. PABLO
Chief of Cadastre