UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Operations Plan for the Southern California Integrated GPS Network, Fiscal Year 1996

By

SCIGN Coordinating Board[1]

Open-File Report 96-283

[1]William Prescott (USGS), Yehuda Bock (UCSD), Ken Hudnut (USGS), Mike Watkins (JPL), Duncan Agnew (University of California, San Diego), Andrea Donnellan (JPL), Larry Fenske (CalTrans), Brad Hager (Massachusetts Institute of Technology), David Jackson (University of California, Los Angeles), Jim Mori (USGS), Don D'Onofrio (NOAA/National Geodetic Survey), Bill Young (Riverside County, California), Frank Webb (JPL), and Frank Wyatt (UCSD)

FY96 SCIGN Operations Plan

2 May 1996

13 June 1996—Appendices B-1, B-2 updated
5 July 1996—Receiver contingency excised

Southern California Integrated GPS Network

William Prescott	Chairman (USGS)

Executive Committee

Yehuda Bock	(UCSD)
Ken Hudnut	(USGS)
Mike Watkins	(JPL, California Institute of Technology)

plus Chairman

Coordinating Board

Duncan Agnew	(UCSD)
Andrea Donnellan	(JPL, California Institute of Technology)
Larry Fenske	(CalTrans)
Brad Hager	(Massachusetts Institute of Technology)
David Jackson	(University of California, Los Angeles)
Jim Mori	(USGS)
Don D'Onofrio	(NOAA/National Geodetic Survey)
Bill Young	(Riverside County, California)
Frank Webb	(JPL, California Institute of Technology)

plus Executive Committee

Other Contributors

Frank Wyatt	(UCSD)

Approvals

The following agency/institution representatives have read this operating plan and agree in principle with the outlined plan. Signatures on this page do not commit any of the agencies/institutions to the detailed budgets included in the plan.

SCEC Science Director	David D. Jackson	4/26/96 Date
SCEC Center Director	Thomas L. Henyey	4/26/96 Date
JPL Program Manager	Charles Elachi	4-26-96 Date
USGS Regional Coordinator	James J. Mori	4/25/96 Date
SIO Director	for EAF Edward A. Frieman	4/29/96 Date
SCIGN Chair	William H. Prescott	25 April 1996 Date

Executive Summary

We plan to expand the Southern California Integrated GPS Network (SCIGN) by the addition of about 30 new sites. This will take the network from its current size of 38 operating sites to 68 operating sites. The bulk of the funds for the current expansion will come from NASA (about $1.4M). In addition the USGS is providing funding for operation and maintenance (about $250K). New receivers will be purchased through the Southern California Earthquake Center (SCEC) from the Academic Research Infrastructure (ARI) price list. Permitting and construction of the new sites will be done under JPL administered contracts.

At the same time, some sites will be added to the network using receivers purchased by University investigators under the ARI procurement. We expect to have three UCSB receivers and seven UCSD receivers from this source. In addition, there are three JPL sites at varying stages in the installation process. Collectively, the 30 sites added with NASA funding plus these already-purchased-but-not-yet-installed receivers will bring the network total to 81 (=38+30+3+7+3). Farther in the future, funding for an additional 45 sites has also been requested from NSF.

SCIGN intends to operate all existing and currently funded stations for a total of five years. At the end of five years, the network will be re-evaluated and decisions about its future will be made in light of the contributions made by the network and the funding situation at that time.

To assist in melding these sites into an integrated network, SCIGN is creating the position of Network Coordinator. This position will be located at SCEC in Pasadena and will be responsible for monitoring and maintaining the entire collection of stations.

Background

In Southern California, a group of scientists from several institutions is pursuing a new approach to studying earthquake hazards. The goal of the project is to complement on-going earthquake hazard investigations in a high-risk metropolitan area with precise deformation measurements from an array of densely spaced continuous GPS sites. To achieve high precision, the sites are being carefully monumented and all the GPS receivers will operate continuously. At present SCIGN includes 38 stations installed and operated by University of California, San Diego (UCSD), NASA's Jet Propulsion Laboratory (JPL), and the U.S. Geological Survey (USGS) (Figure 1). Funding from NASA is available to install another 30 sites and additional funding is being sought from other sources. New stations will be installed both regionally (~30 km spacing) and along three densely (spacing 1 to 3 km) instrumented profiles (A-A', B-B', and C-C' in Figure 1). All data are processed at UCSD and JPL. Discussions of the advantages of including two processing centers have been spelled out in various funding proposals. Briefly, the processing centers use different and independent processing software. The comparison and contrast in the results from the two centers will be essential in interpreting time series obtained from the network. The necessity for two processing centers will be included in the general evaluation at the end of the initial five year experiment. All data from stations in the array are available on the internet (http://scec.gps.caltech.edu/scign.html).

The SCIGN coordinating board includes: Will Prescott (USGS), Chairman, Duncan Agnew and Yehuda Bock (UCSD), Andrea Donnellan, Mike Watkins, and Frank Webb (JPL, California Institute of Technology), Larry Fenske (CalTrans), Brad Hager

(Massachusetts Institute of Technology), Ken Hudnut and Jim Mori (USGS), David Jackson (University of California, Los Angeles), Don D'Onofrio (National Atmospheric and Oceanic Administration/National Geodetic Survey), and Bill Young (Riverside County, California). SCIGN is organized under the auspices of the Southern California Earthquake Center (SCEC) with funding from NASA, the USGS National Earthquake Hazards Reduction Program and the National Science Foundation. The SCIGN Executive Committee consisting of Prescott, Bock, Hudnut, and Watkins makes day to day decisions regarding SCIGN. The body of this document was prepared by this committee. A site-construction subcommittee consisting of Frank Webb, Frank Wyatt, and Will Prescott prepared the some of the appendices. A subcommittee consisting of Ken Hudnut, Duncan Agnew and Andrea Donnellan prepared the maps indicating the locations of the next expansion sites.

Timetable for SCIGN Expansion

Below is a chart indicating the time schedule for the expansion. A few target dates are key:
1996 March 8 ..... Draft operating plan complete and submitted to SCIGN and SCEC
1996 April 1....... SCEC and SCIGN approve operating plan
1996 May 1 .... JPL purchasing departments completes request for bids
1996 May 1 .... Request for bids are advertised
1996 June 1 .... Bidding closes
1996 June 15...... Bidder selected, contract awarded
1996 June 15...... Hire network coordinator
1996 July 1........ Site selection and installation begins
1996 August 8~... Ground breaking/ribbon cutting/press conference
1996 October 1 ... First receiver installed
1997 January 1 ... All sites built and all receivers operational

Activity	1996 Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1997 Jan
Develop operating plan	<-->										
Develop contract specifications	<-->										
SCEC/SCIGN approval of op plan	<-->										
Develop request for bids		<-->									
Hire coordinator	<---------------->										
Accept bids			<-->								
Evaluate bids				<-->							
Select winning bids, award contract					<->						
Ground breaking/ ribbon cutting					<->						
Select sites, permit and install					<-->						
Sites operational								<---------------------->			

Budget

The budgets included below reflect the projected expenditure of the recent (FY95) NASA GPS Array augmentation funds, approximately $1.4 M as of 1 March 1996 and FY96 USGS SCIGN operation funds, approximately $235K. The funds supplied by NASA, NSF, and the USGS for analysis, archiving, interpretation, and maintenance are not included here, but are discussed in the matching funds section. The $1.4M will provide for the procurement of 30 receivers, and the installation of 36 sites. This funding will also provide some enhancements at the processing centers (JPL and SOPAC). Both processing centers are responsible for archiving RINEX data from the array. Raw data from SCIGN sites is archived at the downloading center. Both processing centers have been and will continue to maintain on-line access to the RINEX data and plots of resulting positions or position differences. Funding is allocated to the processing centers to enable this effort to continue for all sites in the expanded array. The funding will also be used to install several receivers provided at no cost to the SCIGN array, and to complete three sites for which receivers are already purchased. We also include a 10% reserve to allow for unforeseen costs or overruns.

Table 1. Budget for NASA funds

FY96 Budget	Overhead rate (%)	No. units	Unit cost ($K)	Total ($K)
Field site costs				
Equipment				
Receivers and antennas	1.0	30.0	14.0	424
Ancillary site equipment	1.0	36.0	0.5	18
Monumentation hardware	6.1	36.0	3.5	134
Equipment subtotal				**576**
Personnel				
Reconnaissance	6.1	36.0	2.0	76
Field engineering	6.1	36.0	1.0	38
Site permitting	6.1	36.0	1.5	57
Site construction	6.1	36.0	5.0	191
Personnel subtotal				**362**
Analysis center costs				
Equipment				
JPL computer hardware	0.0	1.1	100.0	110
SOPAC computer hardware	0.0	1.1	75.0	83
Equipment subtotal				**193**
Personnel				
JPL management	0.0	0.22	160.0	35
JPL scientist	0.0	0.22	160.0	35
JPL engineer	0.0	0.25	120.0	30
JPL Personnel subtotal		*0.69*		*100*
SOPAC management	0.0	0.10	100.0	10
SOPAC administration	0.0	0.10	50.0	5
SOPAC scientist	0.0	0.25	75.0	19
SOPAC programmer	0.0	0.25	60.0	15
SOPAC Personnel subtotal		*0.70*		*49*
Analysis Centers Personnel subtotal		**1.39**		**149**
Expected costs (Field equip.&pers. + Center equip.&pers.)				**1280**
Reserve				**128**
Total (Costs + Reserve)				**1408**

Table 2. Budget for USGS funds

FY96 Budget	Overhead rate (%)	No. units	Unit cost ($K)	Total ($K)
<u>Field site costs</u>				
Personnel				
Receiver installation	0.0	36.0	0.5	18
Site Maintenance (6 visits/yr/site)	0.0	76.0	1.5	114
Personnel subtotal				**132**
<u>Coordinator costs</u>				
Personnel				
Network coordinator	100.0	1.0	40.0	80
Coordinator Personnel subtotal		**1.0**		**80**
Expected costs (Field + Coordinator)				**212**
Reserve				**21**
Total (Costs + Reserve)				**233**

Cost-Sharing

The total cost of the additional stations in the SCIGN network proposed herein and in the NSF proposal will be $4.35M over the next 5 years. At the same time, the groups involved will continue to operate and maintain stations already existing in the SCIGN.

This plan for the NASA funds that have been allocated will provide an additional 30 stations to the network. The NSF proposal included with the appendices to this plan request from the NSF $2M over 5 years to purchase, install, and maintain 45 permanent GPS stations in southern California, and to process and archive all of the data over the 5 year period.

Hence this plan for spending the NASA funds, in combination with proposed support from NSF, will facilitate adding a total of 75 new stations.

The Southern California Earthquake Center (funded through NSF/USGS/FEMA/Caltrans and with cost sharing from its principal institutions) will provide an in-kind match of ~$1.0M in support for analysis of the data from these instruments over the next 5 years to the Scripps Orbit and Permanent Array Center. The United States Geological Survey (USGS) will support maintenance of existing stations in the SCIGN during this 5 year time interval as well. The Riverside County Flood Control and Water Conservation District is funding installation of three UCSD-SIO ARI receivers.

AGENCY	*Support*
FEDERAL	
Air Force	91,000
NASA	3,795,000
NSF	395,116
USGS	802,798
STATE	
Caltrans	12,500
LOCAL	
Orange Co.	51,116
Riverside Co.	187,850
San Diego Co.	5,000
Los Angeles Co.	60,000
OTHER	
SCEC	707,675
Ashtech	50,000
Caltech	30,000
Green Found.	21,000
Mobil	20,000
UCSB	4,000
UCSD	264,000
TOTAL	6,497,055

Table 3: Support of continuous GPS from various sources for the time period 1991-1995.

Expenditures through 1995 on continuous GPS in southern California show that there have been considerable contributions of both programmatic and discretionary funding from a variey of other Federal, State, and Local government agencies, as well as from private sources in the past. We expect this trend to continue and potentially increase during the 5 years covered by the NSF proposal, and discussed within this plan.

Table 4. Support for the installation and operation of the SCIGN. *FY'96 Support* column is for funds that have been either allocated or approved through panel review at this time. *FY97-FY02 Proposed or Requested* column is for funds that have been either formally requested through panel review or discussed with program managers.

Agency	*FY96 Support*	*FY97-FY02 Proposed or Requested*
NASA	$1,359K	$5,000K
NSF		2,000K
USGS	257K	1,250K
SCEC	200K	1,000K

Other relevant developments include the pending proposal to FEMA for improving the digital seismic network, which would provide some of the SCIGN stations with digital real-time telemetry. Also, the County agencies have already been helping SCIGN to identify potential sites where they own land (maintenance yards, etc.) and could greatly facilitate our site selection and permitting. Agencies responsible for public safety of engineered structures have been interested in the SCIGN developments of new methods to monitor engineered structures as a result of our pilot study with Los Angeles County at Pacoima Dam.

The new results of SCIGN have been presented to Program Directors in all participating agencies, as well as members of the United States Congress, the Director of the State Office of Emergency Services, and many others. SCIGN developments will also be presented at the Caltech/USGS Broadcast of Earthquakes (CUBE) Users' Feedback Meeting in late March. The CUBE users include most of the large corporations in public utilities and transportation in Southern California, and provide funding to Caltech for joint projects such as SCIGN through the Earthquake Research Affiliates (ERA) program at Caltech. This is a potentially large source of private funding that is just now being developed. In addition, SCEC has proactively sought funding from the Insurance Industry through a series of meetings with Insurers, including the major one held at USC in November 1995. The scientists involved in SCIGN, along with our partners in the funding quest, have been very actively seeking other sources of funding through a variety of channels, and they will continue to inform people of the capabilities and potential of this new technology.

Outyear plans

SCIGN intends to operate all existing and currently funded stations for a total of 5 years. At the end of 5 years, the network will be re-evaluated and decisions about its future will be made in light of the contributions made by the network and the funding situation at that time. Expansion of the network by the addition of new stations will proceed as funds become available. In light of the uncertainty of the source and amount of new funding we have not made detailed plans for future expansion. We anticipate that such future expansion will be handled in a manner similar to that outlined here for the current expansion. In particular, future expansion plans will probably partition the resources between new receivers, installation costs and enhancement of processing center capability in a manner similar to that proscribed here.

Implementation

Introduction

In order to implement the SCIGN array, we have to purchase the receivers, select appropriate sites, install the receivers, and assure their continued operation. Most of these activities will be carried out under contract. Neither the SCIGN board nor SCEC have the necessary staff for these activities. Nor can an expansion of this magnitude be carried out by the existing staff of the cooperating agencies and institutions.

Several actions will be required:

				Funding Source	Contracting agent
1)	Receiver purchase	(30 @ $14.5K/ea)	$435K	NASA	USC
2)	Site selection and permitting	(30 @ $4.5K/ea)	$135K	NASA	JPL
3)	Site construction	(36 @ $8.5K/ea)	$306K	NASA	JPL
4a)	Receiver placement	(36 @ $0.5K/ea)	$18K	USGS	USGS
4b)	Receiver maintenance	(76 @ $1.5K/ea)	$114K	USGS	USGS
5)	Network coordinator	(1 @ $60K/yr)	$60K	USGS	USC

The biggest challenge will be to identify geologically and geophysically suitable sites, to obtain permission from the owners for these sites, and to construct the monuments at these sites. We have decided to break the network construction into three parts. The skills required for the three parts differ and it is likely that different companies will be required for each. We anticipate that one company will carry out the site reconnaisance, evaluation, selection and permitting. A second company will carry out the actual construction work, putting concrete and steel in the ground, and installing power and communication service. Because these two activities will have to be tightly coupled, we anticipate that there will be a contractor-subcontractor relationship between the contractors. Finally, placement of the receivers at the prepared sites will be done by the network coordinator with assistance from a maintenance contractor.

We have explored various options for all of these contracts. The options that have been discussed included contracting through JPL, through the USGS, through USC, and through UCSD; sole source purchasing, purchasing through the ARI process, and others. After giving consideration to factors such as respective overhead rates and institutional preferences for implementing various parts of the project, we have decided to proceed as outlined below. We will continue to examine the options for each step and expect to revise the plan as necessary to accommodate changing circumstances.

Receiver purchase

GPS receivers will be purchased through the SCEC/University of Southern California. The purchase contract will guarantee the vendor that we will purchase at least 20 receivers and will contain options to purchase up to an additional 20 receivers. The actual number purchased will be adjusted after final bids for all aspects of the work have been received and may be adjusted after some of the sites have been permitted and installed. We expect the procurement to occur in two stages: an initial procurement of 20 receivers and a secondary procurement of additional receivers after the installation is under way and installation costs have been re-estimated. The receivers will meet the University Navstar Consortium Academic Research Infrastructure (UNAVCO-ARI) Continuous Geodetic Reference Station (CGRS) specifications. All receivers purchased will include a Dorne-Margolin antenna with choke ring.

Preferred Receiver Purchase Plan

In order to move the funds for this purchase from NASA to SCEC, USC will submit a proposal to NASA for unrestricted funds in the amount of $435K to be used for the SCIGN network. These funds will come from the $1.4M earmarked by NASA for SCIGN. USC will ask all the ARI participant vendors to submit a "best and final" offer for CGRS receivers. The best and final offers will be evaluated by a USC technical evaluation committee chaired by John McRaney and including the SCIGN Chairman, Will Prescott. The evaluation criteria will include the ability to meet the CGRS specifications (40%), compatibility with existing receivers in the network (40%), and price (20%).

Site selection and permitting

Selection of the approximate locations of the sites to be added to the net at this time will be made by a Site Selection Subcommittee (the "Dots" committee, including Agnew, Donnellan, and Hudnut). In the selection process, consideration will be given to insuring that the sites address important scientific objectives now, as well as providing a rational base for future expansion. The selection process will be driven by the priorities established at the SCEC workshop "Geological and Design Issues of Continuous GPS Networks" held at JPL on 30-31 March 1995 (Figure 1). Our goal is to add 15 new sites to the A-A' profile and 15 new regional sites. Appendix E contains a map indicating the current choices for new stations.

Selection of the specific sites will be carried out under a contract. Recommendations of the Site Selection Subcommittee will be approved by the SCIGN governing board and a set of maps reflecting those choices will be included with the Request for Bids. The SCIGN Board has developed a set of specifications for this process (Appendix A). The contract for site selection will be executed through JPL. JPL's procurement department will turn the specifications into a request for bids. The request for bids will be reviewed by the SCIGN executive committee prior to its advertisement. Bids will be evaluated by a technical evaluation committee that includes the SCIGN Chairman as a voting member.

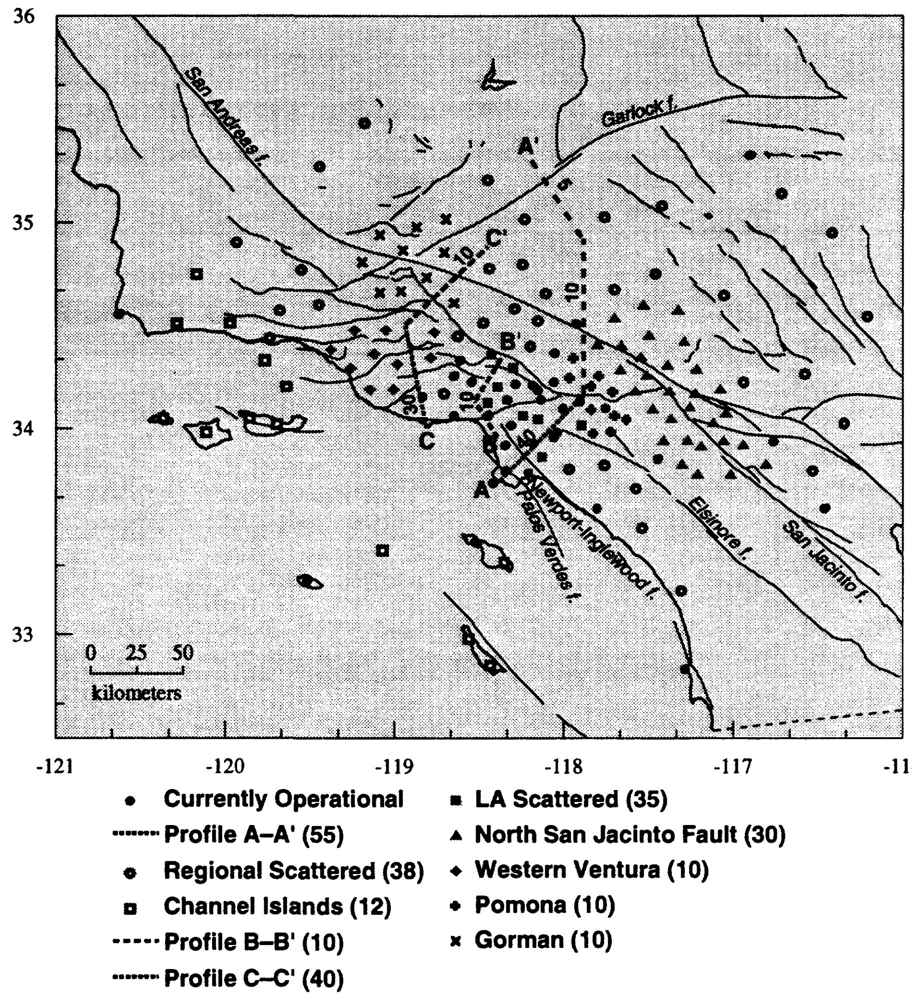


Figure 1. Map showing existing and proposed SCIGN stations. The map was the product of a SCEC Workshop, "Geological and Design Issues of Continuous GPS Networks", held at JPL on March 30-31, 1995. Solid red circles indicate currently operating stations; all the others are proposed sites. For three dense profiles (A-A', B-B', and C-C'), the number of stations on each profile is indicated rather than the individual sites. Various subexperiments are listed at the bottom of the figure in the priority order adopted at the workshop.

Site construction

Site construction will be carried out under a contract. Site construction will include building a antenna monument, installing a receiver box, and bringing in power and communications. The SCIGN board has developed a set of specifications for this process (Appendix B). The contract for site construction will be executed through JPL. JPL's procurement department will turn the specifications into a request for bids. The request for bids will be reviewed by the SCIGN executive committee prior to its advertisement. Bids will be evaluated by a technical evaluation committee that includes the SCIGN Chairman as a voting member.

Receiver maintenance

Maintenance of the receivers will be carried out under contract. One of the first tasks under the maintenance contract will be to place new receivers and antennas at the already-constructed sites. The SCIGN board has developed a set of specifications for this process. The complete specifications are attached (Appendix C). The contract for receiver placement and maintenance will be executed through the USGS. We anticipate that this will be done throught an add-on to existing seismic station maintenance contracts. The SCIGN chair person will participate in negotiating the add-on and the SCIGN board will review the language. If the contract is implemented by competitive bid, USGS's procurement department will turn the specifications into a request for bids. The request for bids will be reviewed by the SCIGN executive committee prior to its advertisement. Bids will be evaluated by a technical evaluation committee that includes the SCIGN Chairman as a voting member. Receiver placement and maintenance are separated into separate contracts because the number of sites will be different for the two contracts, and the time period of performance will be different. However, we anticipate that both activities will be carried out by the same vendor.

In addition there will be other, smaller, procurements; principally for computer hardware for JPL and Scripps. These procurements will be handled entirely by the end user institution. NASA/JPL should transfer the appropriate amount (see Budget section) to the appropriate institution. Upon completing the procurements, but not later than one year after receiving the funds, the receiving institution will provide the SCIGN board with a summary of the expenditures.

Network coordinator

Operation of the SCIGN network will be overseen by a Network Coordinator. The Network Coordinator will be hired by SCEC with funds provided by the USGS. The position will be located at the USGS/SCEC center at 535 Wilson Street, Pasadena, California. The duties of the network coordinator will be to insure that the entire network is maintained in an operational state at all times. A detailed position description is attached (Appendix D).

Glossary

ARI ....Academic Research Infrastructure
Caltech.........California Institute of Technology
Caltrans ....California Department of Transportation
CGRS..........Continuous Geodetic Reference Station
CUBE..........Caltech/USGS Broadcast of Earthquakes
ERA............Earthquake Research Affiliates
FEMA..........Federal Emergency Management Agency
GPS ....Global Positioning System
JPL.............Jet Propulsion Laboratory
NASA..........National Aeronautics and Space Administration
NEHRP........National Earthquake Hazards Reduction Program
NGS ....National Geodetic Survey
NOAA ....National Atmospheric and Oceanic Administration

NSF...........National Science Foundation
RINEX ....Receiver Independent Exchange format
SCEC ....Southern California Earthquake Center
SCIGN ....Southern California Integrated GPS Network
SIO ....Scripps Institute of Oceanography
SOPAC........Scripps Orbit and Permanent Array Center
UCSB..........University of California, Santa Barbara
UCSD..........University of California, San Diego
UNAVCO.....University Navstar Consortium
USC ....University of Southern California
USGS..........U.S. Geological Survey
WWW ....World Wide Web

Appendices

Introduction to Appendices A, B and C

The skills and equipment required for selecting and permitting sites differ greatly from the skills and equipment required for excavating, drilling, building the monuments, and installing communication and power. For this reason we have separated the specifications into two pieces: Appendix A covering site selection and permitting, and Appendix B covering site construction. However, these two activities must be closely coordinated. The construction contractor cannot proceed until the selection contractor has located and permitted the site. And the selection contractor must thoroughly understand the requirements of construction in order to find suitable sites and in order to explain the installation to landowners prior to obtaining permission. Consequently, we expect these two parts to both be awarded to a single contractor who will likely subcontract for one or more of the subparts. This single contractor could be a geologic consulting firm that subcontracts with a construction firm for the actual construction, or a construction firm that subcontracts with a geologic consultant for the site selection. Other scenarios are possible. The prime contractor and all subcontractors must be indicated in bids and must demonstrate that they can meet the requirements of the request for bids.

Placement of the receivers and antennas in the newly prepared sites might logically be done by the site construction contractor. However, once emplaced the receivers will be maintained by a separate maintenance contractor. In order to streamline the handover of new sites to the mainenance contractor, we decided it made more sense to have the maintenance contractor place the receivers in the already prepared sites. Our objective is to reduce the possibility of disputes about responsibility in the event of startup problems.

Appendix A — Site selection and permitting specifications

Introduction

The SCIGN management requires selection, permitting and documentation of approximately 30 new Global Positioning System (GPS) sites in the Los Angeles metropolitan area. We anticipate that this part of the implementation will be done by a geologic consulting firm or by a company with similar suitable expertise. The site construction subcontract must meet the specifications given in Appendix B. The total number of sites needed may be adjusted during the course of the contract, however, the number will be at least 20 and not more than 40.

Definitions

Location will be used to refer to one of the dot locations on the maps provided with the request for bids. *Site* or *candidate site* will be used to refer to a specific place that has been accepted or is being considered for monumenting.

Interface with SCIGN committee

The executive committee will provide the contractor with a set of 1:100,000 scale maps indicating the desired locations of the stations. These maps will indicate approximately 50 target locations. The map will indicate the priority order of the locations. It is anticipated that it will be difficult, impossible or too costly to find sites corresponding to some of the targeted locations (hence 50 locations for an eventual 30 sites; all of the extra sites will be located in the metropolitan area where most problems are anticipated; no extra sites will be indicated in less populated areas). The contractor may skip impossible locations and proceed with next priority ordered location, but, for each skipped location, the contractor should provide contracting officials and SCIGN with documentation indicating the effort expended to find a site near the location and the reason for rejecting the candidate location. Once all the required sites have been found, no documentation is required for any unused locations.

Because the location of the sites is a crucial to the success or failure of the SCIGN project, the contracting officials in consultation with the SCIGN Board will review candidate sites before final selection. Once a viable site has been located, the contractor will submit a site summary (Form A), to the contracting officials and the SCIGN Executive Committee. The Board will respond within 5 working days either advising contracting officials to authorize the contractor to proceed with the site or to reject the site. Failure of the board and the contracting officials to respond within 5 working days will constitute acceptance of the site. The board expects that most candidate sites that meet the criteria spelled out below will be accepted. Once the contracting officials, in consultation with the SCIGN Board, have approved the site, the contractor should finalize permitting and then the construction contractor can proceed with site construction.

Contract requirements

Site Selection

The contractor will be responsible for finding a viable site at each indicated map location.

The contractor will be responsible for negotiating permission to use the site. The final site permission agreement will be between JPL and the landowner (see Permission below).

15 of the sites must be selected from locations along Profile A-A' (Figure 1).

15 of the sites must be located at regional locations.

All sites must be located within 3 km of the target location.

For both the profile and the regional sites, failure to find a suitable site corresponding to a particular target location is acceptable but must be documented on the appropriate form (see Forms).

Note: The SCIGN Board recognizes that finding suitable sites in an urban area like Los Angeles is a difficult task. The following guidelines are designed to indicate in detail the characteristics that are required. We recognize that some compromises will have to be made.

Sky view and multipath

A candidate site must have an *adequate* view of the sky. Adequate is defined by the following specifications.

Preferably the site should have no obstructions of the sky above 15° elevation.
The contractor will make a horizon mask diagram for the candidate site (see Forms).
There must be no more than 4 objects extending above 15°.
All of the objects extending above 15° must obscure no more than 30-5°x5° blocks (count the squares above the 15° line in the horizon mask.
There can be no obstructions above 45°.
There can be nothing above the expected antenna location within 3 m of the expected antenna location.
There can be no transmission power lines within 100 m of the site.
Other wires and other objects subtending less than a 1° angle as viewed from the expected antenna position are allowed.
When accounting for trees on the net mask, allow for 5 years of tree growth. That is the mask should indicate as obscured, any areas that may be obscured by tree growth during the next 5 years (make a reasonable guess—no professional tree evaluation is required).
Preferably the site should be located far from any flat reflective surfaces (such as buildings, chain link fences, etc) that could serve as a source of multipath.

Permanence

The contractor must ascertain that the site will continue to be available for the expected 5 to 7 year duration of this project. Ideally, the site will allow a permanent monument. Geodetic marks have value for long periods of time (decades to centuries).
The contractor will investigate the surrounding area for the presence of signs such as "Future home of______".
The contractor will also ask the landowner or permittee whether there are any known plans for development or changes that would affect the usefulness of the site for GPS observations.
This investigation should include consideration of adjacent areas where modification might block the sky view at the site.

Security & Safety

Sites where public access is restricted or where the equipment is otherwise secure from theft or vandalism are preferred.
Safety of personnel visiting the site should also be considered.
However, monument construction is designed to allow installation of sites that are completely accessible to the public. Consequently, we do not expect any site to be ruled out on the basis of a lack of security.

Site geology

Sites on natural ground are preferred. Any man-made ground or fill present, must be less than 3 m thick.
No sites may be located on landslides.
The local ground slope must be less than 3% within a 20 m radius of the antenna location.
There must be no active oil pumps within 2 km of the site.
There must be no active water pumping out of or into the ground within 2 km of the site.
No sites can be located in areas indicated on precultural maps as intermittent or permanent lakes or ponds.
No sites can be located in areas indicated on precultural maps as drainage channels.
Local drainage should take runoff away from the antenna location, not toward it.

Access

The site must be accessible to the drill rigs, concrete trucks and other equipment required to construct the monument. Heavy equipment access is only needed until monument construction is complete.

Accessibility for construction should consider the following issues:

- Gates/fences
- Time periods when the site is not available
- Time periods when there are noise restrictions
- Maximum load that can be driven in without damaging property
- Maximum width that can be driven in without damaging property
- Maximum clearance around proposed mark
- Will anything be damaged during mark construction (lawns)
- Availability of power and water for construction

The site must also be accessible to visits by maintenance personnel on an occasional, but continuing basis.

Power

110 volt power must be available within a reasonable distance.

Power needs are fairly modest, approximately 15 watts.

Preferably power will be obtained by a drop from an existing power pole to a local box.

If necessary, power can be obtained from greater distances (with trench laid conduit, or overhead lines).

In order to limit costs of providing power while providing flexibility to the contractor, the total distance of all trenching or above ground power runs is limited to 1500 m for all 30 sites (an average of 50 m/site). We anticipate longer than 50 m runs at difficult sites and shorter runs at easier sites.

Often power can be obtained free from the owner.

Alternatively, we can arrange to reimburse the owner for power usage.

At some sites solar power may be a desirable option.

At all sites, space for backup batteries should be provided.

Communications

A telephone-like connection must be available within a reasonable distance.

Preferably telephone will be obtained by a drop from an existing phone line to a local box.

If necessary, phone can be obtained from greater distances (with trench-laid conduit, or overhead lines).

In order to limit costs of providing phone while providing flexibility to the contractor, the total distance of all trenching or above ground power runs is limited to 1500 m for all 30 sites (an average of 50 m/site). We anticipate longer than 50 m runs at difficult sites and shorter runs at easier sites.

Alternatively, communication can be provided by radio modem. The contractor is responsible for designing a communication plan that provides dial-up like access to each site.

Permission

Contractor is responsible for obtaining informal permission to investigate each location.

Contractor is responsible for obtaining formal permission to use each site selected.

This permission should be obtained on a standard JPL form (see Forms).

Permission has to be obtained within a time period that allows completion of construction at all sites by 1 January 1997. (i.e. some can be done early and some late, but they can't all be built last).

Permit has to allow access to: build site, to install receiver and associated hardware, and to maintain receiver and associated hardware.

Preferably the permit should extend for 7 years to 1 January 2004.

If necessary an annual permit with annual renewals is acceptable. Preferably renewal should be automatic.

Landuse fees

Sites with no landuse fees are required with few exceptions.

Exceptions will have to be considered on a case-by-case basis.

The contractor can negotiate proposed landuse agreements on JPL's behalf. Final agreements will be approved and signed by JPL.

Receiver occupation test

Sites with little or no radio frequency interference (RFI) are preferred.

The contractor will occupy each candidate site with a GPS receiver provided by SCIGN and submit the results of the occupation as part of the site evaluation.

Four receiver tests will be conducted. Each test will last 2 hours. Tests will be conducted on a weekday (Monday through Friday) and must cover the four time periods: 2–4am, 6–8am, 2–4pm, 6–8pm.

The data from the test will be analyzed with a quality control program (provided) and will have to meet specifications to be provided

DigAlert

The contractor will call DigAlert for each candidate site.

Candidate sites will be selected so as not to interfere with existing underground utilities.

The contractor will include a summary of underground utilities within a 10 m radius of the candidate antenna location in the station evaluation.

Site description

Upon completion of the site, the contractor will provide a site description that includes: adequate text and graphic information to enable finding the site; description of the geologic environment; name, address and phone number of the owner; name, address and phone number of the contact person; and, an enumeration of any special conditions regarding the site (preferred access times or routes, etc).

The entire description except for graphical information will be in digital format compatible with typical web browsers (Mosaic, Netscape).

SCIGN will provide a template for text data and will convert graphical data to a web compatible format.

Contractor qualifications

Bidders must have demonstrated training and experience in evaluation of surficial geologic conditions.

The Bidders must demonstrate knowledge and experience in identifying landslides, ground type, and modification history of the ground.

Demonstrated prior experience with GPS is preferred.

Demonstrated experience working with construction and drilling contractors is required.

Demonstrated experience working with electrical and communication contractors is required.

References to previous jobs of similar scope and content are requested.

All of the people that will be working on the project should be identified by name.

Qualifications of all of the people that will be working on the project, including subcontractors, should be included.

Supervision

The contractor may be supervised by a representative of the SCIGN board as necessary to resolve problems and to ensure contract compliance.

Appendix B — Site construction specifications

Introduction

The SCIGN management requires construction of approximately 30 new Global Positioning System (GPS) sites in the Los Angeles metropolitan area. We anticipate that this part of the implementation will be done by a company with general light construction experience involving drilling, welding, concrete, electrical and phone. We expect to have a SCIGN representative present for the actual construction. This will be particularly useful for the initial sites.

Contract requirements

The specifications include performance bonuses and penalties.

The contractor is responsible for all labor, material and supplies necessary to the installation.

This contractor will not be responsible for providing or installing the receiver and related hardware.

The contractor will build a site in accordance with these specifications.

At each selected site (see Appendix A) the contractor will build one of two mark types: A "drilled mark" or a "rock mark".

If the site has an outcrop of unfractured, crystalline bedrock that is not deeply weathered, the contractor will have the option of installing a rock mark (see Appendix B-4).

At all other sites, the contractor will install a drilled mark (see Appendix B-1, B-2, B-3).

Contractor will install a metal box (see Appendix B-5) for the receiver and modem. Preferably this box will be located inside a building. If necessary it can be outdoors. In either case the box should be rigidly attached to a wall or post. The box should contain 2-110 V AC outlets and either an RJ-11 phone plug or an RS-232 plug hooked to a suitable radio link.

Power and phone connections should be run through buried metal conduit meeting local code requirements.

Contractor will also install buried metal conduit connecting the box to the antenna location for the receiver-antenna cable.

The contractor will return the vicinity of the site to its original condition, if required by the landowner.

Upon completion of the site construction, the contractor will provide site plans that include a description of the as-built site construction details, and in particular indicate any deviation from the construction plans.

We also require detailed reports on the drilling and grouting operations, including drill logs that summarize as a function of depth: the materials encountered, the problems encountered and the solutions devised.

The contractor may be supervised by a representative of the SCIGN board as necessary to resolve problems and to ensure contract compliance.

Appendix B–1 — Deeply Anchored Monuments - Construction Procedures

NOTE: This document, as of 3/15/96, was writtenassuming an ``intersection" height of 62 inches, 1.57 m. This target height may be changed (or, say, the angle of the boreholes may be changed),which will then require making changes throughout.

Preparation of casing: (2.06)

The casings consist of a 16'-long sections of 21/2" belled-end Sch. 40 PVC irrigation pipe, with 2 x 6' lengths and 1 2 1/2'length of 2 5/8" ID (for 14 1/2') of *Armstrong* insulation foam on it. The foam is slid down the non-belled end of the PVCpipe (if the PVC is very dirty, it's worth cleaning it off so the foam slideseasier), and initially secured to the pipe with PVC cement at the top and bottom of each length offoam. Leave approximately 9" of casing unjacketed at both ends. At the top wewant to do this so the casing sticking out of the ground will be ``clean"(no tape or insulation) when the job is done. The foam is then secured with 1/2" filament tape runningdown the length of the pipe, one or two runs down at 90 degrees to oneanother axially down the pipe, securing the ends of the filament tape at thetop and bottom of the pipe by wrapping the ends radially a few times. The foam is then wrapped radially ina slanting direction, barbershop pole style (overlapping spiral) starting atthe top, with duct tape to make the package smooth. It's important not tocompress the foam too much, as this makes the foam less resilient, and may cause the casing to slip tooeasily into the hole. Finally, at about 1-1 1/2' from the top of the casing(the belled end), the wrapping should be widened so that the casing cannotfall into the hole if the hole is too large. This can be done with some rags symmetrically wrapped aroundthe pipe with layers of duct tape to secure them. Remember, the casing has tosupport the entire weight of the anchoring pipe until the grout has set, soit's important to see to it that it's firmly wedged into place. Ideally, this wedging material (bundleof rags and tape) should be removed when the grout has hardened, to relievethe rigid coupling of the casing near the surface. In the long run it isexpected the rags (and, indeed the compliant foam) will rot away and so relieve themselves.

Geology/Hydraulic Crawlers: (2.01)

This section is written assuming the use of a Hydraulic-Crawler drill rig,which is clearly not the ideal in all cases. It's one great advantage is itsease of alignment. It is the drilling equipment of choice in rock, and hasproven itself a viable choice in most other types of material. One strong recommendation, when doing alarge number of holes would be to carry out a trial drilling exercise at eachsite, prior to full-blown drilling efforts.

When drilling in clay-rich material, you probably want to use the minimumamount of water, otherwise the sidewalls swell and you'll have great troubleat every stage when it comes to pulling back (up) on the bit. The materialbehind the bit will cause the drill string to become wedged. In rocky soil, or decomposing rock (as atTable Mountain for example) lots of water makes the job possible, helping toseal the porous material so air (and spoils) flows up the hole and not out into the formation. It's hard to know which route isproper-lots of water or trying to drill dry-without experience at the site.In either case using water right at the ground surface, to limit cavingthere, is a good initial move.

The hydraulic crawlers can drill fast (say, 12feet in 1 minute) in anything, but can then have a terrible time pulling backonce spoils get behind the bit that aren't being lifted to the surface. Veryimportant: *make sure the drill rig can supply air in high volume*; some rigs seem tohave deficient air-delivery systems.

Layout/Alignment of drill rig: (5.03)

This is best done with two or three people. The vertical hole is to bedrilled first, then the angled holes. The alignment stakes should be laid outbefore the drill rig arrives. It's not very productive to mark the exactentry point of the angles holes until it's time to do them, as the drill rig is likely to tear them up, and wewant them to be aligned, ultimately, with the center hole as-drilled, not as it was staked. When the central hole placement and the angled-holeorientations are decided upon, the alignment stakes (sprayed fluorescentorange) should be placed about 50'-100' away from the center hole, in thedirection we want to drill. We have used a carpenter's square as a sight, to ensure that the holes are laid out at90¤ spacing, but an AutoLevel (or transit) with Tripod and surveying Rod allowsyou to set a much better set of marks; the Autolevel has nice azimuth markerson it. When it comes time to actually mark where you want the bit to enter the ground for the angledholes (during the drilling operation) it's useful having a short section ofpipe to hold over the vertical hole as this makes its position easier to seefor the person at a distance.

After drilling the center hole measure out 43 1/2" horizontally from thecenter of the center hole and put a very small stake there-say 2-4" long(popsicle stick?), and marked with orange spray paint-whose lateral positionneeds to be established by someone standing over an alignment stake and looking toward the center hole.You may also need a short piece of pipe, positioned briefly over the stick inthe ground, so the person at azimuth mark can ``see" where the short stickis. Remember, when measuring out from the center hole, to compensate for any ground slope: if theground slopes down the stake will have to be located farther out, if itslopes up, closer in. We want the angled pipe to pass through 43 1/2"-out ata elevation equal to that at the ground around the center casing. Sometimes a small section of pipe or wood isuseful to help give a sense of level between the two places.

The hydraulic crawler rigs have a foot on the tower which bears weight whiledrilling, a lot of weight. The foot, and hence the bit position will tend tomove (skid or sink) as pressure is applied, making it harder to get the drillrod aligned as desired. A solution to this is to do some shovel work in advance; this really helps.Starting at the desired drilling point, 43 1/2" out and no farther, create asmall sloped cut, sloping at 35° from horizontal, back toward the center hole. This should be about 2' wide(in the direction of the foot) and about 1' deep, being deepest back towardthe center hole. This gives the drilling foot a place to land that's perpendicular to the hole we want to drill.(On some rigs the tower foot is under the drill rod as opposed to being offto the side; in that case the slanted hole will have to be cut down deepertoward the center hole. You get the idea.) You can now use the entry point and alignment stakes tosight-in the drill rig. Have one person at the rig, giving instructions tothe driller on (1) the position of where we want the bit entering the groundand (2) keeping close track on the angle of the drill-rod/tower (35° from vertical, *not* horizontal), and (3) checking that the drill rod appears to be exquisitelycrossing over the center of the center hole (actually do this last, after thestep which follows). Have the second person sighting from the appropriate azimuth stake making sure the rig tower looksvertical and that it's not canted over to one side, from their perspective atthe azimuth point. It's easy to get fooled by optical illusions here. (If youset up, say, the Autolevel you could really do this well, using its crosshairs.) Finally, both playersshould check that that the drill rods seems to be headed directly over thevertical hole. Recheck the angle of the drill rod.

It may be necessary to make some adjustment,some allowance on the subsequent holes, during drilling of the other angled holes toget everything to meet in one place The primary aim here is to do thingsconsistently, even if this sometimes means following a poor result from thefirst effort. One important thing to keep in mind is that the drill bit tends to `skid' outward as itbegins its boring, making the final pipe intersection point (where the pipeswill meet in the air) higher than planned. An allowance of 1"-2" for this isthe most that should be acceptable. In fact, you may want to start the first hole at (say) 42 1/2" from thecenter hole (an inch closer), to allow for the anticipated slippage, and thenfollow whatever result you get for the other holes, including this sameassumed-slippage distance, if that's what it takes.

Before you begin this alignment procedure, warn the driller that he will berequested to iterate (try, try, again) when it comes time to aligning therig. It's has always proven to be worth it. It turns out that the iterativeefforts, while annoying, seldom take more than a few minutes, once you're close,and dealing with poorly aligned holes can take a lot of time and lead to amuch less well braced mark.

(A list of..) Some steps/issues while drilling-overview:

0. Prepare alignmentmarkers; prepare tamping/blowout tube.
1. Align the rig, and keep *detailed* notes ofsoils/issues while drilling.
   It's hard to know when trouble will develop, then you'll wantfacts.
2. While drilling, fully prepare anchoring pipes with clamps andcouplings.
3. After drilling each hole ``prove" it (blowout tube with maxpossible diameter);
   rebore (or decide to blow out later) if necessary.
4. Get drill rig's help to set casings, pushing them in. (Want themlevel, about 6" above the surface.)
5. When done drilling, have them blow out each hole using their airon blow-out tube (if necessary).
   If really troubled, install anchor pipes and apply air to them(keeps the rig around longer).

Casing Setting: (5.05)

In clayey soils, or with a drill bit of only 4 1/2" diameter we have had to use the drill rig toset the foam-padded casings. First they've pushed with some portion of thetower and then, when the drill stem could be aligned, pushed with the bit. Wewant the casings (all five) to end up with their midlines at 6" about the ground, level with thecenter casing (even if the ground is sloping). Also the casings should besnug at the surface so they won't slip during grouting. Important.

As each casings is set, we need to jam some rags around it, below the surface, to seal off any loose material. Thenthrow fill around the casing to make the ground level again (this assumethere will be some caving during drilling). Also we want to tape the top ofthe casing with duct tape, again to preserve the borehole.

Testing the Holes: (5.06)

Keep good notes throughout drilling and pipesetting on the hole depths. Remember to write down what the driller says isthe total depth (T.D.), as this number make never show up again. As soon as the drill rod clears the hole the driller will usually sound the holes witha tape measure. Record this. This value will generally be ``short" becauseof loose spoils. You should then should use a fiber-glass-taped (forinsurance against breakage) PVC sounding/blow-out tube to see what depth it gives. (Having someone restrain theend of this, providing resistance to it such that the pipe bends into theair, helps to get this flexible tube in and out. Think of someone polevaulting.) With the end of this tube open, there's a good chance (especially if water has been used in thehole) that you can actually extract material while making this measurement.This is a very good idea if you should want the hole deepened, though itcores a narrow hole. Remember this later.

		Depths - YOURSITE					
		TD	Tape	Tamped	Shimmed	Pipe	
#1	Vert	38'	32	35 1/2'	34'	32'	Example
#2							
#3							
#4							
#5							

All depths here are given from theground surface. Recall the target hole depth at most sites is 35' (shimmed if necessary). This depth leaves 3' of clearance for any spoils thatnight fall in during anchoring pipe installation and thus should provide formore worry-free grout filling of the holes.

There's a real urge to start tamping at thispoint to establish the depth of the hole attainable with compacted spoils.Don't do this *unless* you're very likely to achieve the compaction you want, the final depth youwant. Note that spoils tend to become jammed only a few feet ahead of thecompaction tool, so it's usually hard to get more than say 4-8' of compaction, even with 20' of loosematerial. (This column of material can become much more compacted when thepressure-head of wet grout is introduced, though we can't assume that willhappen.) In any event it's probably best to ``sound" at this point with open-tube sounding tube (don'thave it sealed at this stage). Record numbers.

Before the casing is set, the driller can be asked to reopen the hole.

After setting casing you may want to soundagain. You certainly will want to sound the holes when they are all done andjust *before* the drill rig is released. We have tried to have the right fittings andhoses to be able to connect the drill-rig's air to our sounding/blow-outtube. Blow out the holes as needed. (Except, their air supply, in many cases,can be so feeble as to be useless-at which point a real compressor is needed.) Tamping can also be used todeepen holes, if there are lots of spoils. Starting out with a small-diametertamper (i.e., rebar, though this is a bit dangerous) will achieve the best tamping depth. You can and shouldeventually tamp with the sounding tube, sealed with an end cap and otherwisebroadened (duct tape?) as much as you dare, to make sure the bottom reachesof the hole are as wide as possible where the pipe will extend. Remember, the grout has to make itthrough the annulus outside the pipe and inside the hole (broaded? by thetamping); if this annulus is narrowed to only a fraction of an inch withcompacted spoils, the grout may not flow. This would be real trouble.

For those hole that are found to be too deep (say, with more than 3' ofclearance below the anchoring pipe's bottom-35' you can shim them with finegravel which compacts naturally. We do this so we are less likely to run outof grout. Sound the holes as you carefully do this.

Centralizers: (5.07)

Maybe worth pursuing, maybe not. Owing to spacelimitation, at this time (9/95) we're leaning toward applying these only onone side of pipe and trying to keep the anchoring pipes oriented as we lower them, which is doable but potentiallypointless later on if we chose to rotate one of the pipes.

Assy. of Pipe: (5.08)

There are a couple of diagrams which shows howthis all goes. The 21'-long pipes should be cut to size (nominally, 32' below ground, with 79" above the ground for the angled pipes and 66" for thevertical, so cut lower sections to 17' 7" for the angled and 16' 6" for thevertical before heading out to the site (change this someday if we decide todeliberately have the couplings end up outside of the casings). The bottom lengthof pipe should be cut to size since we don't need threads on its bottom end.This leaves the top as a full section. This means, for the angles holes, thatthe coupling will be inside the casing (a good situation to avoid it getting stuck below the casing'slip), while for the vertical pipe it will be just beyond the casing which isworkable because the pipe is dangling. After sounding the holes in the field,the pipe lengths should be reconsidered, possibly cutting off of some excess pipe to assure the pipebottom will be well clear of the hole bottom: maybe only 1' necessary - ifyou don't fear lots of loose spoils falling when the pipe is being installed.Remember we're trying to achieve anchoring over the entire length of the exposed pipe, so giving up alittle pipe length at the end means very little.

Set the U-bolt clamps-measured from their tops:

Angled: 72" Vertical: 60" Casings: 6" (abovelevel ground)

Before installing the pipes it's best if you decide whether you want a clockwise oranti-clockwise arrangement. The results of drilling usually favor one overthe other. Install the vertical pipe first. The upper piece of pipe for eachhole needs to be assembled in mid air which is tricky. You'll need a tall ladder and as many people as youcan gather for this, and everyone needs to know what the objectives are. Bevery careful, someone could get hurt by the clamp if the pipe gets loose.Take your time. Hard hats for everyone and have a plan for fingers to get clear if needed. First, just slipthe lower pipe down into the hole, making sure there's a secure coupling ontop, and that someone is at the hole opening holding the "Y" choke-plate inplace. With it across the hole opening the pipe can't fall down the hole. When this pipe is in and thecoupling is resting on the "Y", assemble the upper piece of pipe, first byhand (to minimize risk of cross threading) and then with pipe wrenches, witha well positioned ladder held in place by someone. Positioning of the ladder and seeing that it's stableis critical before proceeding. The ladder needs to be located such thatsomeone standing on it can support the pipe above its center, above itscenter of mass-that person always handling it there, or very nearly there so the pipe doesn't want to get awaybackward. After tightening the pipes firmly, lower the final section down thehole. Watch out for the support clamp, and have an ``all clear" plan.

It's important at this point to check that the hole is still open to the bottom of the pipe (it'spossible that spoils have become knocked loose or that the pipe is jammedwith material from the side walls). We use a "breath test" to make sure thatthe pipe is clear, blowing down the pipe should yield no perceptible back pressure. If you do sense any backpressure at all it's time for some serious thought.

We don't want the upper (temporary) couplings ontoo tight as we'll want to remove them without stress during the groutingoperation.

Aligning the Pipes: (5.09)

A nice diagram exists which shows the aim. We want the pipes to make contact3 1/2" below top of vertical pipe, with the upper edge of the angled pipes 1"down from the top at the spot where they are inline with the outer edge ofthe center pipe. You'll need to play with the clamps to get the heights to be ``just so." Putting amark next to the clamp on any pipe that is to be raised or lowered helpsconsiderably in making subtle adjustments. Remember the casing were put in by eye and so the pipes resting on them will likely be different fromthe ideal by inches. As you are doing this you should try to move the pipeslaterally to get good contact with the center pipe (you can move the centerpipe as well). Slight lifting of the pipes helps allow the clamps to skid better across the mouths ofthe casings. It would be nice to end up with the pipes away from thesidewalls of their casings-but it's hard to think of any reason other thanaesthetics for doing this (so don't do it). The key thing in laterally aligning the pipes is to make sure thelateral resiliency of the isolation insulation is not used up, that none ofthe pipes is laterally stressed to begin with.

As a final step-not to be done unless absolutely necessary-it's possible tobend the pipes permanently to make better contact. Once bent even slightly,small rotations of the pipe will cause a big difference in how things fittogether. You can use this to your advantage. Don't do any more bending than is absolutely necessary; doingso weakens the mechanical bracing of the final mark.

Grouting: (5.10)

After assembling the appropriate materials, grouting can begin. This is messyand not the best thing for your health; dust masks are worthwhile. It's alsoimportant that preparations be made both at the mixer and the mark fordealing with grout spoils (sometimes substantial), ideally capturing the excess material and recycling it.

We'll want to keep **a good tally** of thegrout volumes at all stages: amounts sifted into preparatory trash cans, inthe mixer, lost, and-especially-in the boreholes.

Your Site Name - DD-Mon-9X -Bags Used

Time	ID	Sifted	Mixer	_Hole_	Lost
X:XX	Vert.	NN	MM		
X:YY	Vert.		JJ	HH	KK
Y:YY					

The most important issue being aclear record of what went into the _Hole_.

Mixing the grout is tricky, We've had muchbetter luck since we began sifting the grout in advance; the grout from thebag is sometimes not free of clumps and clumps can cause a stoppage duringpouring (a real setback for good cementing). Small amounts of water and grout (in that order at thestart-water first) should first be combined in the mixer, keeping the mix as``stiff" as possible as more grout is added, to avoid allowing the sand toprecipitate out (which can become a real problem downhole). First more grout and then more water.

We have a set of instructions from *Hub* foruse with their *ChemGrout* grout pumper which suggests always adding thewater first. Outside of getting started, with a small initial volume of grout in the mixer, we think this is a poor idea. (They must know somethingwe don't.) These instructions are worth reviewing before leaving the lab;they provide lots of info on volumes.

Typically we find we need 9 50-lbs bags per hole (and this should leave youwith some excess). Stack the empty bags flat to help keep count. Forreference: a 50 lbs bag of expansive grout yields typically 0.43 cubic feet;we expect to need 3.6 cubic feet per hole, or 8.4 bags.
To avoid disappointment, if it seems you are going to run out of grout before completing the day's project, it'spossible to make up your own grout using Portland cement, sand, bentonite,and an expansive additive. Armed, in advance, with the latter two components(they're needed in small volumes and are not expensive) a hurried trip to a hardware store to purchase thecement and mortar sand will keep you in business.

But, back to grouting. A ``one sack" (9 cubicfeet, but you can only fill it half full) mixer is the ideal size for fillingone holes at a time. The important things are: (1) at the start, make sure the drygrout and water are mixing and not caking up on the bottom of the mixer- shakein the grout, and (2) there's not so much water in the mixer that theaggregate (sand) separates. It helps to run the mixer as fast as you can manage, as this helps mix thegrout and water. It's most important not to add so much water that the groutbegins to separate (with the sand at the bottom), but one wants to keep thegrout very thin when it's ready for pouring. There is a critical point at which the grout has absorbed asmuch water as it can and any more water begins to cause separation. At thispoint, another pan-full of water is too much. A roughly analogous to thedesired viscosity would be that of a fluidy milkshake.

When the batch of grout is ready, it can be poured into the pipe using thepatented "grout funnel" (currently at the Smithsonian trailer at Pinon).Hammering on the pipe with a top maul can increase the flow rate a little(but risks causing the pipes to become misaligned-not so good a trade off), but thebest idea is (1) to make sure the grout is thin, (2) that the pour iscontinuous. Perhaps the most difficult part here is to keep the supply ofgrout coming; we don't want trapped air down the hole. You'll need bulk of the crew assigned to mixer and theirresponsibilities well established beforehand.

If things go well the grout will come back up tothe ground surface around the outside of the pipe. But if it doesn't quitemake it, you should first try to measure down the annulus with a tape measure (orrebar) to establish what depth fill was achieved and then the remaining groutcan be poured down the annulus to fill the gap to the surface. Again thefunnel is quite useful. Do your best to keep grout off the pipes. And again, record the number of bags used,and how full the hole got before top filling. Typically if the grout has notmade it back to the surface it's because the grout didn't have enough waterin it to keep flowing, and became too viscous while pouring (remember the borehole will be absorbinglots of moisture). It's important that we get a good pour through the pipe atleast back up to the casing (~15' down). It's a good idea to keep an eye onthe grout in the pipe as it begins to harden as this usually involves some settling and the addition ofgrout can help achieve both a full pipe and a non-meniscus seal where thepipe and the casing meet.

Rebar: This is added to improve the odds thatthe monument will last a long time. Rebar inside the pipe should provide longitudinal strength for a veryvery long period, even in the event of severe corrosion of the pipe.Basically we push this down the pipe just after adding all the grout. To dothis, two 20'-long sections of rebar must be wired together to be ~38' long, using bailing wire, with thebailing-wire ends nicely folded so no one gets hurt, and so the overlappingpart of the assemblage will fit into the pipe. This joint, with wire, is atight fit in the pipe; the wire must be low profile. We want the top of the rebar to end up just below the topof the pipes (say 1-2").

Finishing off the cement work: When you're finishing up the work with thegrout we want to make sure there isn't a water-entrapping area near theground surface where the pipe comes out of the grout in its PVC casing. Thegrout will tend to settle during drying and we don't want a meniscus there that would tend to allow water topuddle and ultimately corrode the pipe. As the grout stiffens it shouldbecome possible to add grout to this area forming a sloping (and thus, watershedding) surface.

Also, we want to top off the insides of the pipe to reduce the amount ofwater that can stand in this volume. Do this with coupling on the center pipein place, finger tight, to assure those threads stay healthy. (Scoop out anygrout much above the actual pipe top.) Don't put a wrench on the pipes or do anything else stressfulwhile the grout is hardening, we want a good seal of grout to pipe at thecasing tops.

To accomplish this finishing work it's oftennecessary to mix up a small patch of grout (say 1 gallon's worth) to have forbuttering.

Welding: (5.11)

We expect the weld to be under a lot of stress after some period and that theweld will have to hold. Our aim is to make sure the weld is strong enough tocause whichever pipe is causing the most stress to yield to the others-to bepulled through the ground. Wow. Plans exist for welding-gussets to permit each of the angled pipes tobe attached to the vertical one. Alignment of the pipes is crucial here, though all you can dois slide the contact point around, obviously it's impossible to mess with thelength. We need at least 1" of clearance from the top of the vertical pipe tothe upper lip of the angled ones. Using the detailed plans, align things as well as possible. ColdGalvanizing: The weld will tend to corrode fast. Wire brush it thoroughly,and spray with cold galvanizing. Then, after the cold galvanizing hashardened, spray the whole assembly with paint.

Pipe Finishing - Painting: (5.12)

We should clean, prime and **paint** the pipe,*and* the cement at the juncture of the two, to improve the resistance tocorrosion. Particularly at this juncture, corrosion is a major concern.

Adaptor and Reference Height: (5.13/5.14)

This section actually covers a number of issues,usually dealt with at one time. The tools (denoted below by lines that endwith open squares) are listed as well in the supplies list, so they could beerased from here.

1. U-clamps remove/returned: most importantly because they're hazardous.
   Tools: you will need some (wire brush, crescent wrench, etc.) []
2. Pipe/concrete interface inspected and worked on to fix drainage (todiscourage corrosion).
   Perhaps fill lower half of adaptor with sealant, to reduce watercatchment.
   Material: This would require grout, sealant, or paint. [ ]
3. Painting of pipes especially at pipe/concrete interface.
   Tools: Some paint and brushes (or spray paint). [ ]
4. Adaptor installed, *forever*, verifying first that levelrange is adequate.
   Components for this: lower pipe-threaded portion (4 1/2"), upperleveling portion, nut, antenna support washer, and lots of bolts. [ ]
   Tools: Two largish pipe wrenches (one very large: 24") for forcefulattachment; anti-seize; [ ]
   lab bubble-level; Allen wrench (5/32"); crescent wrench (small);more. [ ]

4.5 Dome support plate and Dome added. Tools: need special screw drivers forscrews.
   Components: support plate, dome, and special screws and drivers. []
   (screws made fairly tight so can't be unscrewed easily). [ ]

5. Reference divot drilled into vertical pipe, and lots of measurementsmade.
   Tools: Cordless drill. Small bit (~2 mm diameter). Drawing of typicalmark (what we want). [ ]
   Tape measure (w/ English and metric); machinist scale. [ ]
6. Stamp REF PT (for example, next to the divot:.
   Tools: Special letter-punches for steel. (Do in lab?) [ ]
7. Stamp the name of the monument somewhere: (say) ``CSUN"
   Tools: Again, special letter-punches for steel. (Do in the lab, inadvance?) [ ]
8. Take Pictures: both details and setting (including collapsed parkingstructure). Camera. [ ]
9. Installation/leveling and documenting: of adaptor and dome.
   Drawings: Take copies of what we've done before, and proceduredescription (below). [ ]

Adaptor leveling: [this is the source-area for the procedure]

1. Make sure alignment marks on top and bottom parts of the adaptorare aligned. (Letter-stamped: ``A".
2. Leveling screws should not be extended much more than needed for levelcompensation.
   A final minimum gap of (say) 2 mm should be adequate for any subsequentfine adjustment.
3. With the antenna in place and the *lab bubble level* onsome portion of its flat surface:
4. Level with all three clamping bolts loosened, any one can bind theleveling.
5. Tighten the clamping bolts sequentially and gradually, adjusting theleveling screws as you go.
   Final leveling could be done by adjusting all three leveling screws-tightening.
6. Measure the height of the various elements of the adaptor, relative tothe vertical-pipe divot
   in as many redundant ways as seems possible:
   each element of height, with overlapping intervals, at three differentazimuths, metric and English.

For the reference height work it's mostvaluable to bring along a copy of some previous measuring work, as model.

Your Site Name -DD-Mon-9X

	N	(eng)	S	(eng)	E	(eng)	W	(eng)
A	x.xx cm	y.yy"						
B								
C								
D		1.50"						

E
F
G
A+B
C+D+F+1.0

A - Top of upper half to top of outer lip of lowerhalf (~¨"-3/8" from top of lower half).
B - Top of outer lip of lower half to top of referencedivot.
C - Gap from bottom of lower half to top of referencedivot [on ______side].
D - Full height of lower half (from its bottom, pastouter lip, to its top).
E - From very top of lower half to top of upper halfcylinder (should be "F" and 1.00").
F - Gap between upper and lower half (i.e.,verticality adjustment wedge).
G - Overall height estimate from top of divot to topof upper-half cylinder.

Checks:

A+B = *G* And, the table shows thatit _does, or does not_.
C+D+E = *G*

At this site:

N, is really at azimuth of ___¤

Height: Thus the height for the *top* of the adaptor'supper half-cylinder is X.XXX", or **X.XX cm.**

Angle of vertical post as inferred from *F*: The diameter of the wedge area is 3.5". Thus a maximum gap difference of 0.0__" means the vertical post at this site must be tipped 0._¤ (0.0__ radians) to the ___.

Enclosure (7.02)

This requires an adequate foundation, andconstruction study enough to discourage vandalism.

Appendix B–2—Specifications for a Deeply Anchored and Braced Geodetic Monument (Drilled and Grouted)

1. Introduction

This document, together with the attached listings and drawings providesspecifications for a standard ``Wyatt type" braced geodetic monument.Attachments:

GPS Drawing Index,	(same name)
Assembly drawings	GPS-LA-100 through 103,
Subsurface/Pipes drawings	GPS-LA-1 through 4,
Antenna Adaptor drawings	GPS-LA-21 through 25.5, and
Parts List for GPS Antenna Mount.	(same name)

Except as otherwise stated here, the dimensions and other specifications onthese drawings shall be considered to be part of the specification of what isto be built.

In this monument design the legs of the monument (which are pipes) aregrouted into boreholes. The upper part of the hole is cased, and the casing is surroundedwith compliant foam to provide decoupling from the ground. The lower part ofthe hole, being uncased, is where the legs are attached directly to thesurrounding soil or rock. The grout fills the holes and casings all the way to the surface both to anchor thelegs and to provide protection against corrosion.

2. Drilling

There shall be four holes for the anchoring pipes. One shall be vertical towithin +-2°, the other four shall be drilled at 35° from vertical, to within +-2.5°. The centerlines of all holes shallintersect within 6 inches of a point (though deviations of within 2-4 inchesshould be routinely achieved) whose height above the ground will be specifiedin each case by the SCIGN Coordinator). (This is referred to hereafter as the ``intersectionpoint"). All holes shall have a minimum diameter of 4.5 inches. All holesshall be straight enough that the foam encased casing specified in Section 2can be inserted to its full seating depth, 15.5 feet (+0 and -4 feet), and that the pipe used for theanchoring legs (1.66 inches OD) can be freely lowered-not forced-for 33 feet.If there is a likelihood of ``hole wander" during drilling (boreholecurvature) the diameter should be increased but it should be kept as small as possible to minimize the amount ofgrout needed. The holes shall have a minimum length of 35 feet, as determinedby actual measurement after drilling, and achieved, if necessary, by removingany loose material from the hole (commonly, by blowing it out with compressed air delivered to thebottom). The directions of the angled holes should be at 90° from eachother, +-5°. Where there is no advantage to one orientation of the holes over another(e.g., to make drilling easier or to minimize the monument footprint in some direction), the holesshould be aligned in the cardinal directions, North, East, South and West. Asa matter of practice, the vertical hole should be drilled first.

A record of the progress (e.g., times and drilling rates) and all pertinent events (e.g., depths andobservations) during the drilling operation shall be kept and thisinformation supplied to the Network Coordinator. Especially, all evidence ofrock type and changes in ground composition and any evidence of ground water shall be recorded. We do not have in mind theneed of a geologist for this effort.

3. Casing

The casing shall be one 16-foot length of belled-end Schedule 40 2.5 inch PVCpipe (2.875 inches OD). This casing shall be jacketed with compliant foam 0.75 inches thick, from within 0.75 foot of its top towithin 0.75 foot of its bottom, attached in such a way as not to slip duringinstallation. A clamp or collar on the casings shall be employed to cause thetop of the casings to come to rest with approximately 6 inches extending above ground (measured tothe midline for the casings in the angled holes), and for them to stay thatway when loaded with the weight of the galvanized pipe and any otherconstruction activities. The casings shall be inserted prior to inserting the anchoring pipes (below), usuallyduring drilling to ensure the holes stay open, and with the intention thatthe tops (midlines for angled holes) of all casings are caused to be verynearly at the same level. These casings may be forced into the ground, using moderate weighting, but notusing so much as to jeopardize the intended compliance of the jacketing foam.

4. Pipe

The legs shall be constructed from 21-foot sections of threaded Schedule-801.25-inch galvanized pipe (1.66 inches OD) joined with 1.25-inch Schedule-80, small-diametercouplings (that is, approximately 2.07 inch OD couplings) . Each hole willrequire two sections of pipe, with the bottom section of pipe cut off tocreate the desired overall length: 32 feet of pipe below the ground surface and an appropriate amount aboveit. The pipe for the vertical hole shall be cut so that the upper threadedend will extend between 3 and 4 inches above the intersection point; thislength is to be adjusted later to 3.5 inches. During construction this threaded end, in particular, shall beprotected from damage. All couplings should be tightened firmly, to at least50 ft-lb of torque. A centralizer or pipe collar shall be used on the lowersection of pipe to ensure that the pipe is not everywhere resting against the borehole sidewall;drawing GPS-LA-4 shows a possible design.

5. Pipe Insertion and Alignment

Prior to insertion of the casing and pipe, all loose material above 35' hole length shall be removed from the hole, and the remaining material shall be compacted (doing this manuallyseems to work well) to assure a firm hole bottom. Shim material, smallgravel, may be used to raise the level of the hole bottom (providing a securebottom should any of the pipes get loose during construction and to reduce the amount of grout needed).Adjustable clamps shall be employed to support each of the five assembledanchoring pipes on the upper lip of their casing, with the desired length ofpipe extending above the ground. With the casing already in place, each pipe section shall be lowered intoits hole the connections made between paired pipe sections. The pipes mustend up freely hanging in the holes (possibly judged by whether a singleperson can manually raise and lower the pipe).

Prior to grouting of the pipes their alignment shall be verified andadjustments made to achieve the following result: the vertical pipe shallextend 3.5 inches (- 0 and + 0.5 inches) past the intersection point and theangles-hole pipes extend 2.5 inches past their side contact with the vertical pipe at theintersection height. Drawing GPS-LA-2 shows this arrangement, with the angledpipes contacting the vertical one either in a clockwise or counterclockwisepattern. Length adjustment can be easily done by adjusting the support clamps. Lateral position adjustments mayrequire the introduction of slight, permanent bends into the pipes where theyexit the ground surface. These bends must not amount to more than 5 degreesof deflection (6 inches of displacement over 6 feet of pipe), putting a high priority on carefulalignment of the boreholes, as discussed earlier. The pipes shall betemporarily held together at the intersection point to assure that they arein their correct position throughout grðuting.

6. Grout and Grouting

The anchoring grout shall be both pumpable and expansive, using anon-metallic expansive additive. The expansive additive shall have completedno more than 20% of its total expansion at the time the grout is emplaced.This requires that the grout be made and poured in a timely fashion.

The grout shall be emplaced by pumping or pouring it through the interior ofeach pipe--not down the annulus between the pipe and the casing--until itreappears at the top of the casing, having made its way from its exit at thebottom of the pipe back to the ground surface. The grout shall be emplaced in such a way that no airbubbles are introduced. Ensuring a continuous flow of grout down through thepipe and back up the borehole to the surface requires proper materials (grout type and mixture) and grout-handlingequipment. (Under ideal conditions, it is possible to perform this operationsimply by pouring the grout, though this approach should not be pursuedinitially.)

After the grout has been emplaced in each pipe, at least 35 feet of half-inchreinforcing bar (typically two 20 foot sections of rebar lashed together withsome overlap) shall be inserted inside the pipe. After emplacement the groutlevel inside the pipe shall be made flush with the top of the pipe to inhibit corrosion due to puddled water there.This step, of topping off the holes, can be done later if welding of the pipeis to be done immediately, before the grout begins to harden. In this casethe grout level inside the pipe should be kept below the level of the weld but clearly visible (not toofar down) to allow for monitoring the integrity of the grout inside the pipe.The grout at the surface of the casing (the annulus around the pipe near theground surface) shall be finished off neatly and in such a way as to avoid puddling of water aroundthe pipes: conically for the vertical pipe, and sloping or conical surfacefor the angled ones.

The total amount of grout emplaced in each hole shall be accurately recorded,and this information supplied to the Network Coordinator.

As each hole is completed the alignment of the pipes at the intersectionpoint shall be verified, and every effort made to avoid agitating the pipesduring curing.

7. Welding

It is expected that in most cases the welding will not be done simultaneously with grouting. In thissituation the welding shall not be done until a minimum of 36 hours havepassed since grouting. The pipes should be welded together with gussets asindicated in Drawing GPS-LA-2. The weld should be done to first-class standards, with galvanizing removedfrom the pipe in advance of welding. It is essential that the threads on thevertical pipe be kept in good condition and that there be at least 1 inch ofclearance (to use these threads) from the top of the vertical pipe to the highest point of any of theangled pipes. While the welding equipment is present, it would be prudent totack-weld the bottom section of the antenna adaptor in place (for security,discussed below), in a manner where the weld could be cut away with a saw should we want to remove theadaptor. After welding the surfaces shall be thoroughly wire brushed toremove all weakened material and contaminated surfaces, and the surfacesprayed with ``cold galvanizing" to assure long life of the weld.

8. Finishing

A clearly distinguishable, permanent divot (drilled with a bit approximately0.063 inches in diameter, and to a depth of about 0.1 inches) shall be placedon the vertical pipe at least 0.375 inches and no more than 0.75 inches fromthe lowest point of the threads on the vertical pipe. The mark shall be metal stamped (along side)with the wording REF. A description of this reference-height divot, includingits position and azimuthal location, shall be recorded. The exposed portions of all pipes (except for the threaded portion of the topof the vertical pipe) but including the grout-filled ends of all pipes shallbe coated with one coat of primer and one coat of exterior paint. Thevicinity of the site shall be returned to its original condition. The area within 2 feet of each of the pipesshall be regraded as necessary to avoid the collection of water around them.

9. Adaptor

(1) An adaptor, (2) a antenna dome, and (3) a dome support plate shall beprepared in accordance with Drawings GPS-LA-21 through 26. The adaptor shall be fabricatedfrom Type 304 or 316 stainless steel. The adaptor shall be attached to thethreaded end of the vertical pipe firmly, using large pipe wrenches. The aimof securing the adaptor firmly is both for good stability and for reducing the prospects of vandalism.Toward these ends, it is suggested that the adaptor's lower section be tackwelded into place after it is tightened. [The SCIGN representative, whenadjusting the adaptor for level and installing the antenna, should use drawing GPS-LA-100dim as a templatefor height-reference measurements.]

10. Inspection and Compliance

As the below-ground work can only be evaluated during the constructing workit is the intention of the SCIGN committee to have a representative presentduring the drilling and grouting phases of construction with authority toexamine any part of the work. A representative will also review the final drilling and grouting records andinspect the finished monument and surrounding area and will report to theSCIGN Board on the quality of work and agreement with thesespecifications.

Appendix B–3 — Drawing Index -- GPS Monuments

Subject and Titles	Drawing No.
Assembly	
Total Installation	GPS-LA-100
Complete Assembly	GPS-LA-101
Center Assembly	GPS-LA-102
Dome Assembly	GPS-LA-103
Assembly Drawing - Ht	GPS-LA-101dim
Subsurface/Pipes	
Subsurface Assy. Plan	GPS-LA-1
Surface Assy Plan	GPS-LA-2
Casing Prep	GPS-LA-3
Pipe Centralizer Plan	GPS-LA-4
Adaptor	
Washer	GPS-LA-21
Tilt Block	GPS-LA-22
Base	GPS-LA-23
Plastic Base	GPS-LA-24
Modified Dome	GPS-LA-25
Plastic Dome Side View	GPS-LA-25.5

Parts List -------

<u>Early - Rock and Wall Type</u>		
GPS Stand for Pine Meadows	GPS 0	[NA]
SIO2 Antenna Mount - Ht	GPS 1	[NA]
Rocha Antenna Mount - Ht	GPS 2	[NA]
<u>Parkfield-93 - Two-Color EDM</u>		
Parkfield Center pipe	GPS 3	[NA]
Parkfield Center Pipe fitting	GPS 4	[NA]
Parkfield Subsurf. Assy. Plan	GPS 5	[NA]
Parkfield Borehole/Pipe/Insulation Choices	GPS 6	[NA]
Parkfield Surface Assembly Plan	GPS 7	[NA]
Parkfield Reflector Fitting	GPS 8	[NA]

Appendix B–4 — Rock mark specifications

Appendix B–5 — Receiver box

Minimum dimensions:
Minimum gauge steel:
Builtin lock
Water tight
Box must be ventilated.
If outdoors, the box must include thermostatically controlled forced ventilation.

Appendix C — Receiver placement and maintenance

Introduction

The SCIGN management requires placement of Global Positioning System (GPS) receivers at approximately 36 newly constructed sites in the Los Angeles metropolitan area. The SCIGN management also requires maintenance of approximately 76 sites in the Los Angeles metropolitan area, 40 existing and 36 new. We expect that this will be done primarily by a Network Coordinator (Appendix D) located at the SCEC offices in Pasadena. To assist the Network Coordinator in this effort we expect to execute an add-on to an existing seismic station maintenance contract (with Allied Signal) currently in place at the USGS Pasadena.

Contract requirements

The contractor will assist network coordinator in installing a receiver at each new site.

The contractor will make one routine maintenance visit to each site in each six month period.

In addition, the contractor will respond within 48 hours, to requests from the the data processing centers about the status of particular sites.

The add-on agreement should specify that GPS station mainenance receives equal priority with seismic station maintenance, particularly during critical post-seismic time periods.

The contractor will assist the Network Coordinator in maintaining a www-accessible log file for each station in the array.

The contractor will add an entry to the appropriate log file for each visit to a station, documenting the station condition and any changes that were made.

The contractor may be supervised by a representative of the SCIGN board as necessary to resolve problems and to ensure contract compliance.
Detailed specifications for construction of the mark are included in Appendix C–1
Detailed drawings for construction of the mark are included in Appendix C–2

Appendix D — Network coordinator

Introduction

Operation of the SCIGN network will be overseen by a Network Coordinator. The network coordinator will be hired by SCEC with funds provided by the USGS. The position will be located at the SCEC center at 535 Wilson Street, Pasadena, California. The duties of the network coordinator will be to insure that the entire network is maintained in an operational state at all times. SCIGN is a distributed network. Downloading occurs at three locations; processing and data archiving are done at two different processing centers. To insure that the entire network functions smoothly, SCIGN needs someone who will take responsibility for checking on the whole network. When there are problems, the network coordinator will work with the various data centers and maintenance people to correct them. The network coordinator will also act as a single point of contact for the network.

Job announcement

The Southern California Integrated GPS Network (SCIGN) is seeking a Network Coordinator.

Note: In an attempt to circulate this widely, we are distributing it to several mailing lists. We apologize to anyone receiving more that one copy.

Introduction

SCIGN is a distributed Global Positioning System network with data downloading and archiving occurring at several locations. Currently SCIGN consists of about 40 sites; the number of sites is growing. The duties of the network coordinator will be to insure that the entire network is maintained in an operational state at all times. The network coordinator will work with the various data centers and maintenance people to insure that the network operates reliably and to maintain adequate records on the stations that compose the network.

Location:

The position will be located at the SCEC center at 535 Wilson Street, Pasadena, California adjacent to the U.S. Geological Survey Pasadena office and to the CalTech campus.

Position description

Coordinate selection of new SCIGN sites.
Coordinate construction of monuments at new SCIGN sites.
Supervise or carry out the placement of receivers at the new sites.
Check status of all network stations daily.
Insure that all stations are tracking and providing data to the appropriate data center.
Coordinate trouble shooting on any down stations to locate the source of problem.
Coordinate the required maintenance to bring down stations back on line.

Coordinate all hardware, firmware and software upgrades to the receivers.
Maintain site logs for all sites.
Maintain site change logs for all sites.
Be responsible for downloading sites that come into Pasadena office (SCIGN sites are downloaded at a number of different facilities).
Maintain communication with both processing centers (JPL, SOPAC) to insure that stations are providing needed data and information.

Qualifications

Experience with Unix, Mac and PC operating systems
Experience with GPS receiver hardware and data handling
Experience with data communications via modem, radio, and telephone links.
Ability to interact constructively with the variety of groups involved in operating SCIGN.
Ability to pay attention to details.
Ability to work independently.

To apply

Send extended resume to the chairman of the selection committee:
Ken Hudnut (hudnut@seismo.gps.caltech.edu)

Applications will be accepted until the position is filled.

Appendix E — Forms

Site evaluation

Location rejection

JPL Permission form

Station Horizon mask

Site Evaluation Form (1 of 2)

Site name, number, or description ______________________________

Observer's name ______________________ Date ____________________

Sky view and multipath ______________________________

____

____

Permanence ______________________________

____

____

Security & Safety ______________________________

____

____

Site geology ______________________________

____

____

Access ______________________________

____

____

Power ______________________________

____

____

Phone ______________________________

____

____

Site Evaluation Form (2 of 2)

Site name, number, or description____

Observer's name ______________________________ Date________________________

Permission ____

____

____

Landuse fees ____

____

____

Receiver occupation test ______________________________________

____

____

DigAlert ____

____

____

Attach eight photographs of the site: looking north, south, east and west from the site; and looking north, south, east and west at the site. The proposed antenna site should be marked with a stake that appears in four of the photos.

Attach additional pages if more space is needed. It is not necessary to transcribe information onto this form. If it is more conveniently available in another format, just attach copies. Copies of other relevant information should also be attached.

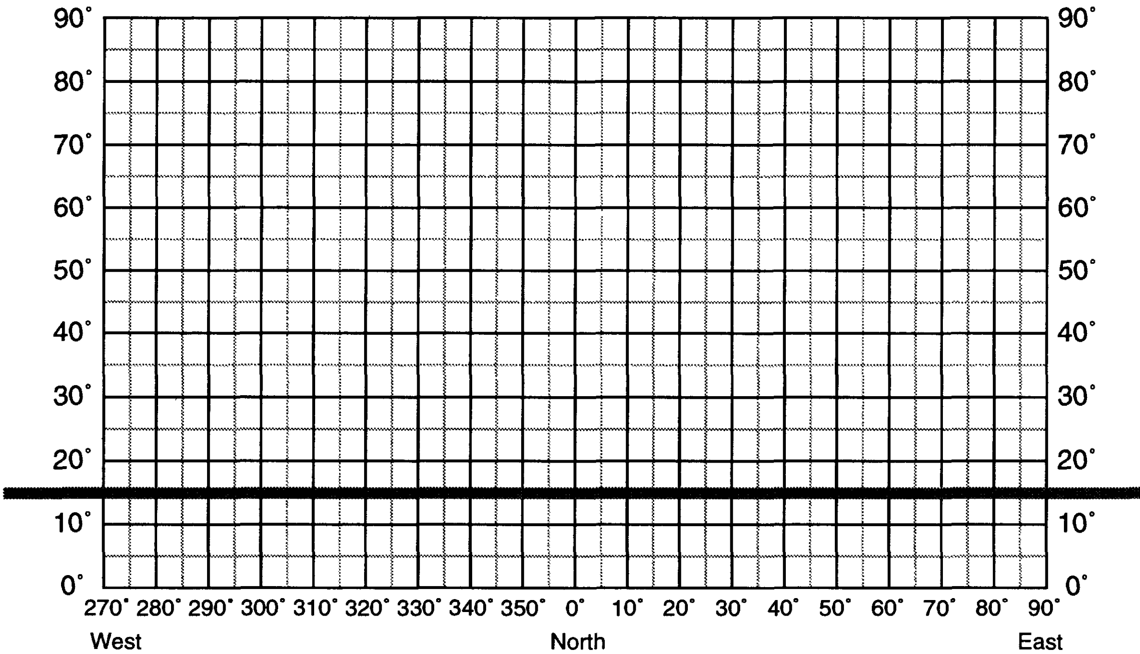
Station Horizon Mask

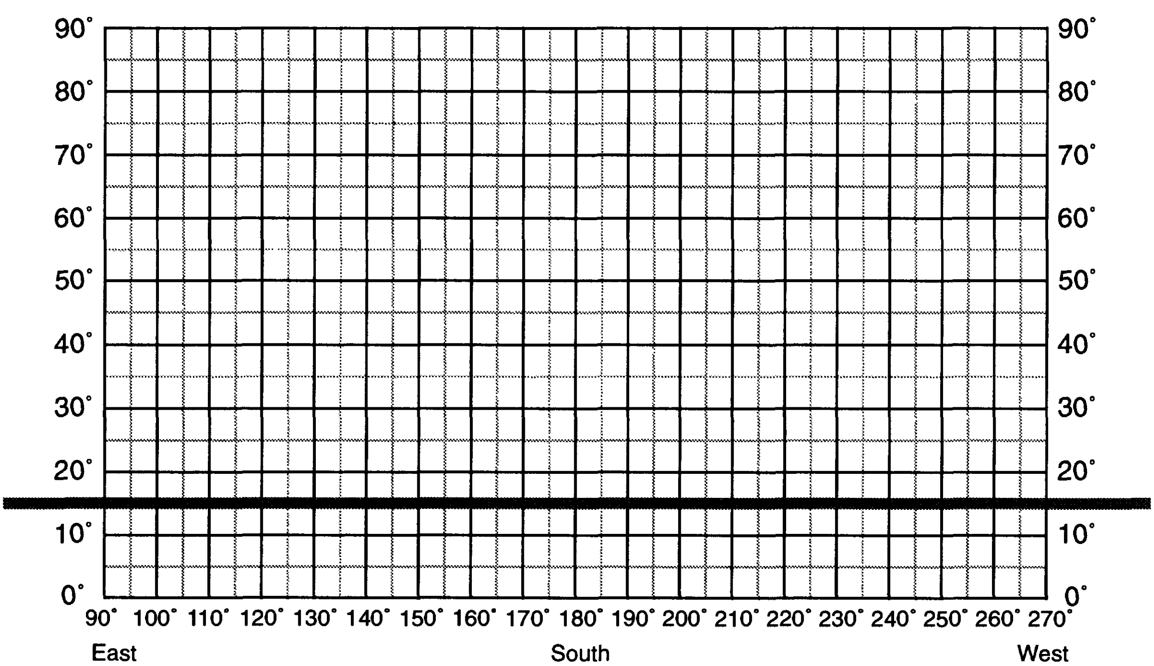
Station Name or Number: ______________________ Date: _________

Location/description: ____

____

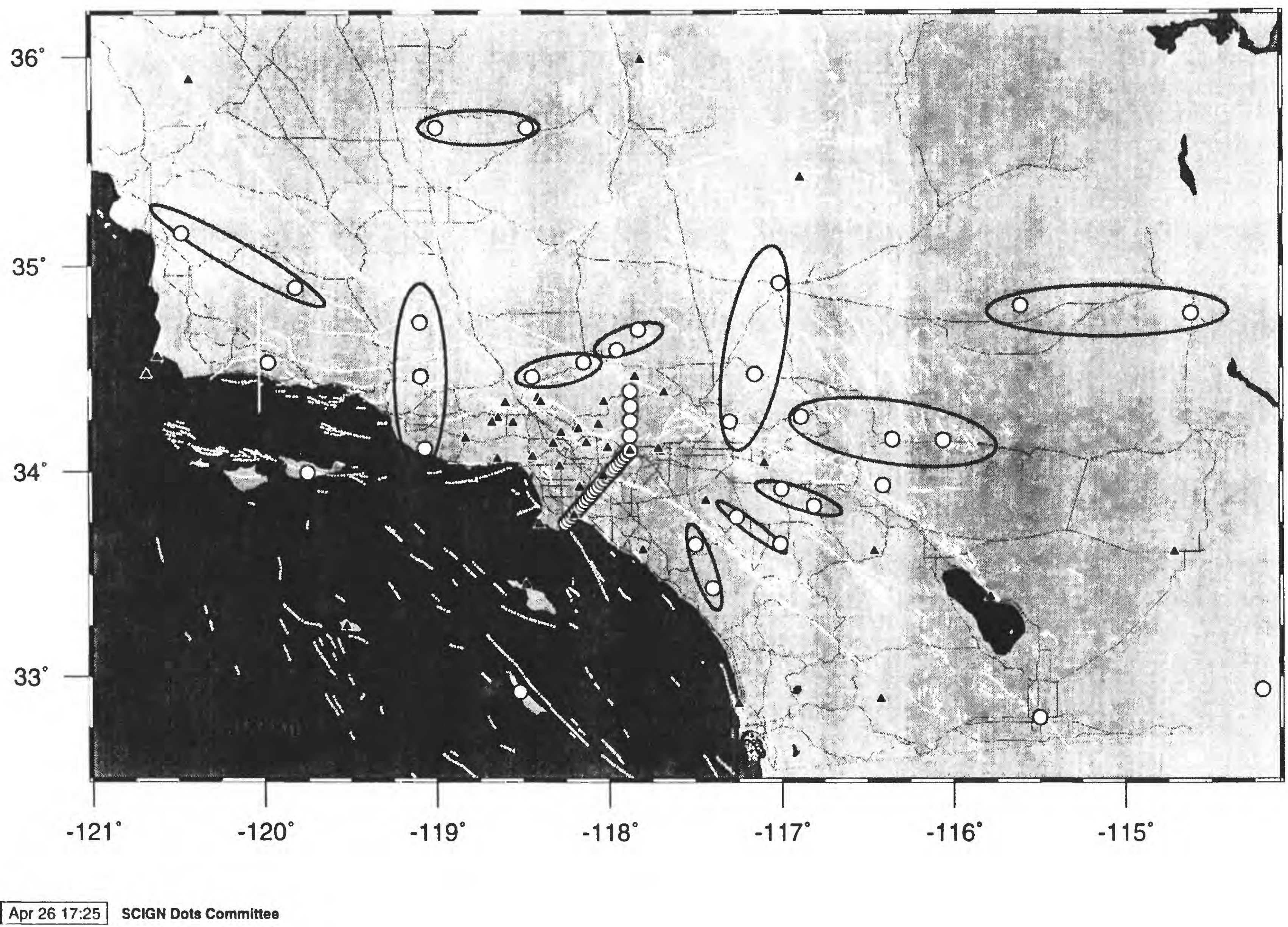
Total number of obscured blocks above 15˚: _________ Observer's name: ___________________

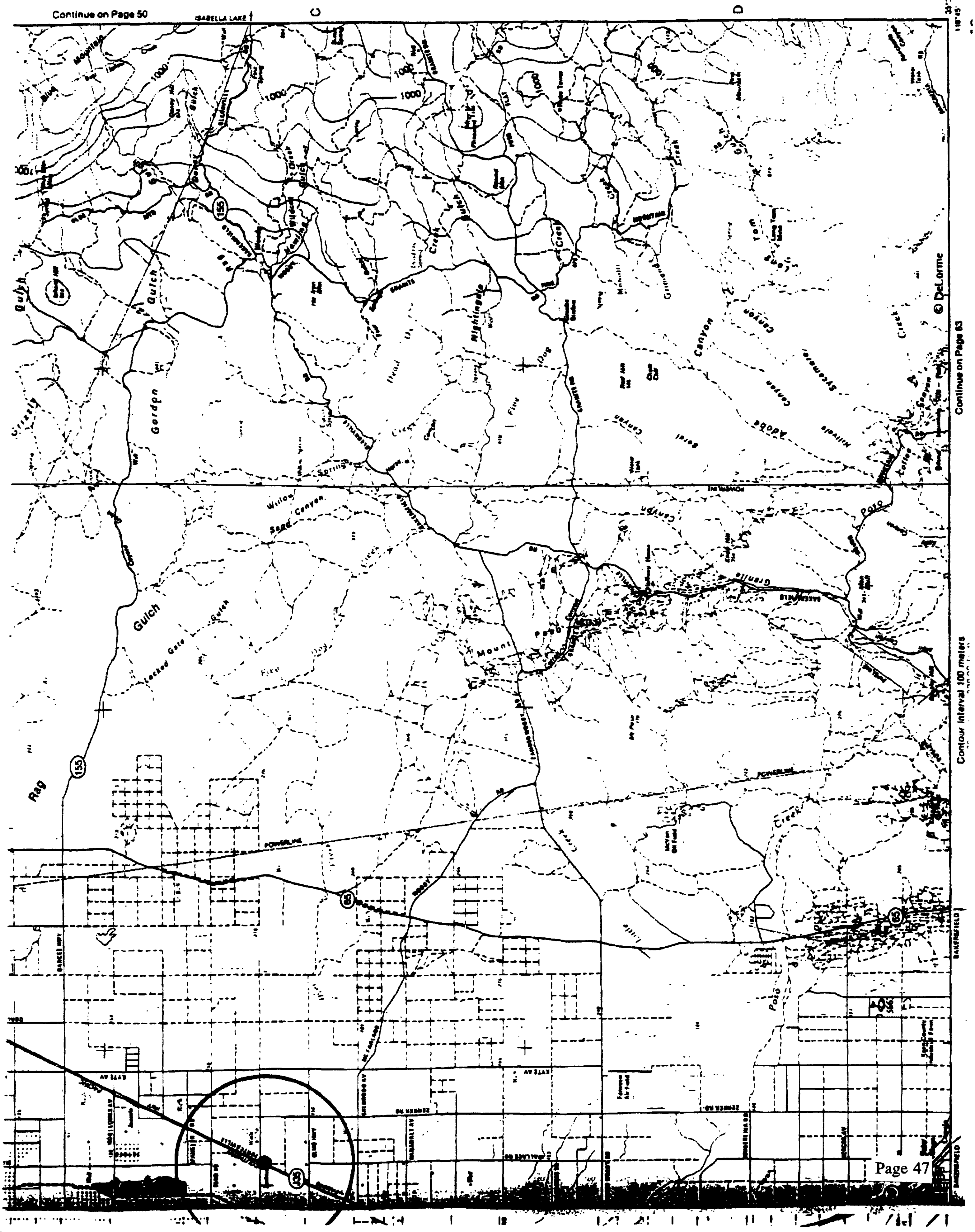




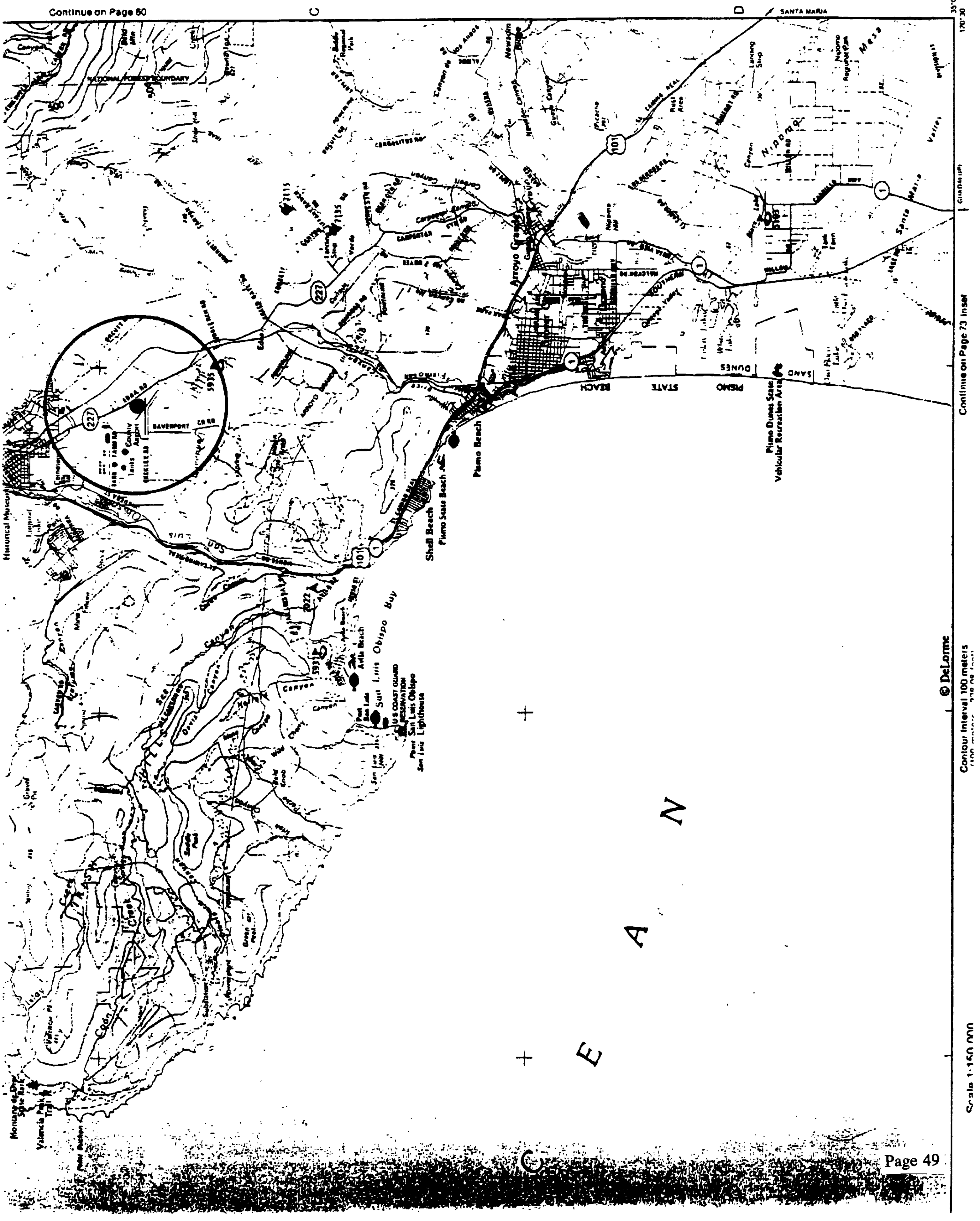
SCIGN 1996-03-03

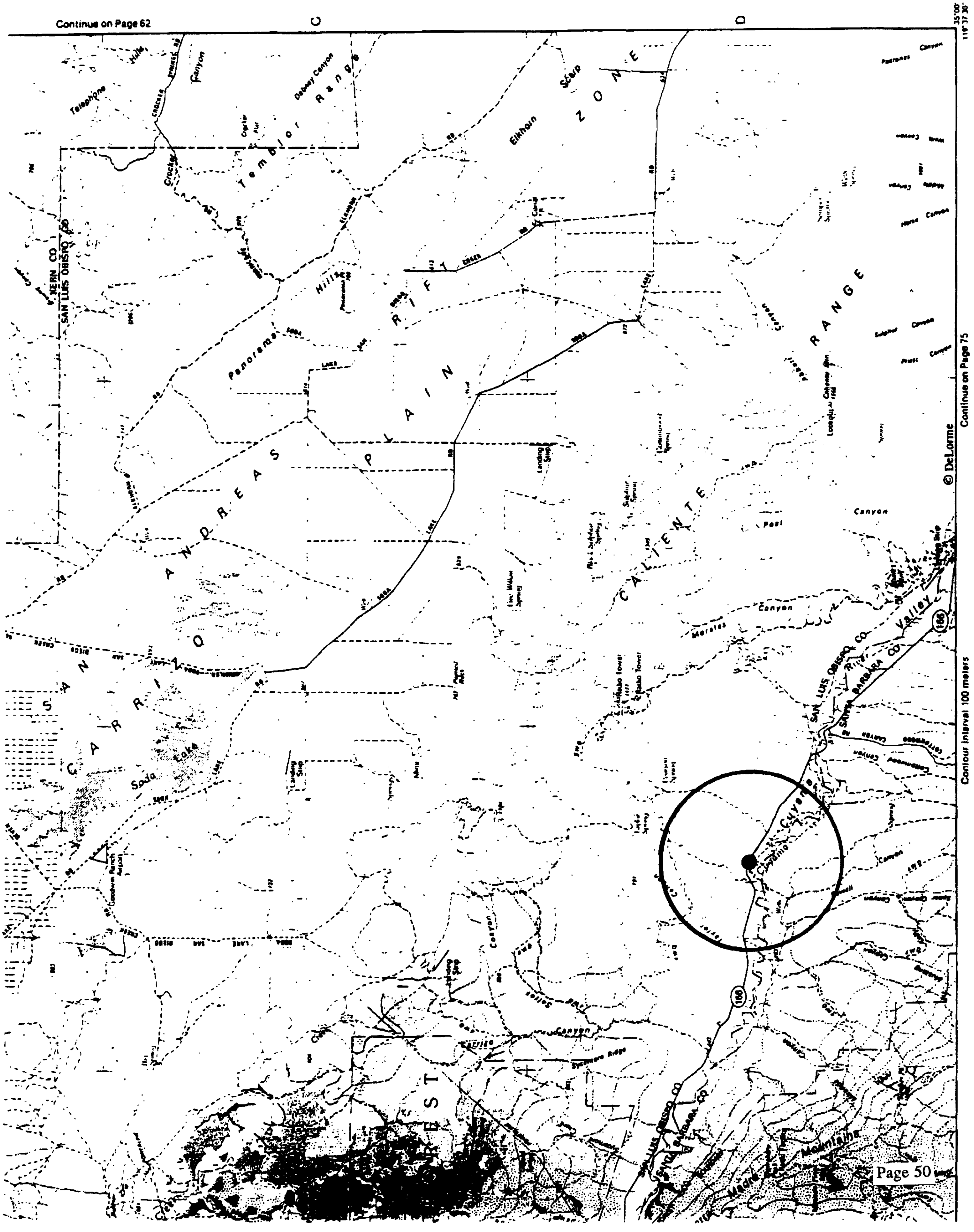
Appendix F — New site location maps


36°
35°
34°
33°
-121°
-120°
-119°
-118°
-117°
-116°
-115°
GMT Apr 26 17:25
SCIGN Dots Committee


Continue on Page 50
ISABELLA LAKE
C
D
Blue Mountain
1000
Gulch
Gordon
Grizzly
Rag
155
Willow
Sand Canyon
Spring
Creek
Nightingale
Dog
Canyon
Sycamore
Adobe
Long Tom
Poso
Mount Poso
Granite
Locked Gate
POWERLINE
65
© DeLorme
Continue on Page 63
Contour interval 100 meters
Page 47

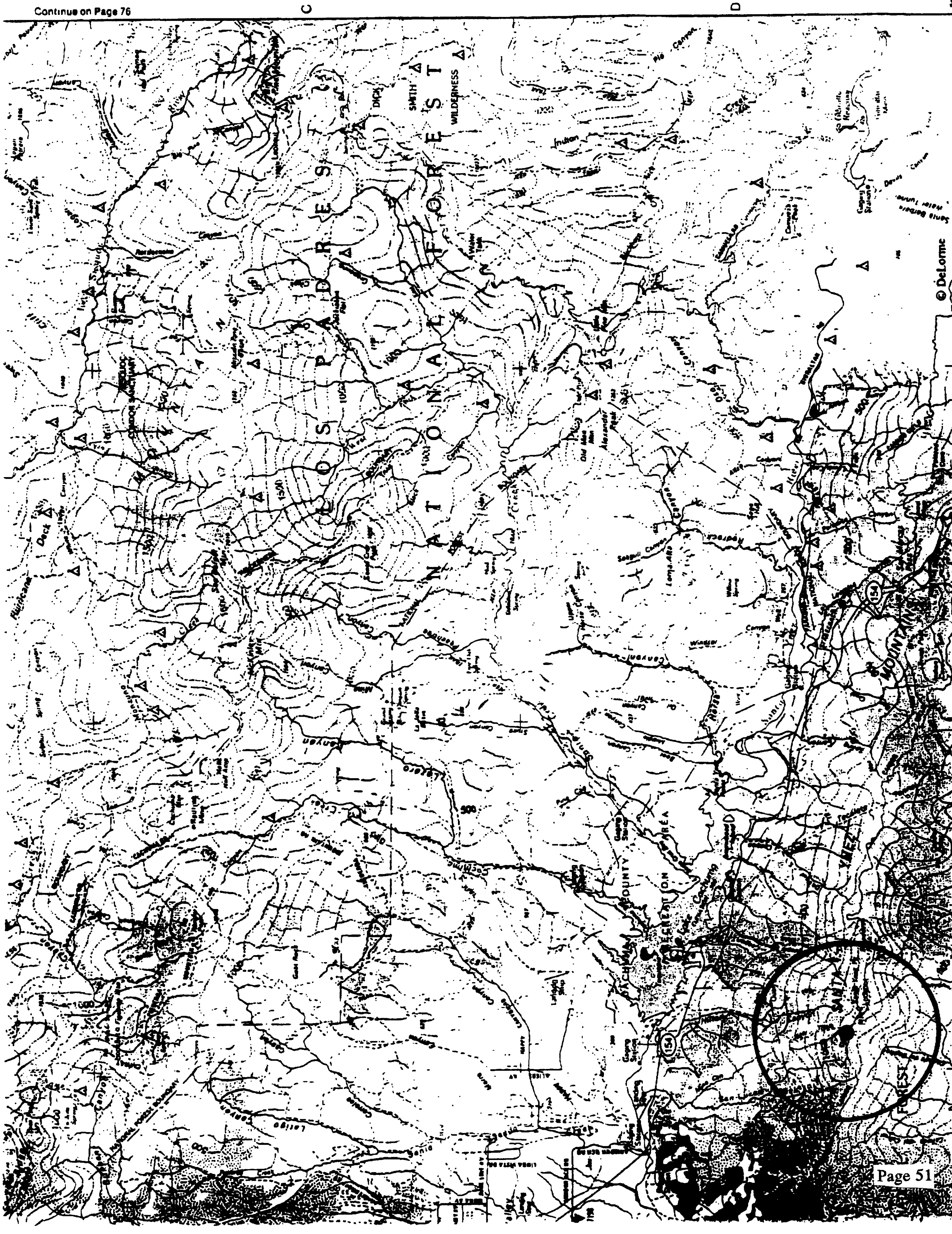

ISABELLA
LAKE
Continue on Page 64
© DeLorme
Continue on Page 49
50

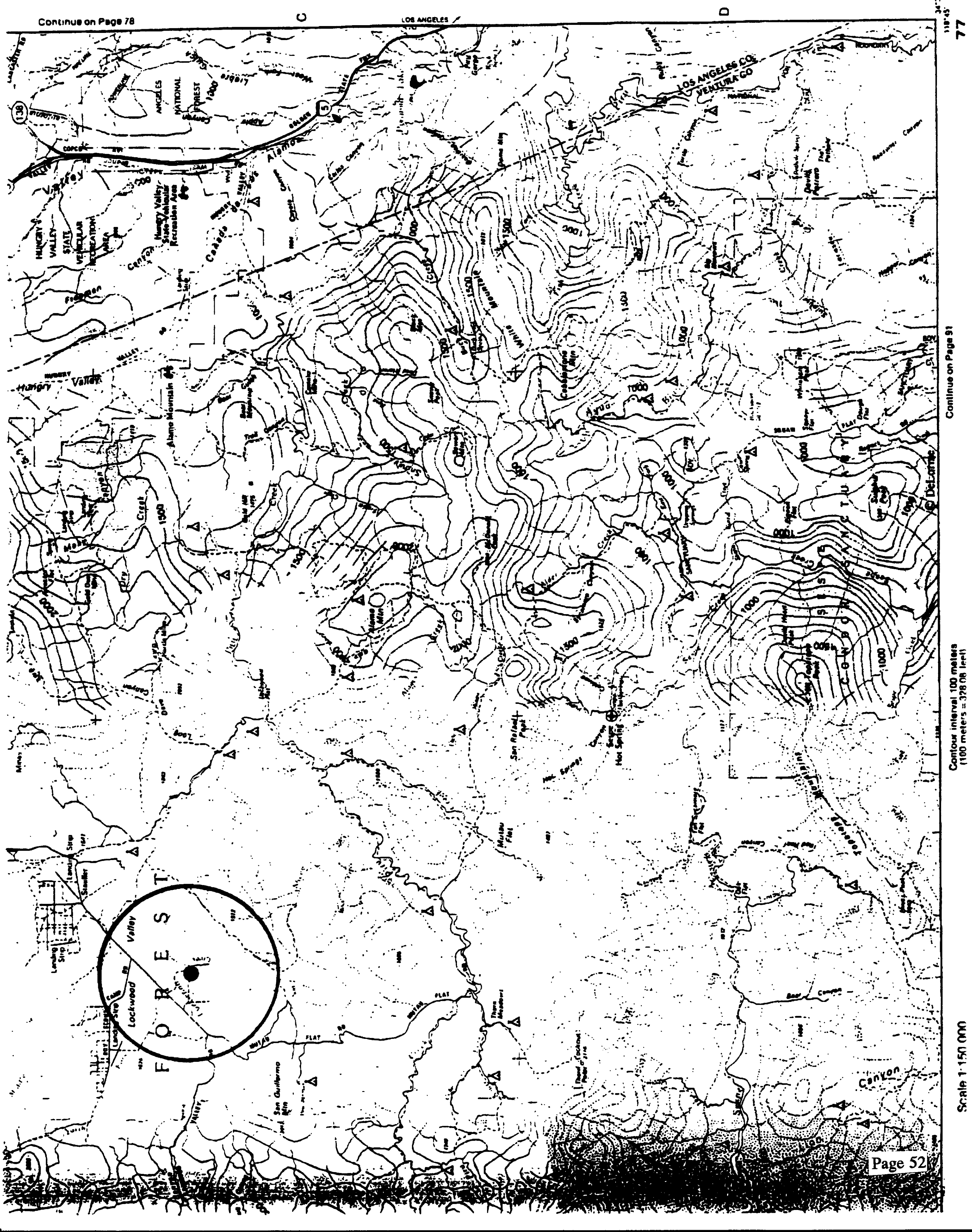

Continue on Page 60
SANTA MARIA
NATIONAL FOREST BOUNDARY
Arroyo Grande
Pismo Beach
Shell Beach
Pismo State Beach
PISMO STATE BEACH
SAND DUNES
Pismo Dunes State Vehicular Recreation Area
Continue on Page 73 inset
Nipomo
Santa Maria Valley
San Luis Obispo Bay
Avila Beach
San Luis Obispo Lighthouse
U.S. COAST GUARD RESERVATION
Historical Museum
Montana de Oro State Park
Valencia Peak Trail
County Airport
© DeLorme
Contour Interval 100 meters

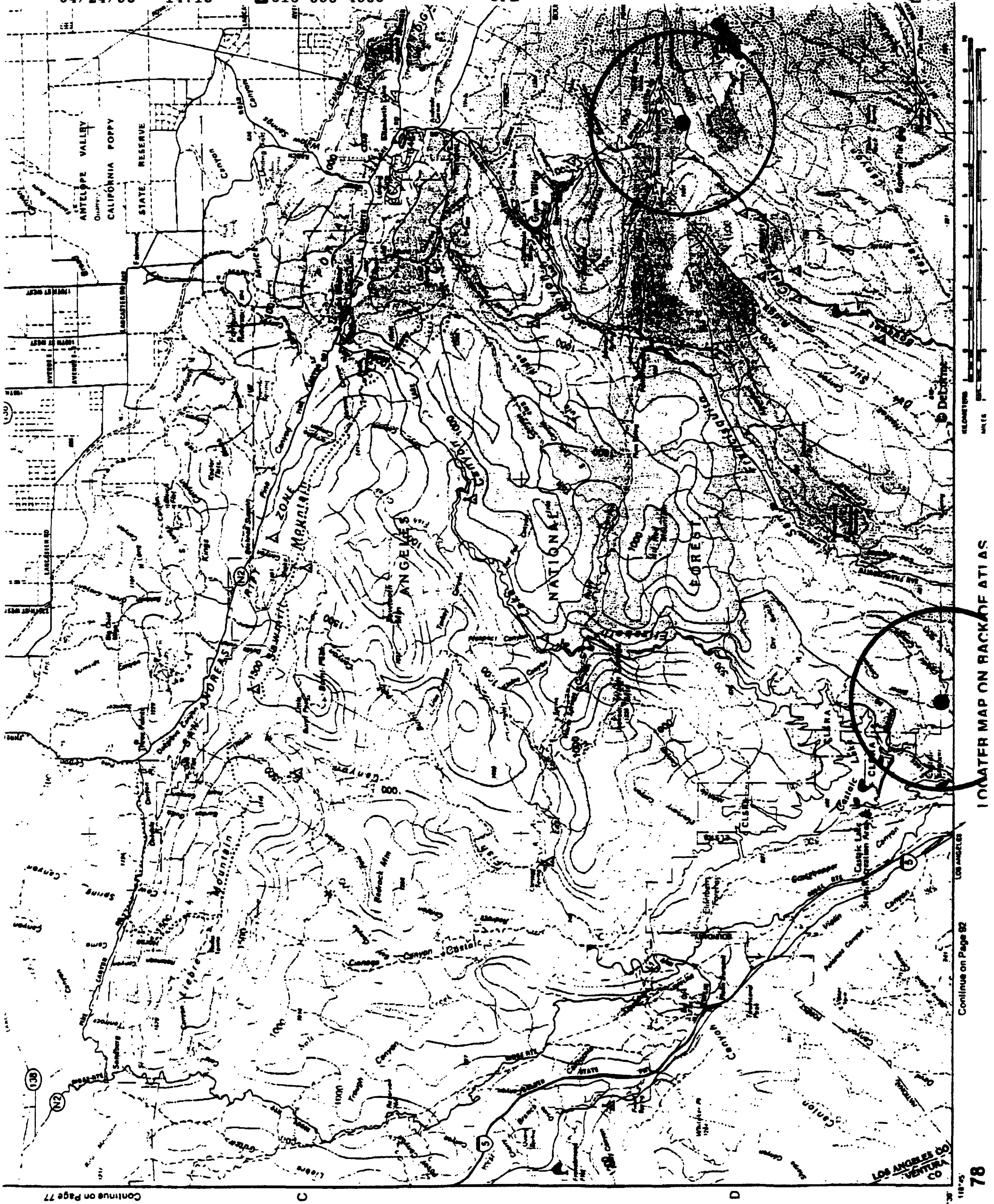


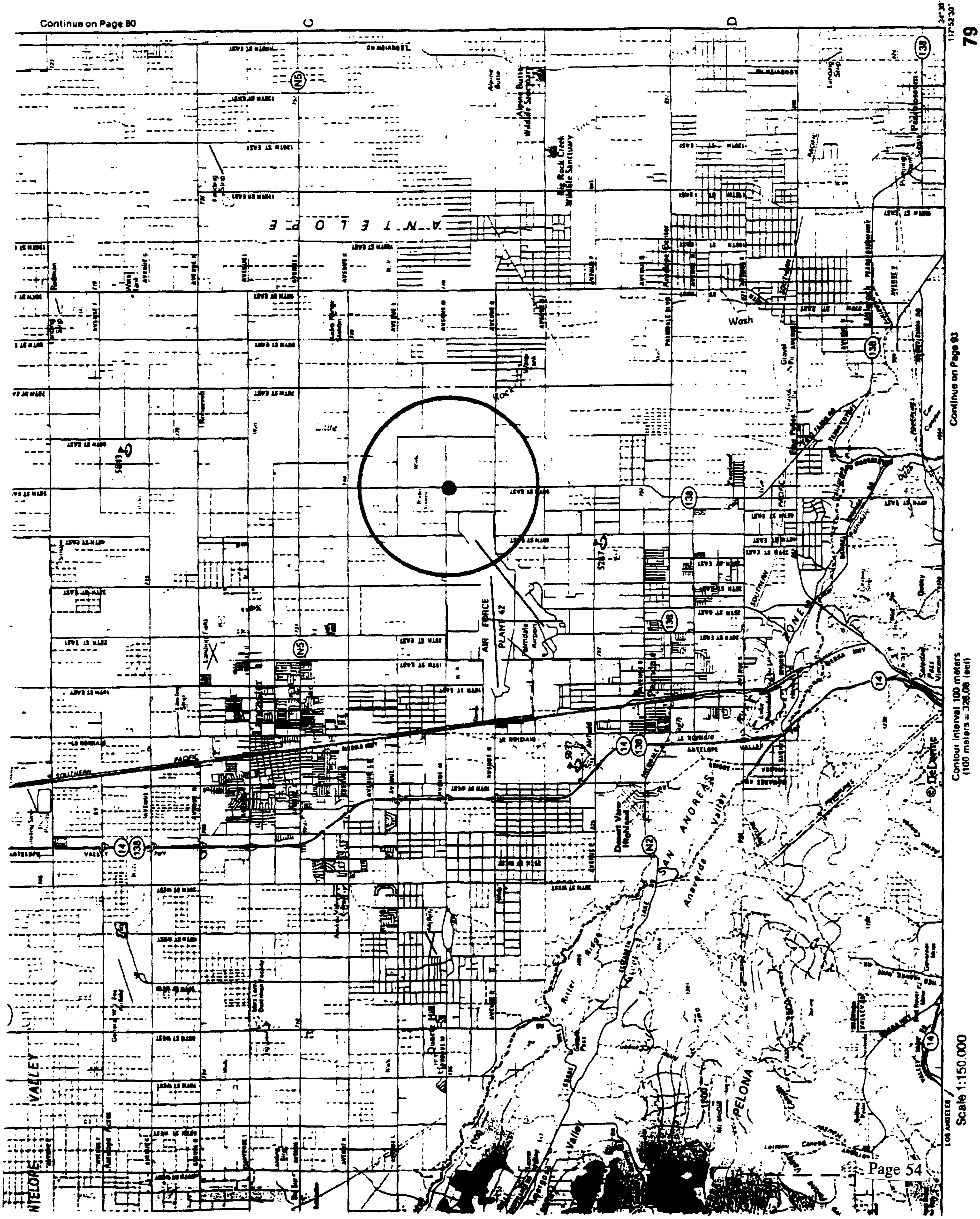
Continue on Page 62
C
D
Continue on Page 75
Telephone Hills
Temblor Range
Elkhorn Scarp
Panorama Hills
SAN ANDREAS RIFT ZONE
PLAIN
CARRIZO
CALIENTE RANGE
KERN CO
SAN LUIS OBISPO CO
Soda Lake
Morales Canyon
Cuyama
SAN LUIS OBISPO CO
SANTA BARBARA CO
Valley
166
Sycamore Ridge
Canyon
Contour interval 100 meters
© DeLorme

Continue on Page 76




Continue on Page 78
C
D
LOS ANGELES
77
LOS ANGELES CO.
VENTURA CO
Hungry Valley
Alamo Mountain
Lockwood
Valley
F O R E S T
Hot Springs
Canyon
Continue on Page 91
© DeLorme
Contour interval 100 meters
(100 meters = 328.08 feet)
Scale 1:150,000
Page 52


ANTELOPE VALLEY
CALIFORNIA POPPY
STATE RESERVE
SAN ANDREAS
RIFT ZONE
ANGELES
NATIONAL
FOREST
Continue on Page 77
Continue on Page 92
LOS ANGELES CO
VENTURA CO
78


Continue on Page 80
C
D
79
34°30'
117°52'30"
ANTELOPE
Wash
Continue on Page 93
AIR FORCE PLANT 42
Palmdale Airport
SOUTHERN PACIFIC
SAN ANDREAS
Anaverde Valley
Ritter Ridge
PELONA
VALLEY
Contour Interval 100 meters (100 meters = 328.08 feet)
© DeLorme
Scale 1:150,000

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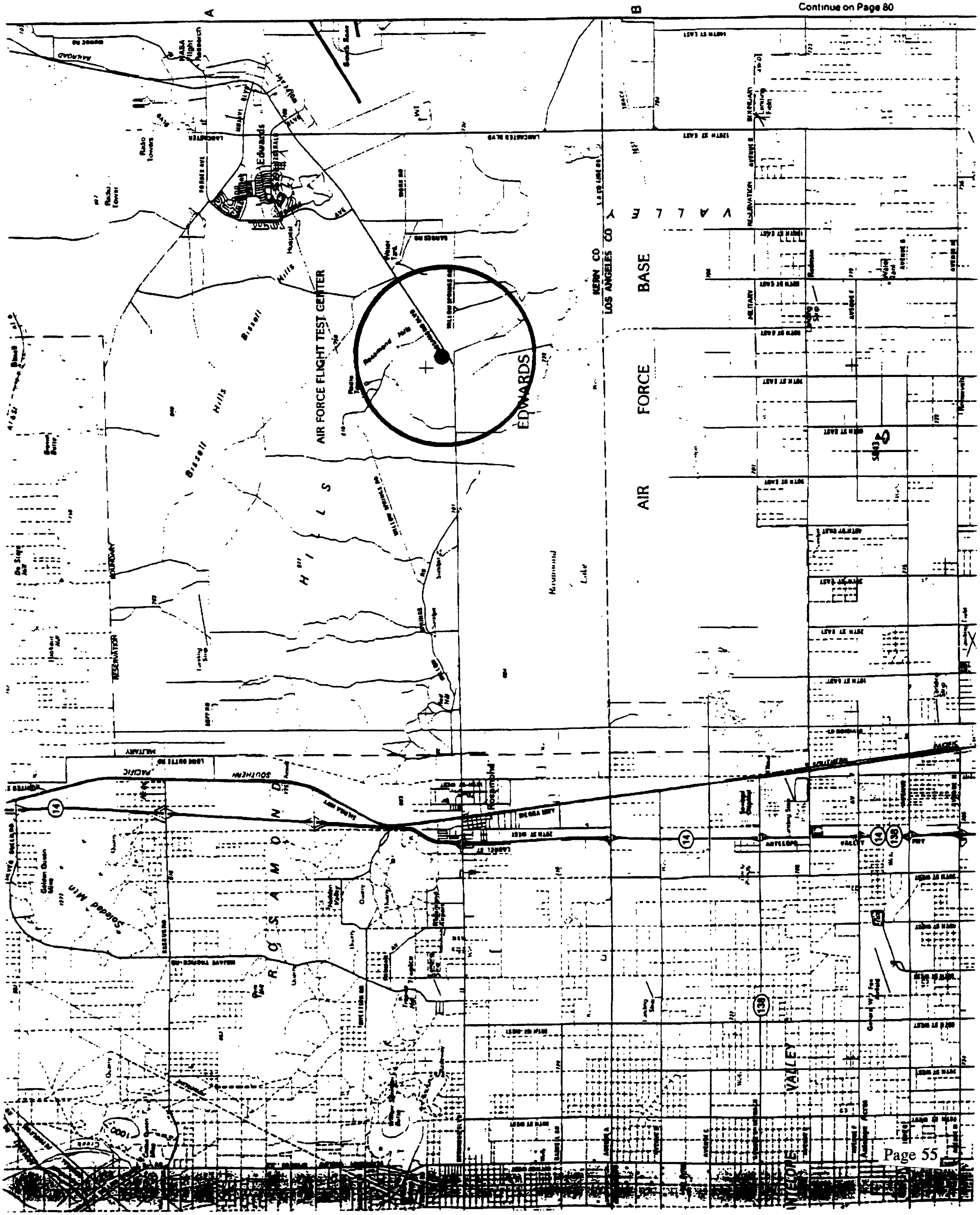
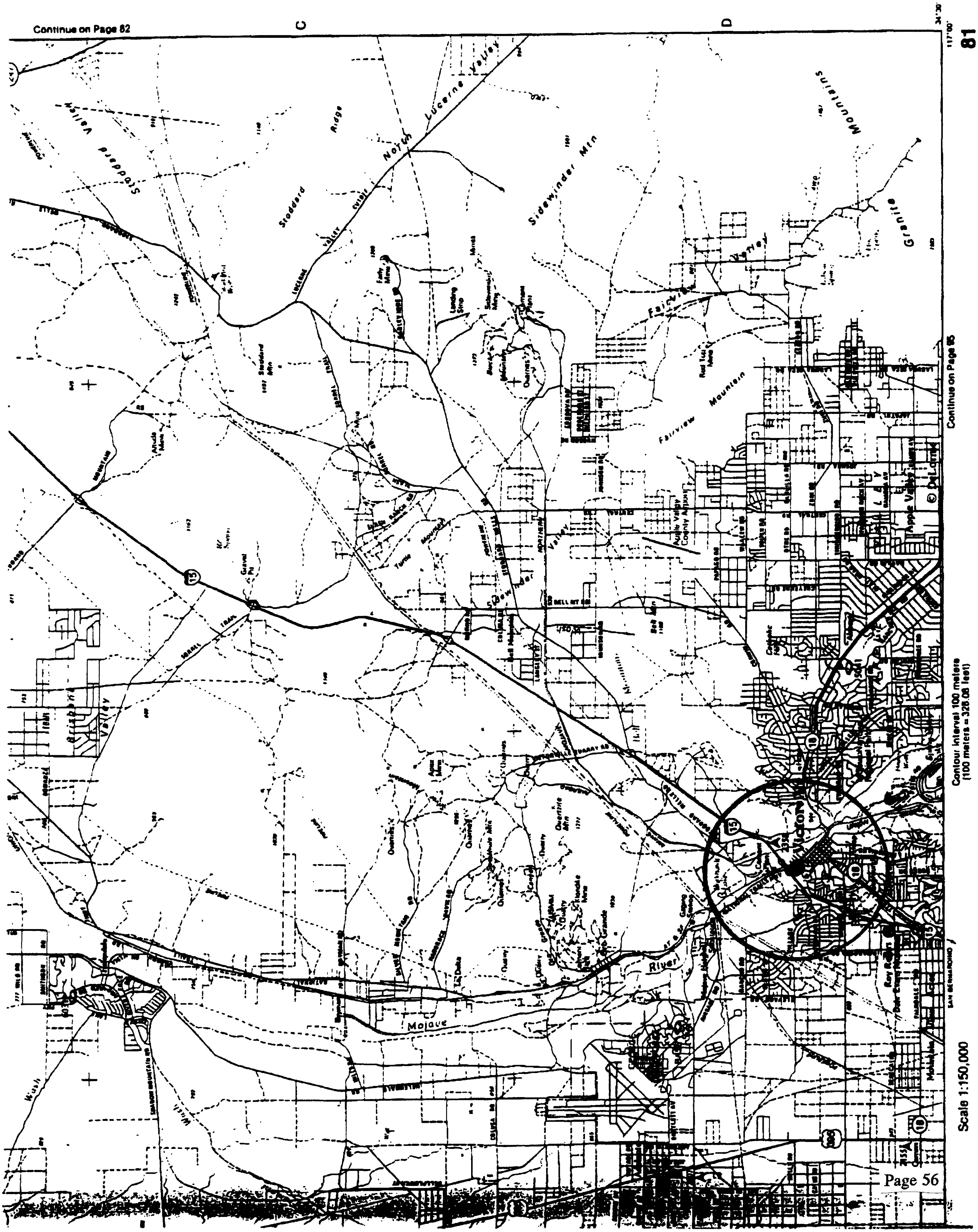
Continue on Page 80




Continue on Page 82
C
D
81
Continue on Page 85
Contour interval 100 meters
(100 meters = 328.08 feet)
Scale 1:150,000
Page 56
Stoddard Valley
Stoddard Ridge
North Lucerne Valley
Sidewinder Mtn
Mountains
Granite
Fairview Valley
Fairview Mountain
Apple Valley County Airport
Apple Valley
Sidewinder Valley
Turtle Mountain
Bell Mtn
Brisbane Valley
Mojave
River
Wash
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04/24/96 14:20 ☎818 393 4965 JPL 013

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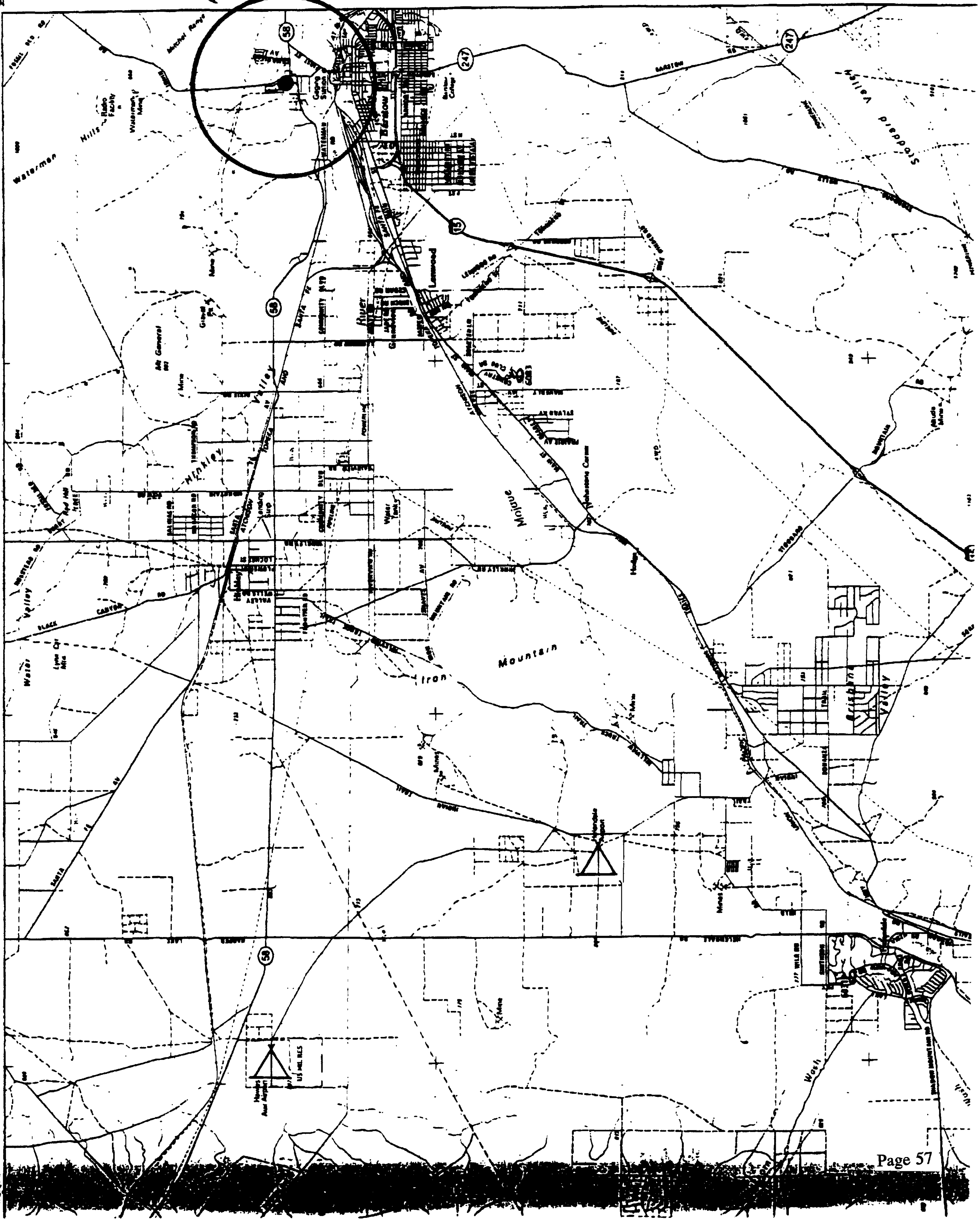
Continue on Page 87



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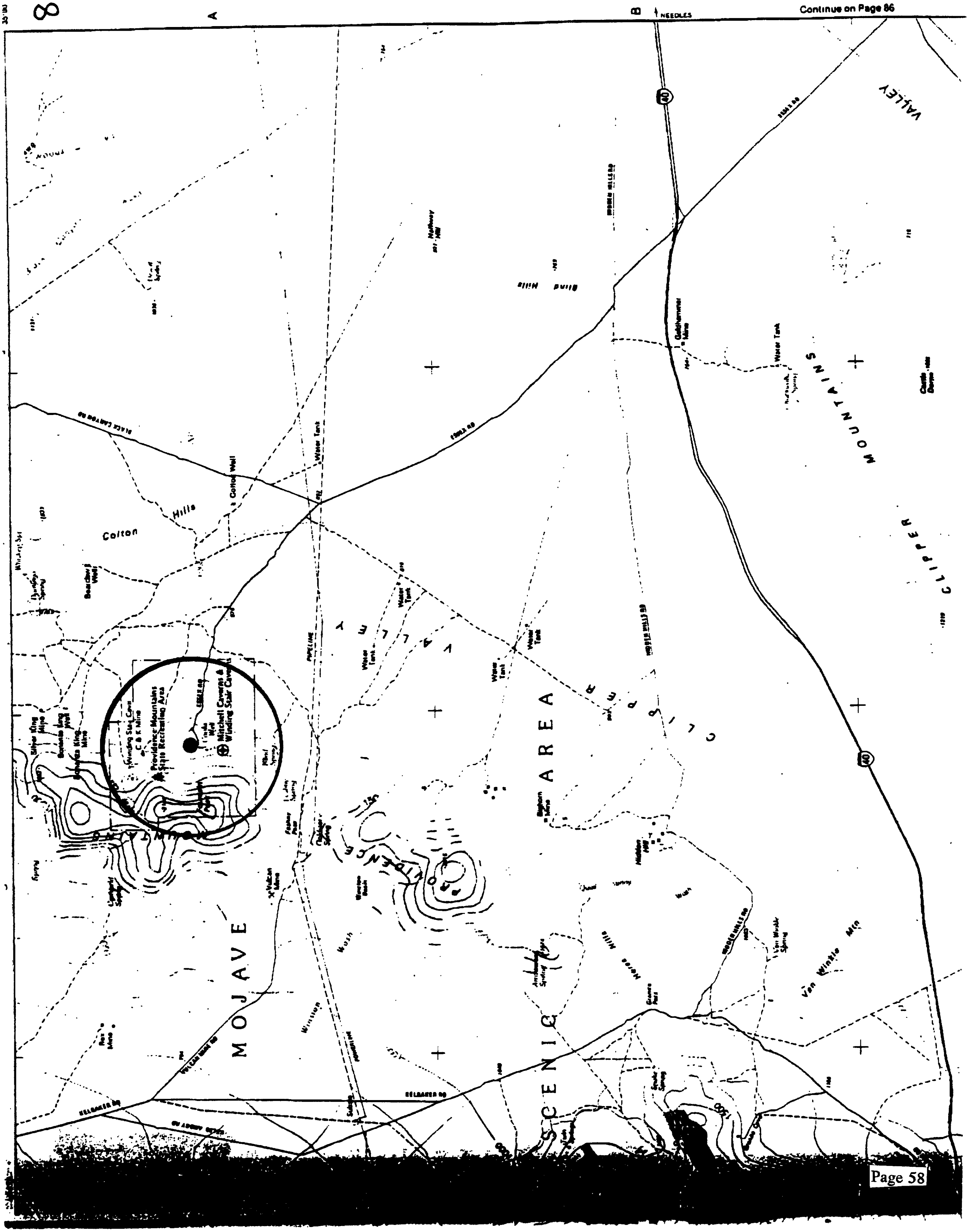
Continue on Page 86
NEEDLES
VALLEY
CLIPPER MOUNTAINS
CLIPPER VALLEY
MOJAVE SCENIC AREA
PROVIDENCE MOUNTAINS
Colton Hills
Providence Mountains State Recreation Area
Mitchell Caverns & Winding Stair Caverns
Blind Hills
Water Tank
Van Winkle Mtn
PIPELINE
KELBAKER RD
Page 58

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Continue in DeLorme's Arizona Atlas & Gazetteer

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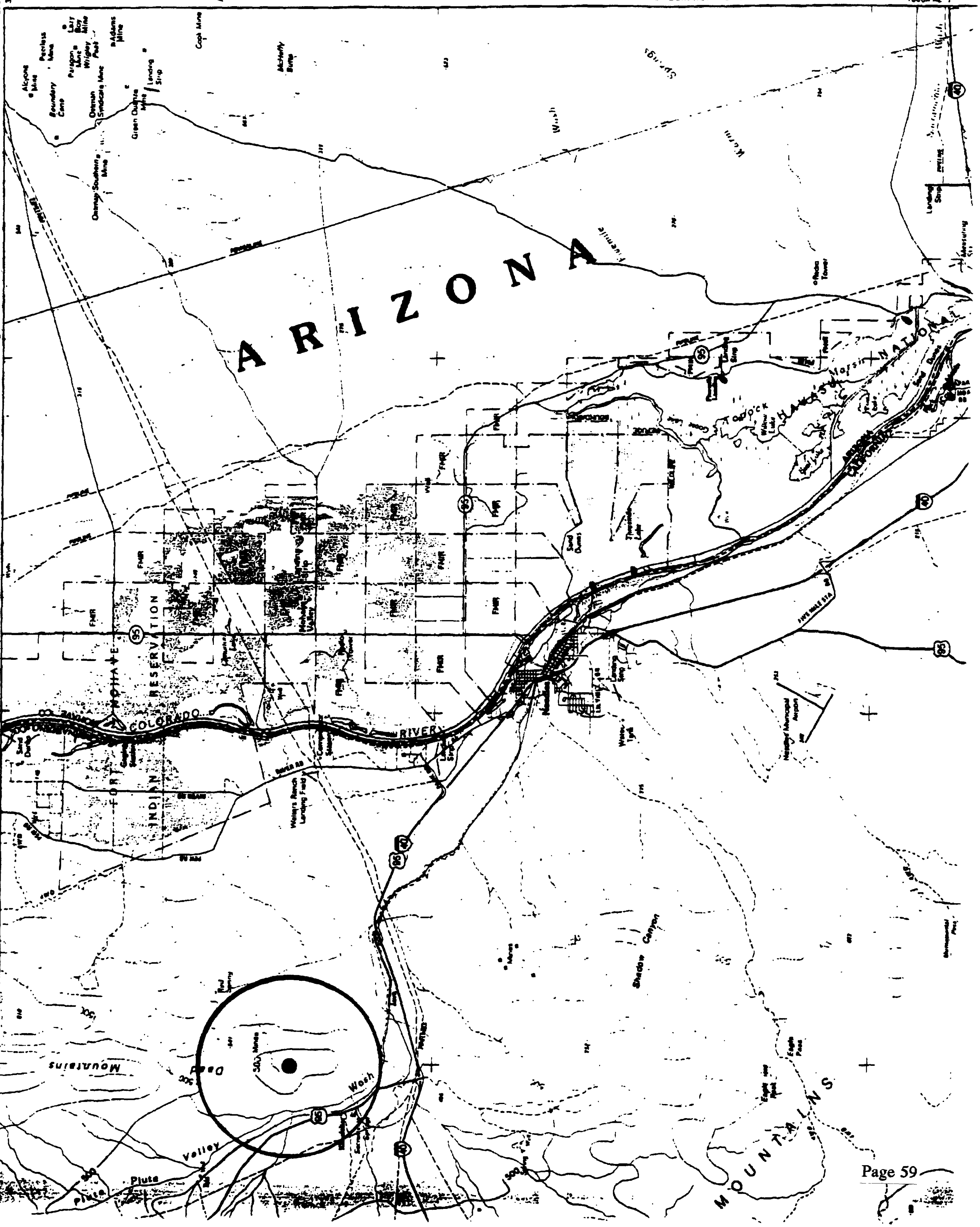
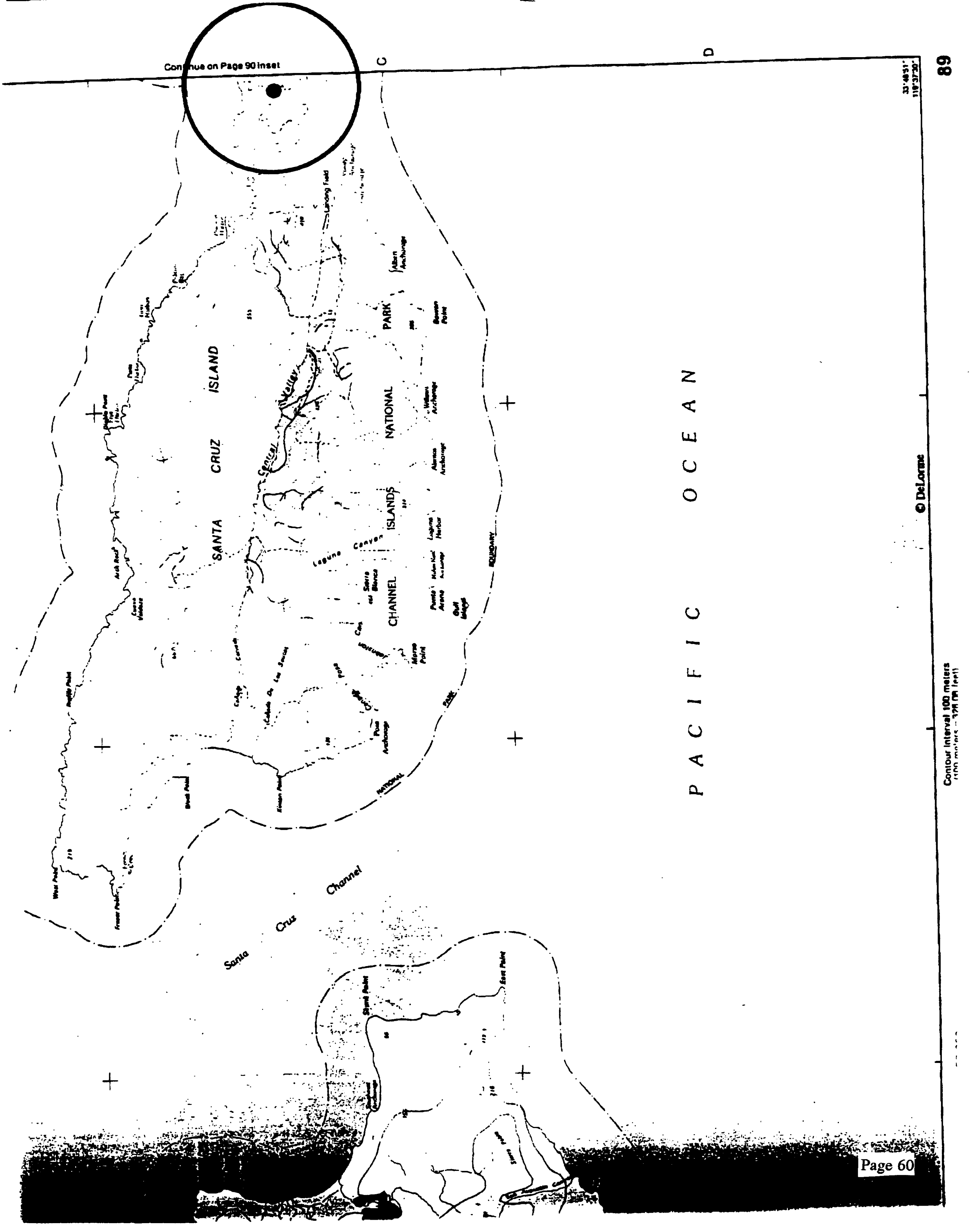
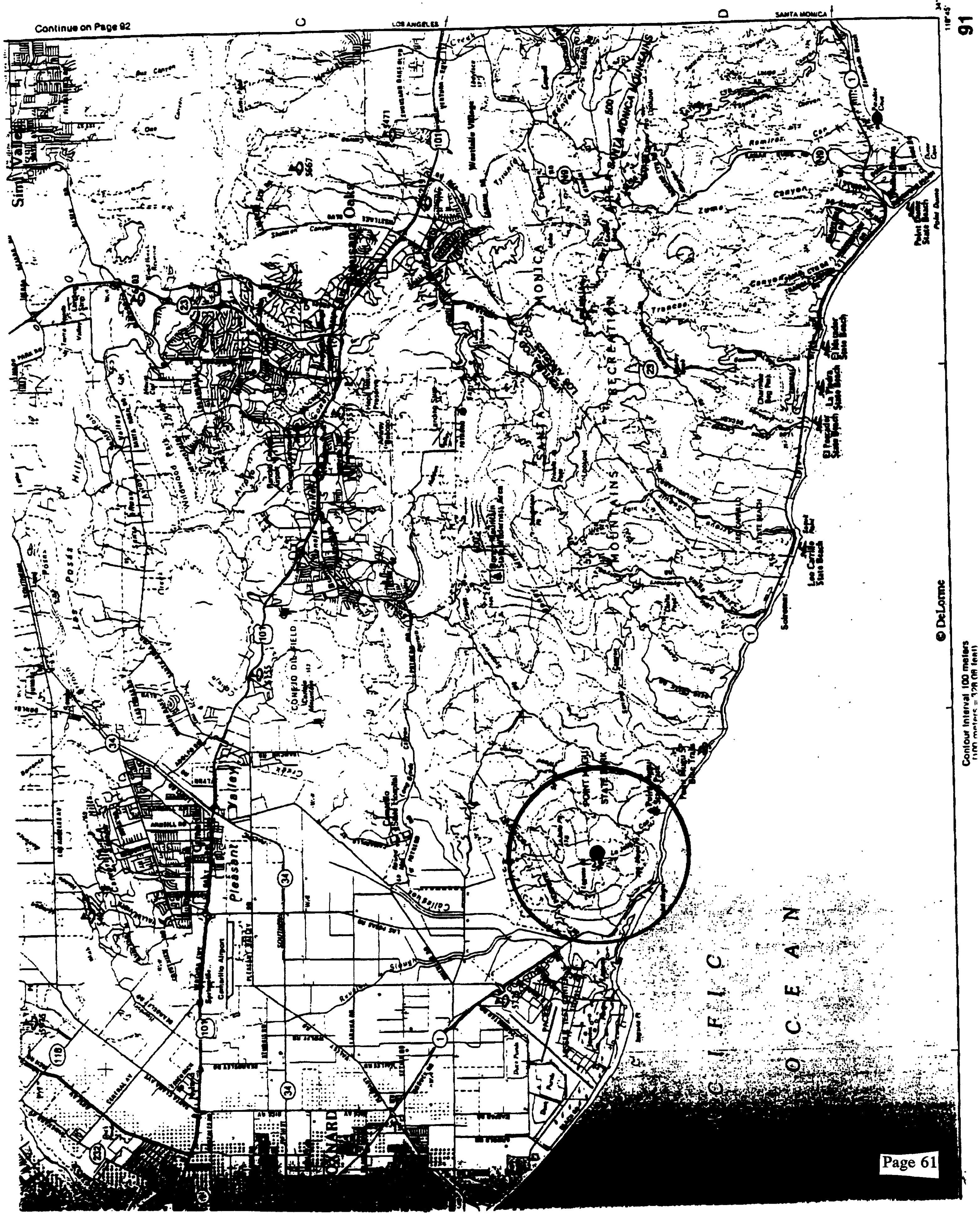



Continue on Page 90 inset
89
SANTA CRUZ ISLAND
CHANNEL ISLANDS NATIONAL PARK
Central Valley
Laguna Canyon
Landing Field
Santa Cruz Channel
NATIONAL PARK BOUNDARY
PACIFIC OCEAN
© DeLorme
Contour interval 100 meters


Continue on Page 92
LOS ANGELES
SANTA MONICA
SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA
POINT MUGU STATE PARK
OXNARD
Camarillo Airport
CONEJO DIV FIELD
PACIFIC OCEAN
© DeLorme
Contour interval 100 meters
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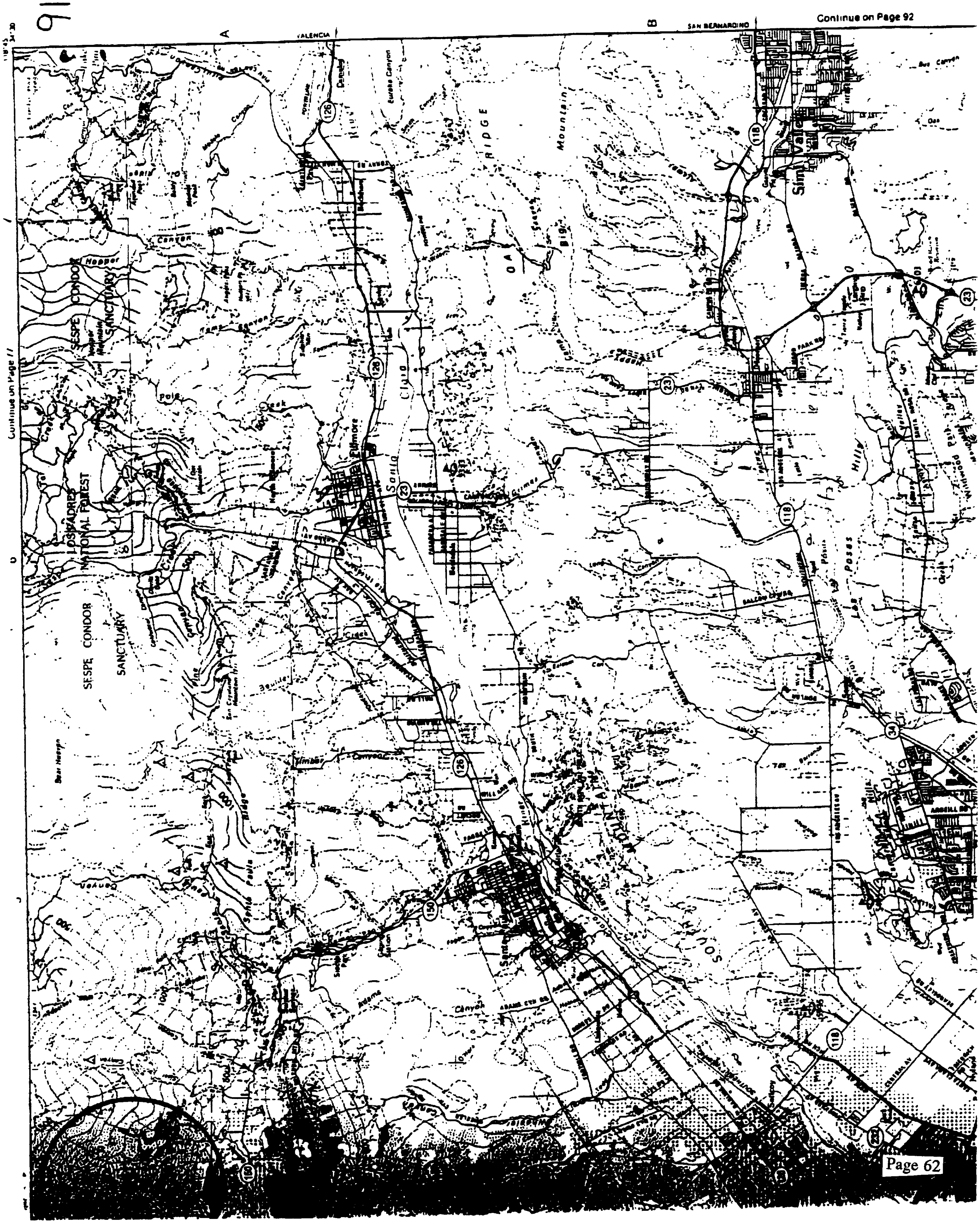
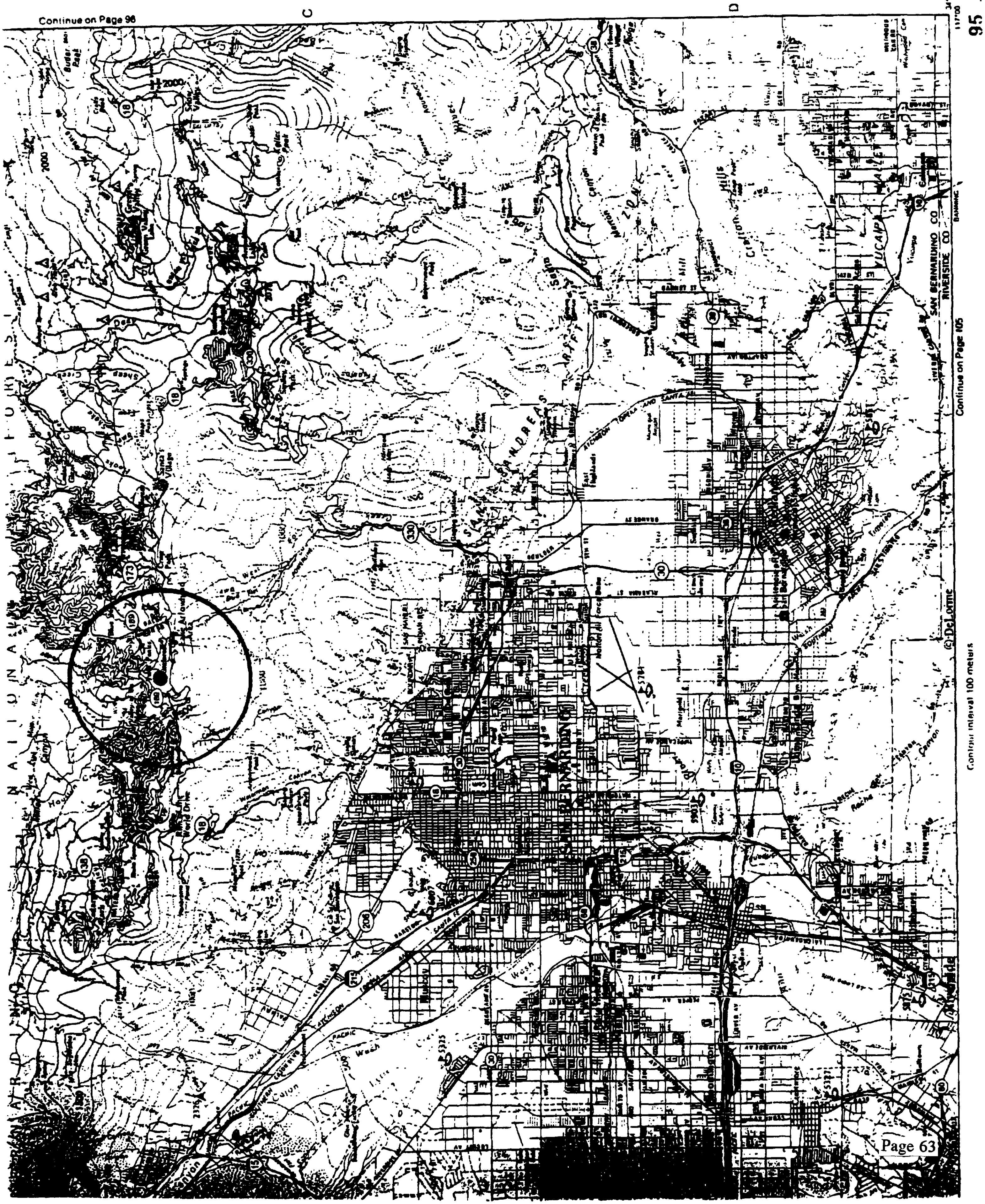
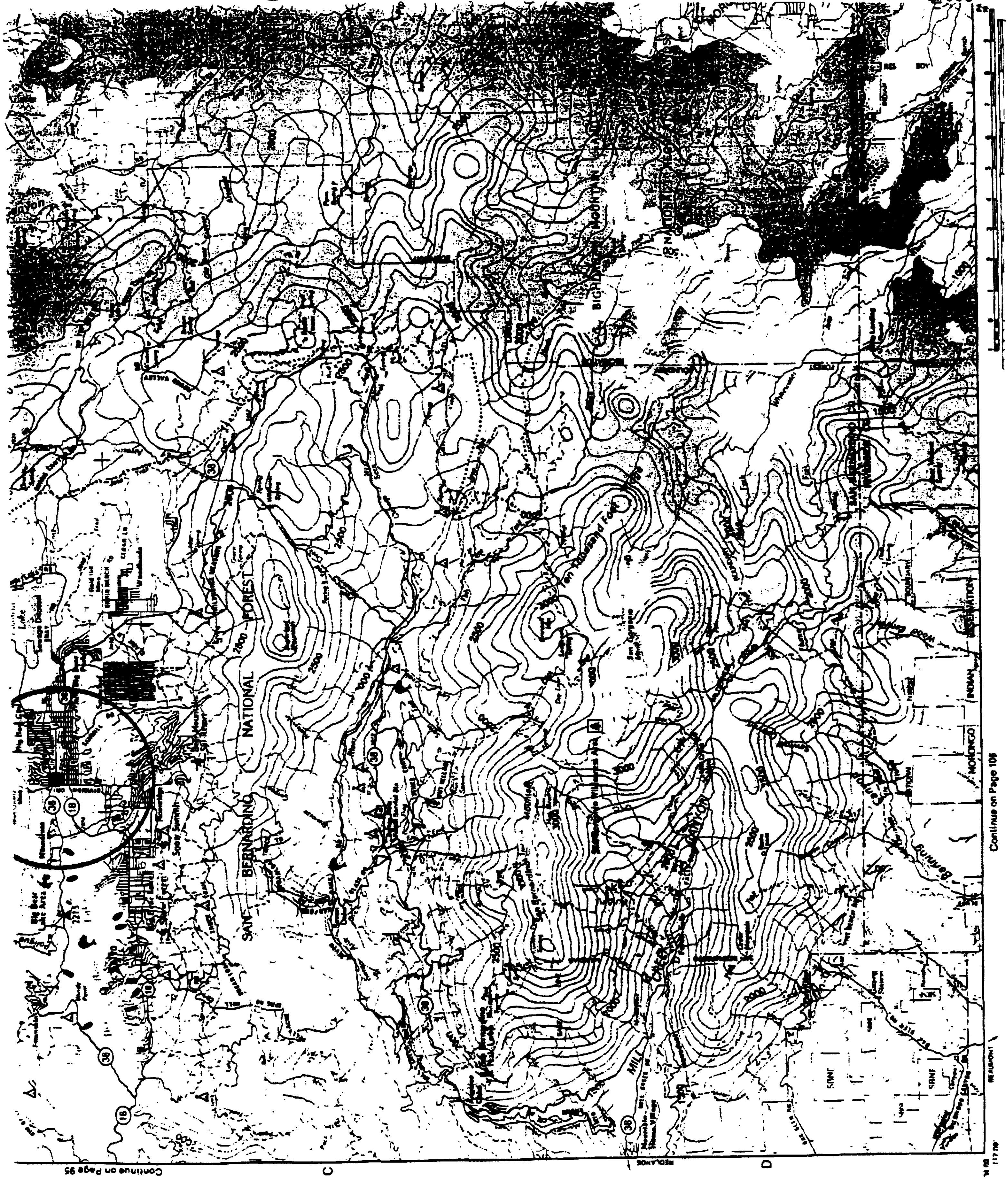
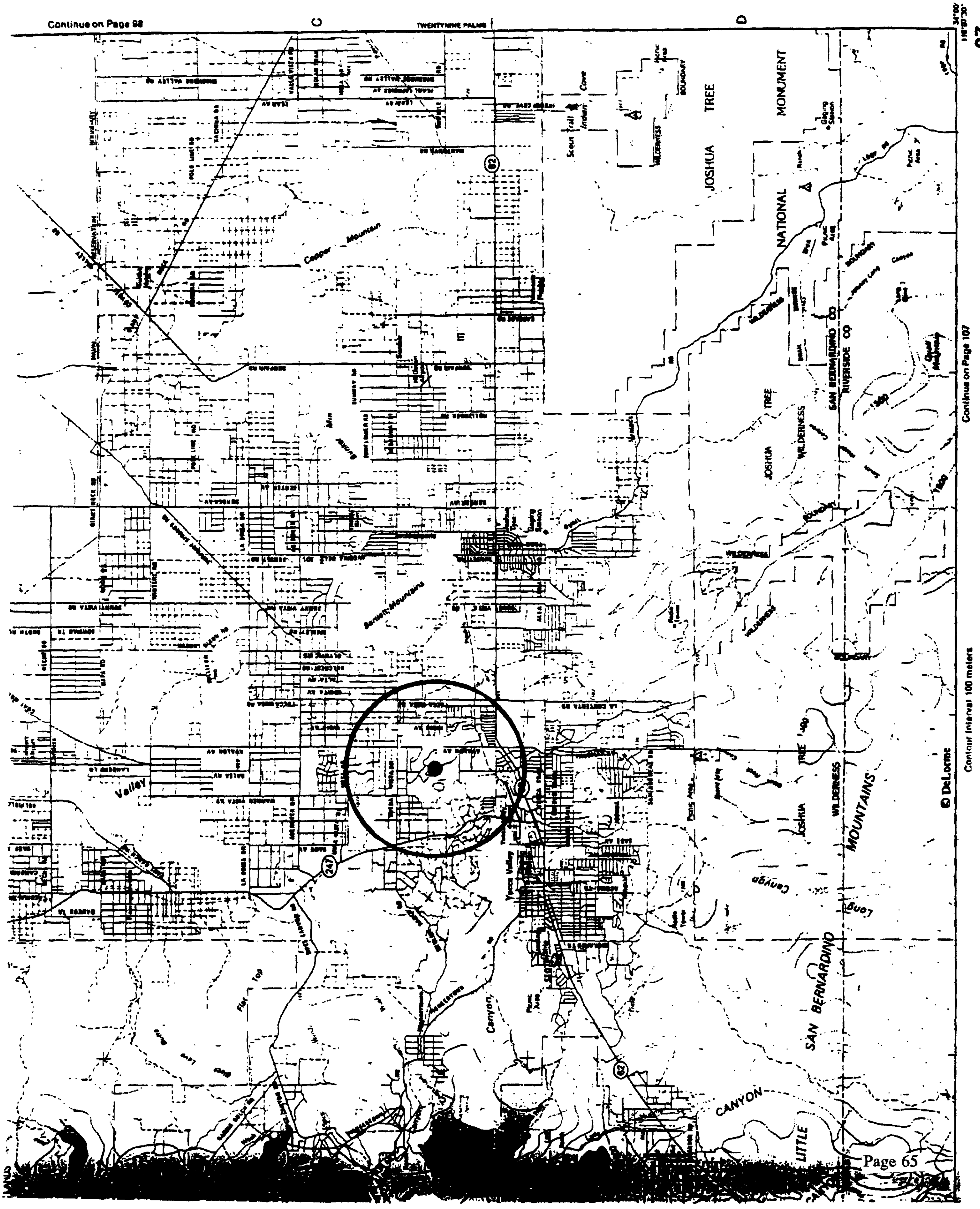
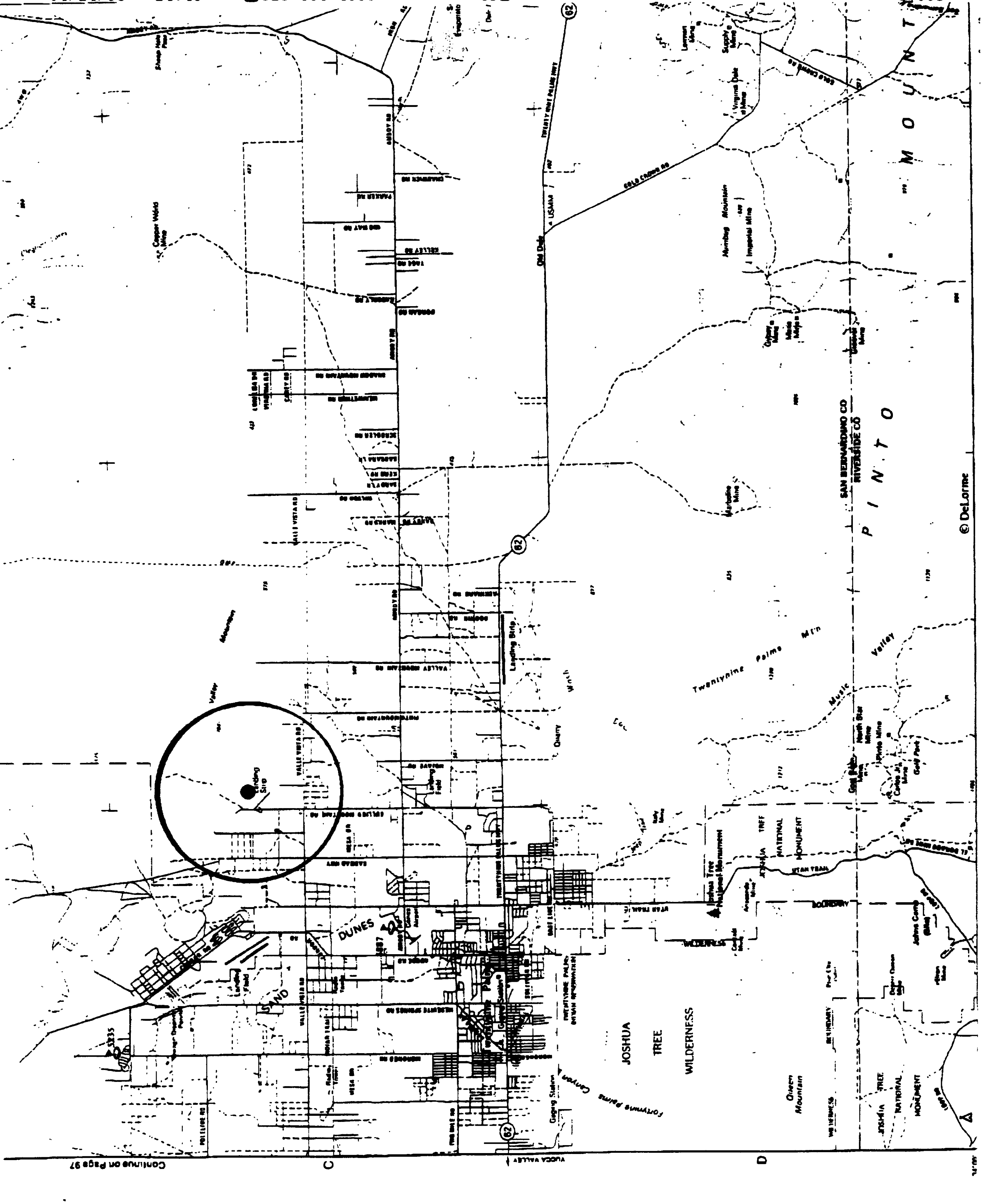
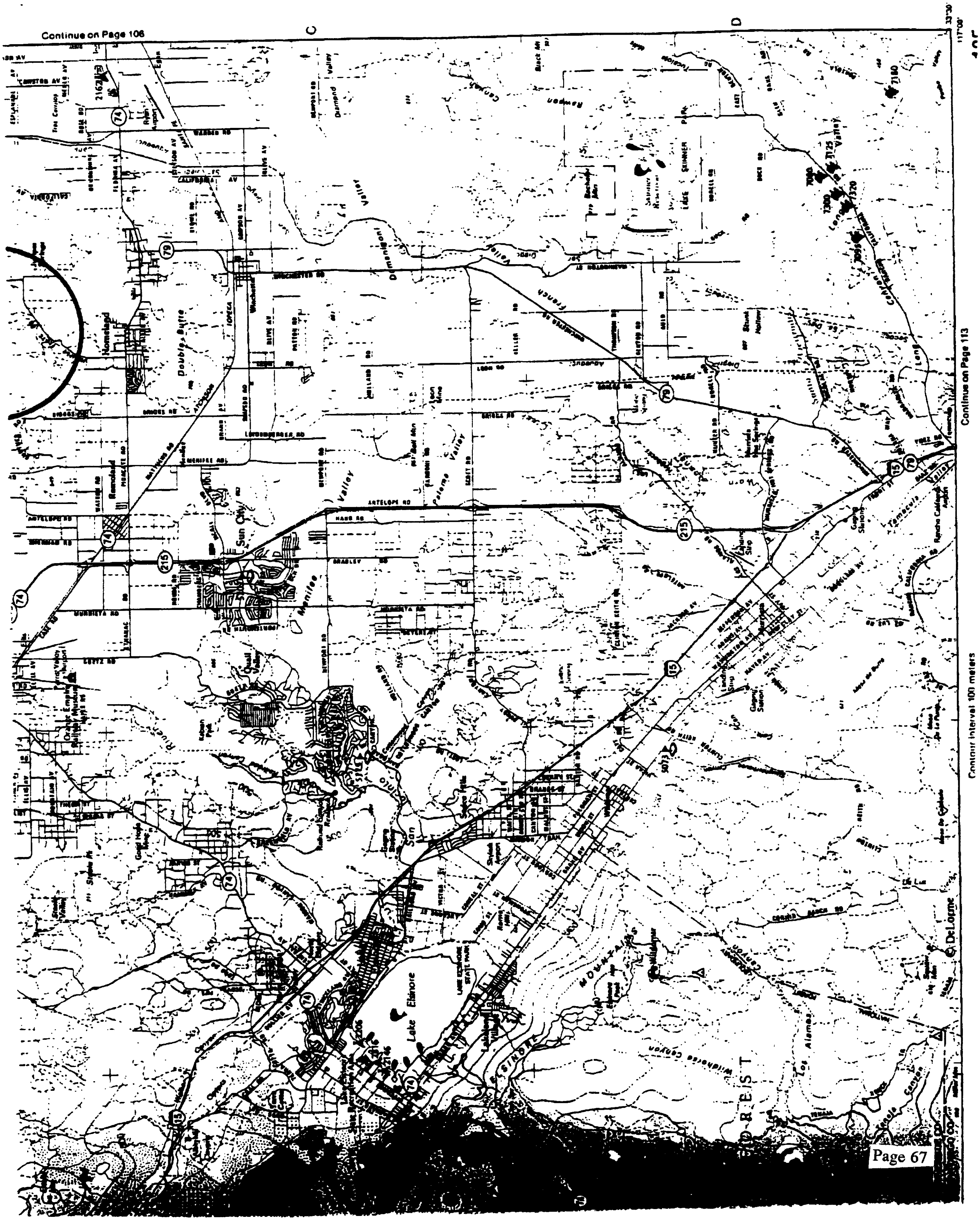

16
Continue on Page 92
Continue on Page 77
VALENCIA
SAN BERNARDINO
SESPE CONDOR SANCTUARY
LOS PADRES NATIONAL FOREST
SESPE CONDOR SANCTUARY
Fillmore
Santa Clara
RIDGE
Mountain
Simi Valley
Las Posas
SOUTH MOUNTAIN
Page 62

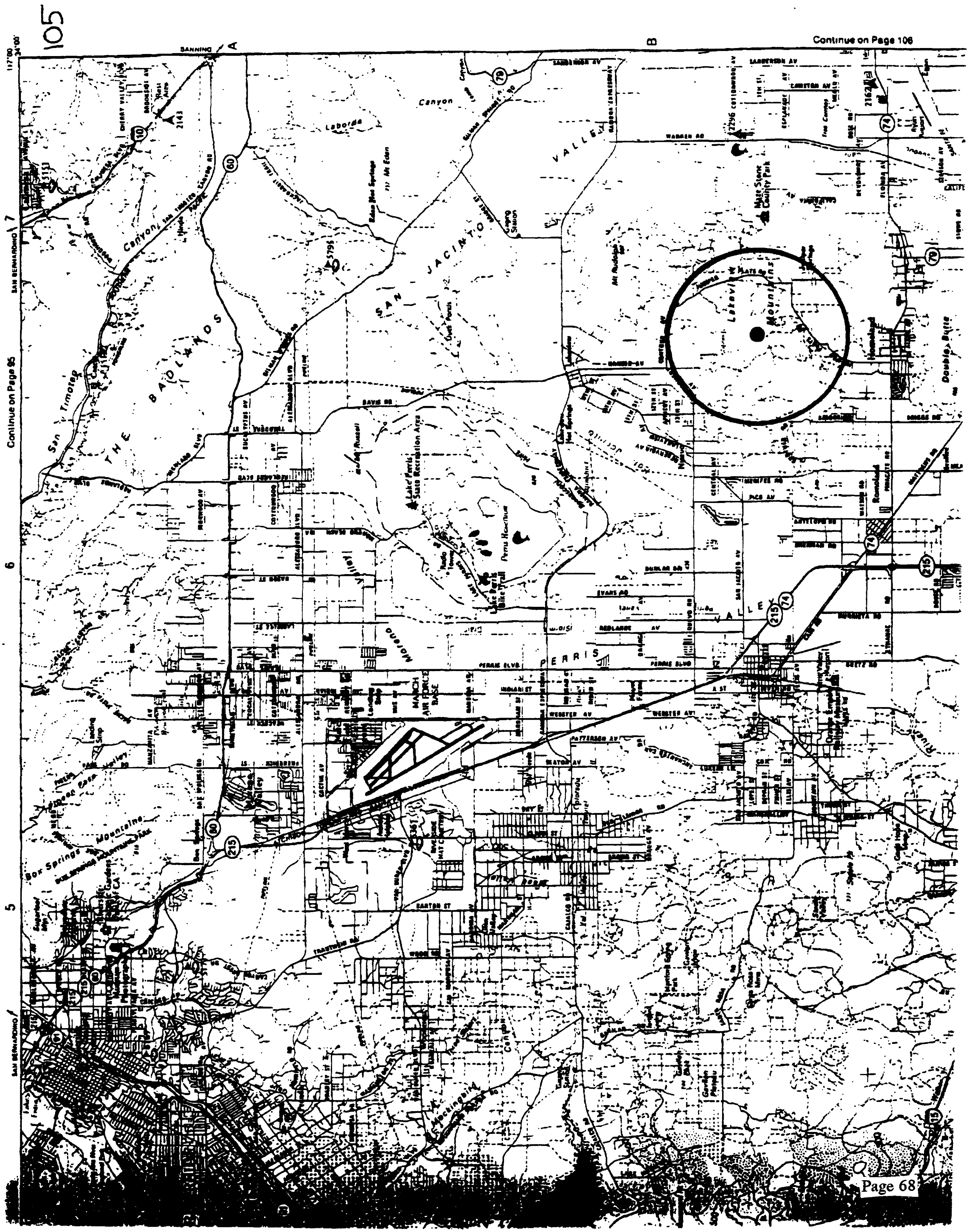

Continue on Page 96
C
D
95
SAN ANDREAS
SAN BERNARDINO CO
RIVERSIDE CO
YUCAIPA
Continue on Page 105
© DeLorme
Contour interval 100 meters
Page 63

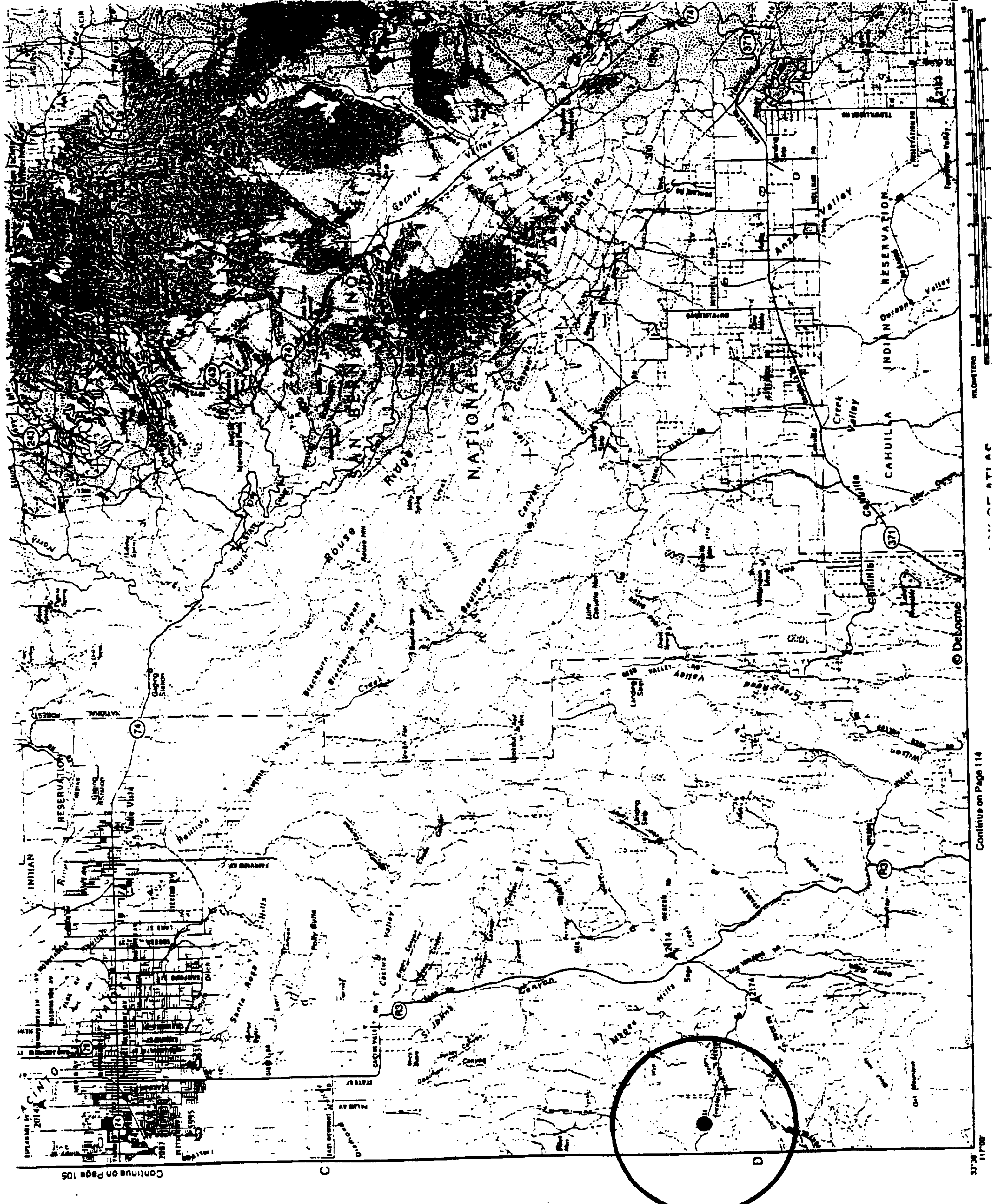

SAN BERNARDINO NATIONAL FOREST
BIG BEAR
Continue on Page 106
Continue on Page 95
C
D

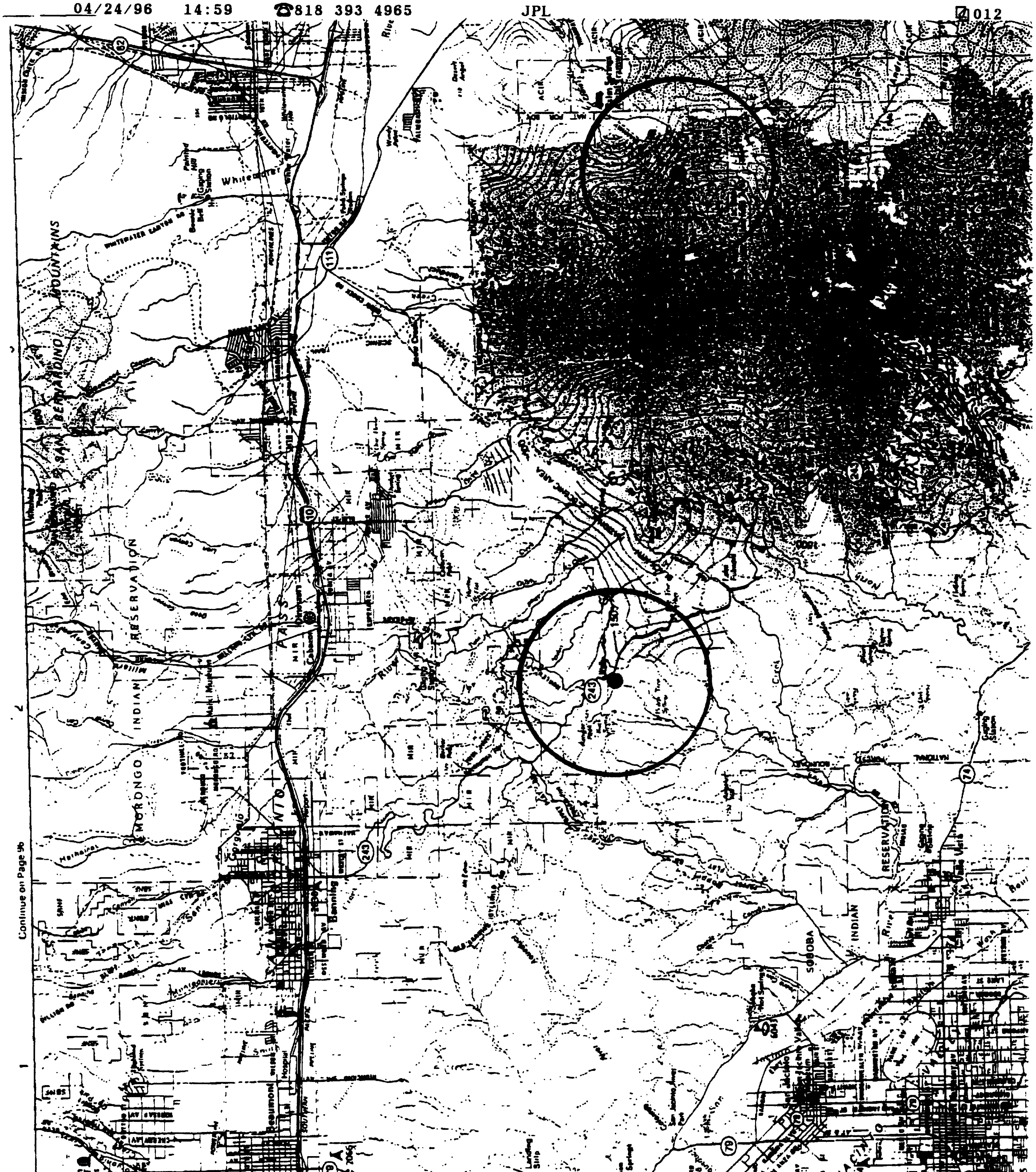

Continue on Page 98
C
TWENTYNINE PALMS
D
97
JOSHUA TREE NATIONAL MONUMENT
Indian Cove
Copper Mountain
WILDERNESS
BOUNDARY
SAN BERNARDINO CO
RIVERSIDE CO
JOSHUA TREE WILDERNESS
Continue on Page 107
Contour Interval 100 meters
© DeLorme
Valley
Yucca Valley
247
62
Canyon
Flat Top
Long Canyon
SAN BERNARDINO MOUNTAINS
LITTLE SAN BERNARDINO MOUNTAINS
CANYON


JOSHUA TREE WILDERNESS
PINTO
MOUNT
SAN BERNARDINO CO
RIVERSIDE CO
Twentynine Palms Mtn
Music Valley
DUNES
SAND
Landing Strip
© DeLorme
Continue on Page 97


Continue on Page 106
Continue on Page 113
Contour interval 100 meters
Homeland
Double Butte
Winchester
Sun City
Menifee
French
Lake Elsinore
Wildhorse Canyon
Los Alamos
© DeLorme
Page 67


105
BANNING
Continue on Page 106
Continue on Page 95
SAN JACINTO VALLEY
THE BADLANDS
San Timoteo Canyon
Lakeview Mountains
Double Butte
WARREN RD
DAVIS RD
Lake Perris State Recreation Area
PERRIS VALLEY
REDLANDS AV
EVANS RD
PERRIS BLVD
WEBSTER AV
MARCH AIR FORCE BASE
Box Springs Mountains


Garner Valley
Anza Valley
INDIAN RESERVATION
CAHUILLA
Cahuilla
Cahuilla Creek Valley
NATIONAL
SAN BERNARDINO
Ridge
Rouse
Blackburn Canyon
Bautista Canyon
Santa Rosa Hills
Magee Hills
Canyon
© DeLorme
Continue on Page 114
Continue on Page 105
KILOMETERS
C
D


SAN BERNARDINO MOUNTAINS
MORONGO INDIAN RESERVATION
SOBOBA INDIAN RESERVATION
Whitewater
Banning
Continue on Page 96
Continue on Page 105

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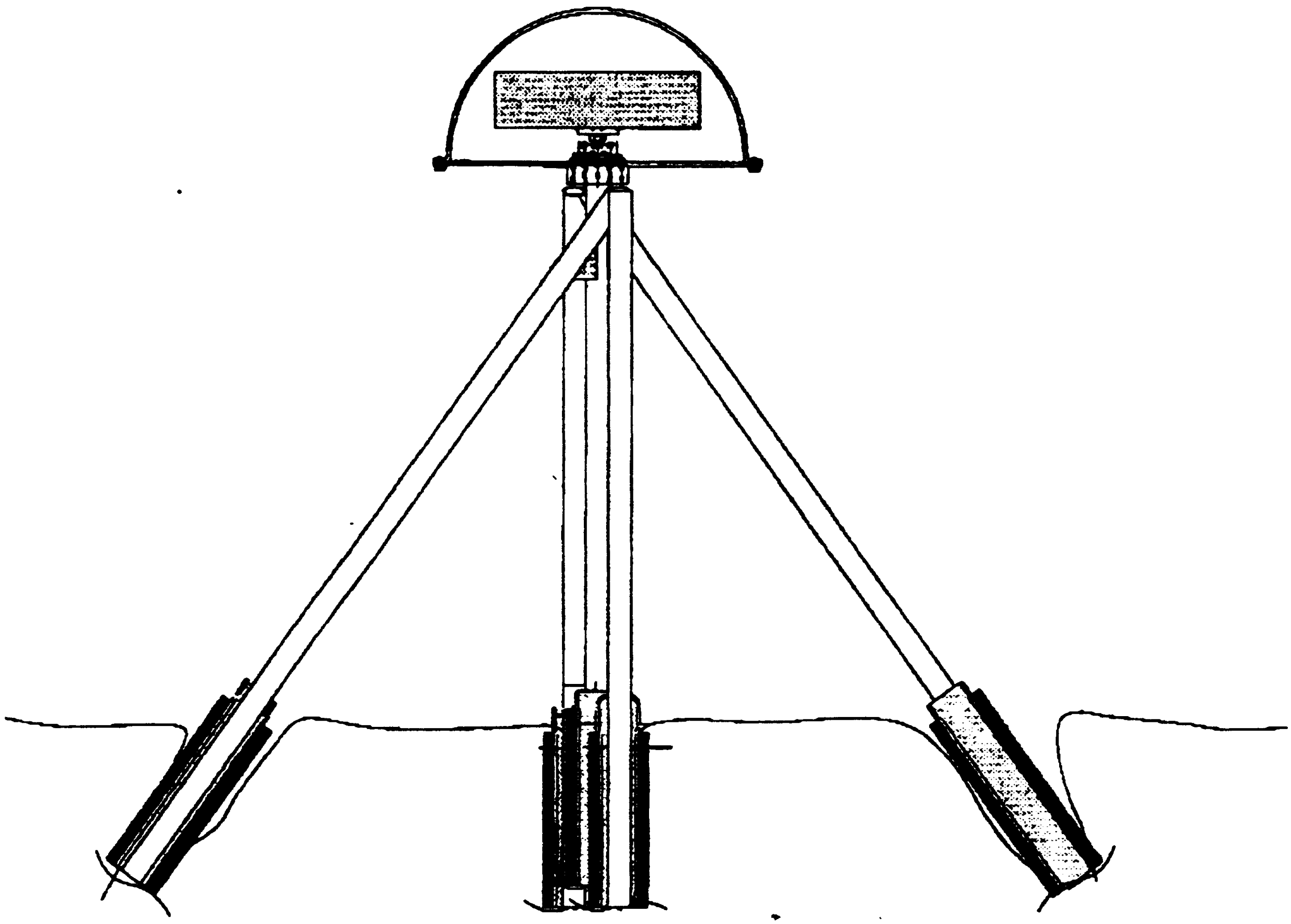
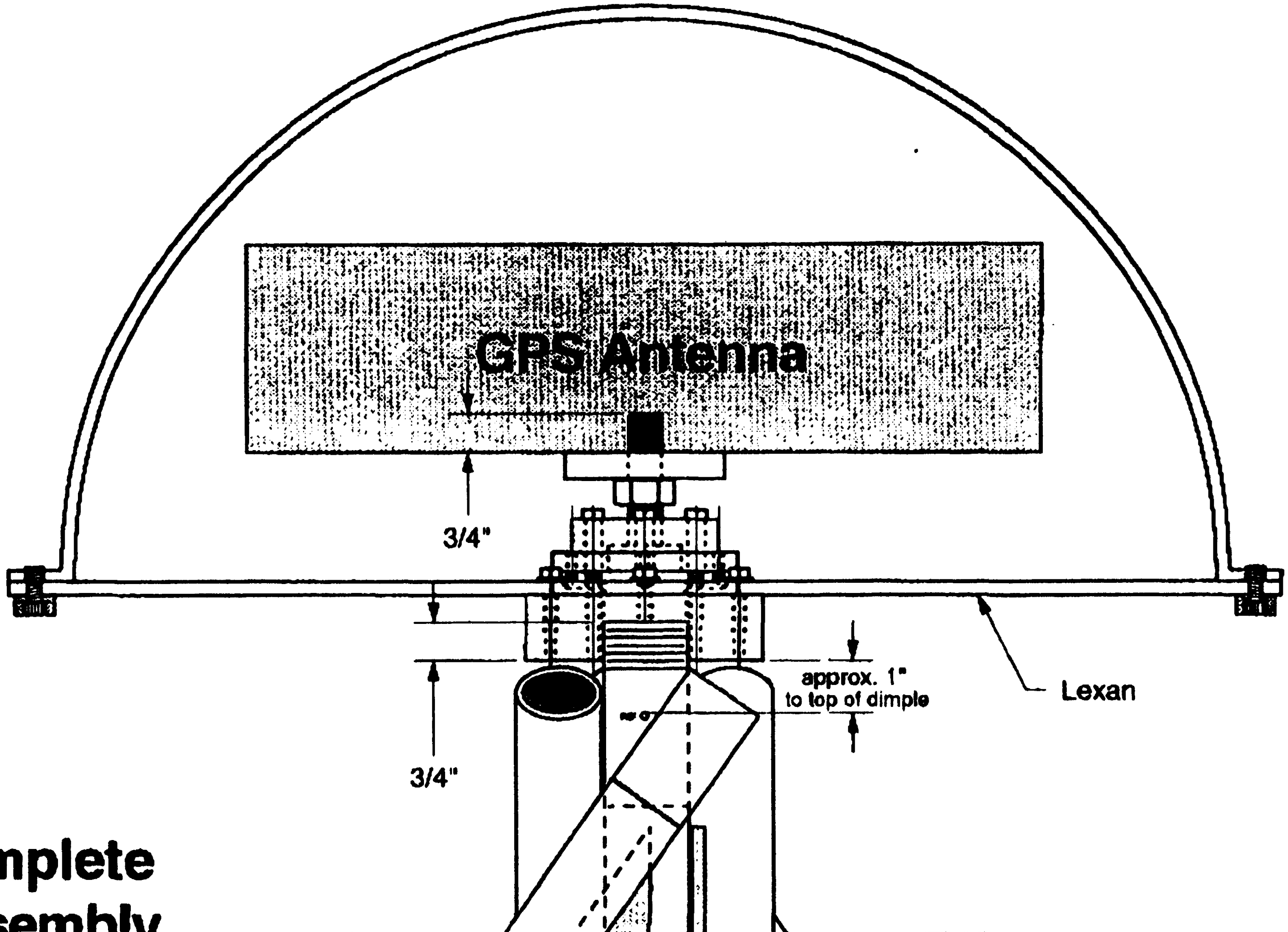
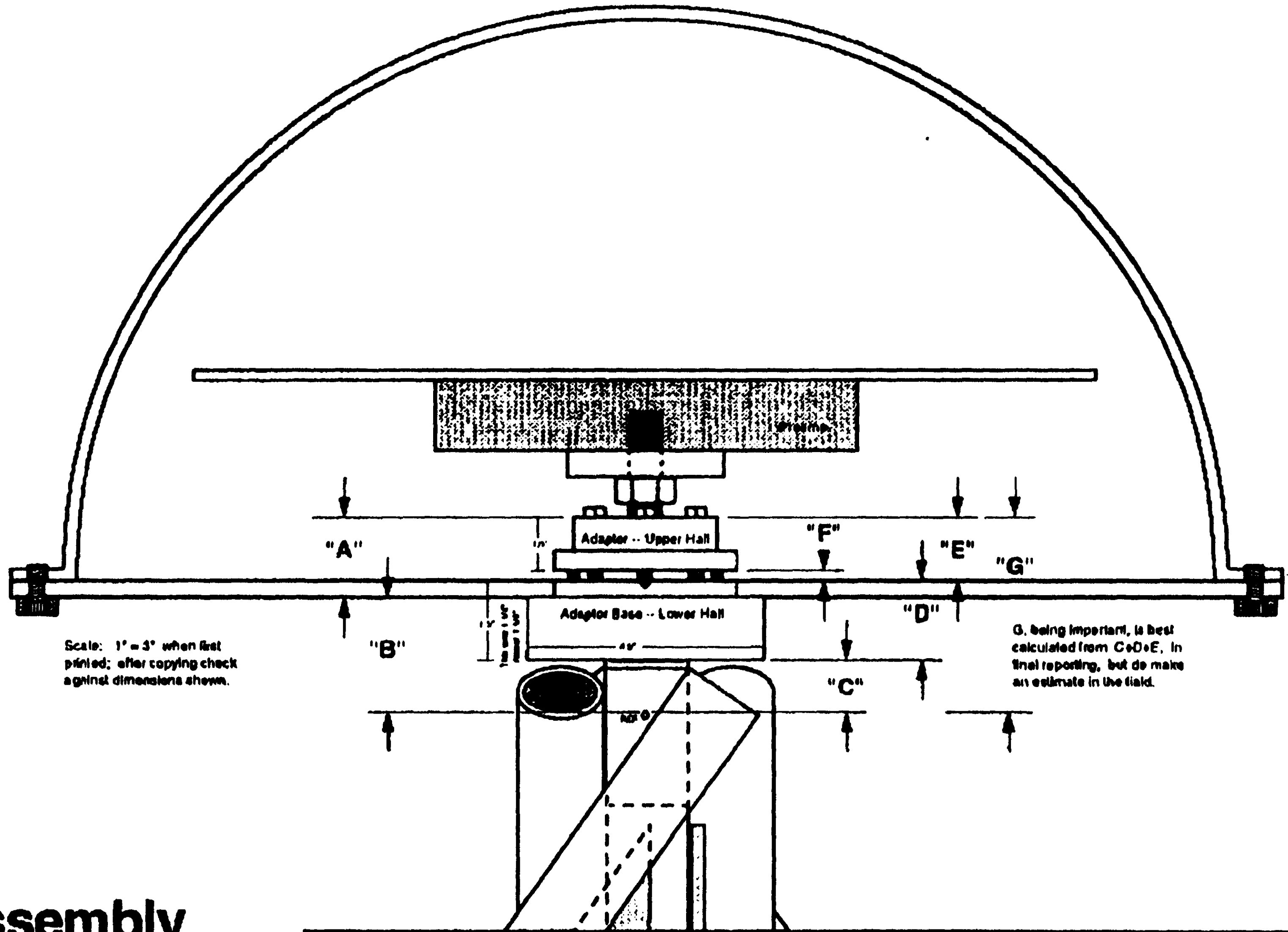


University of California IGPP 0225 La Jolla, California 92093 GPS LA Antenna		TITLE Total Installation	
DRAWN BY P Zimmer/ CBH	DATE 13Apr95	DRAWING NUMBER	GPS-LA-100
Do Not Scale This Drawing	SCALE 1"=8"		



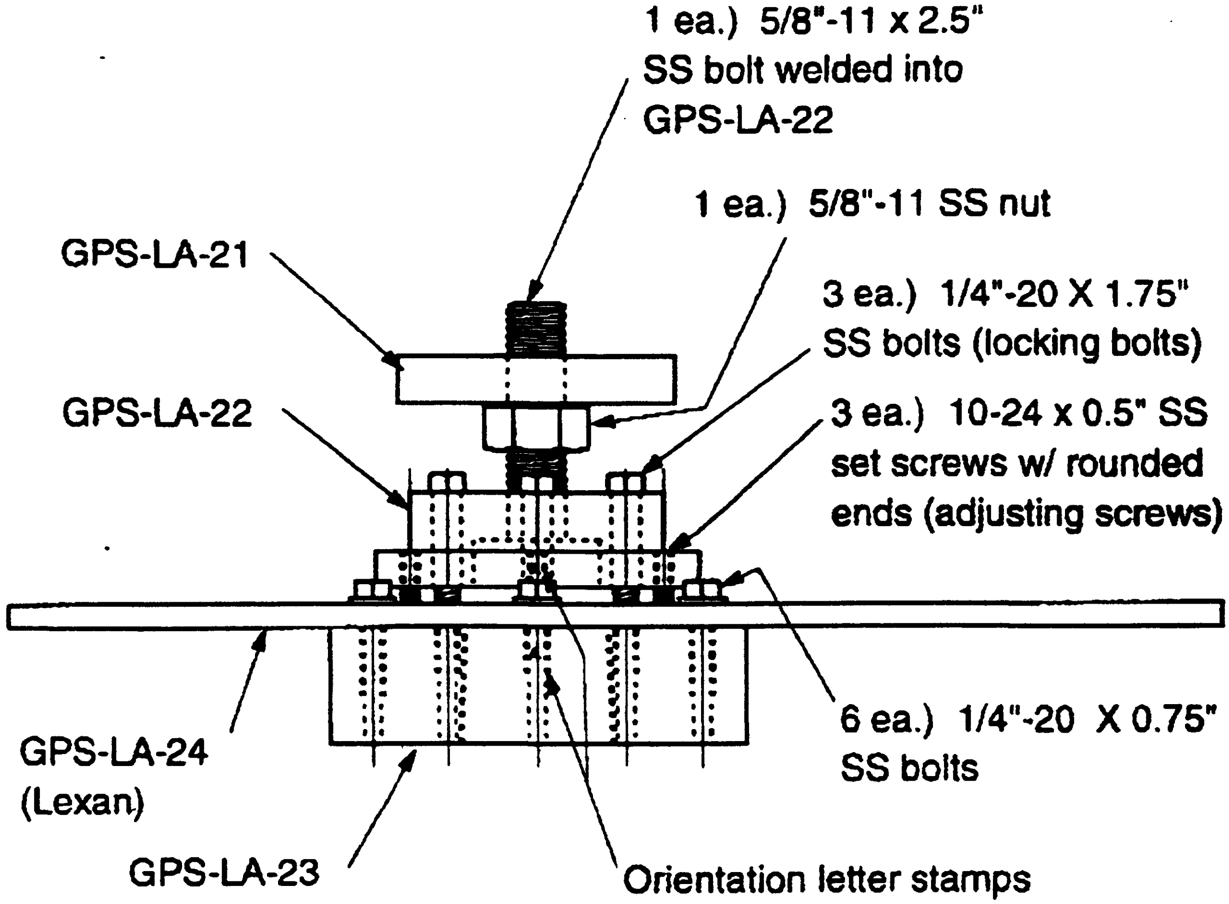
Complete Assembly

University of California IGPP 0225 La Jolla, California 92093 **GPS Antenna Mounts**		TITLE **Complete Assembly**
DRAWN BY C. B. Hollinshead	DATE 12Apr95	DRAWING NUMBER **GPS-LA-101**
Do Not Scale This Drawing	SCALE 1" = 3"	



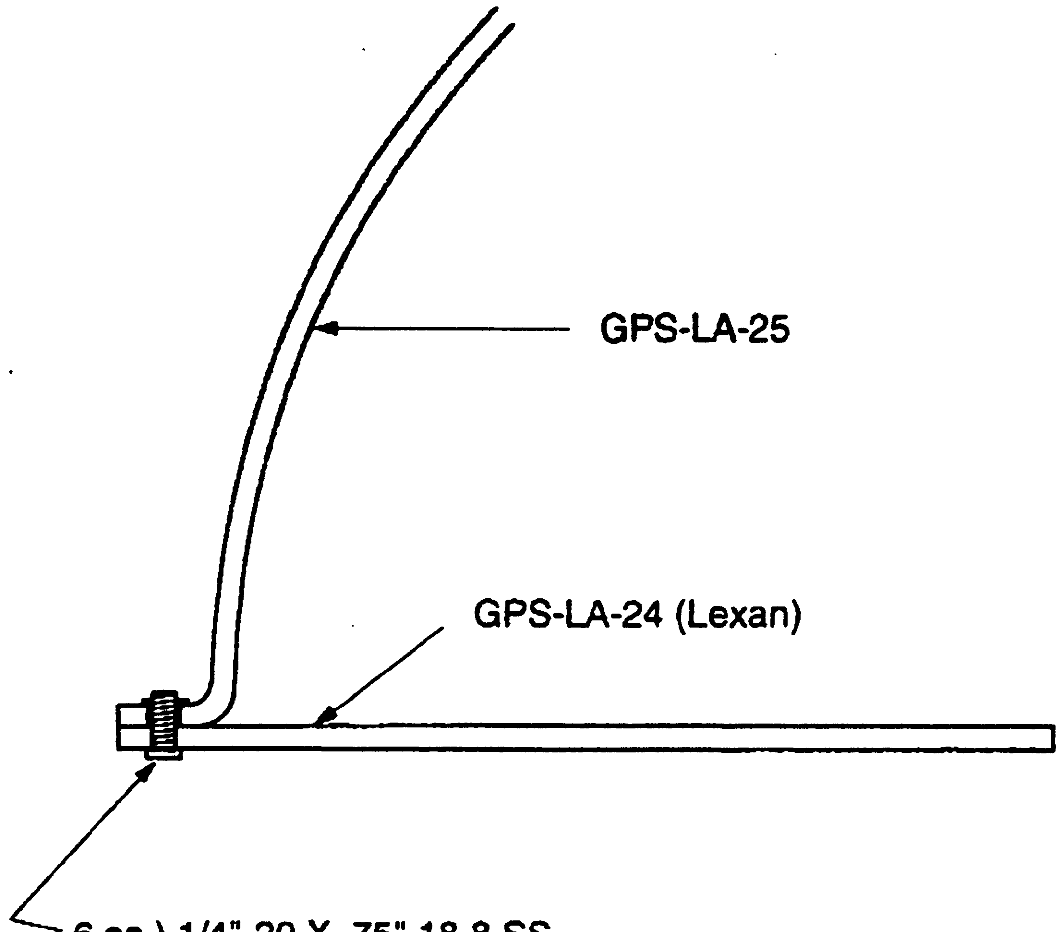
Assembly Dimensions

University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Dimensions		TITLE Assembly
DRAWN BY mod. Frank Wyatt	DATE 31Oct95	DRAWING NUMBER GPS-LA-101dim
Do Not Scale This Drawing	SCALE 1" = 3"	



Center Assembly

University of California IGPP 0225 La Jolla, California 92093 **GPS Antenna Mounts**		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Center Assembly
DRAWN BY C. B. Hollinshead	DATE 11Apr95	DRAWING NUMBER GPS-LA-102
Do Not Scale This Drawing	SCALE 1"= 2"	



Dome Assembly

University of California IGPP 0225 La Jolla, California 92093 **GPS Antenna Mounts**		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg
		TITLE **Dome Assembly**
DRAWN BY C. B. Hollinshead	DATE 12Apr95	DRAWING NUMBER **GPS-LA-103**
Do Not Scale This Drawing	SCALE 1"=2"	

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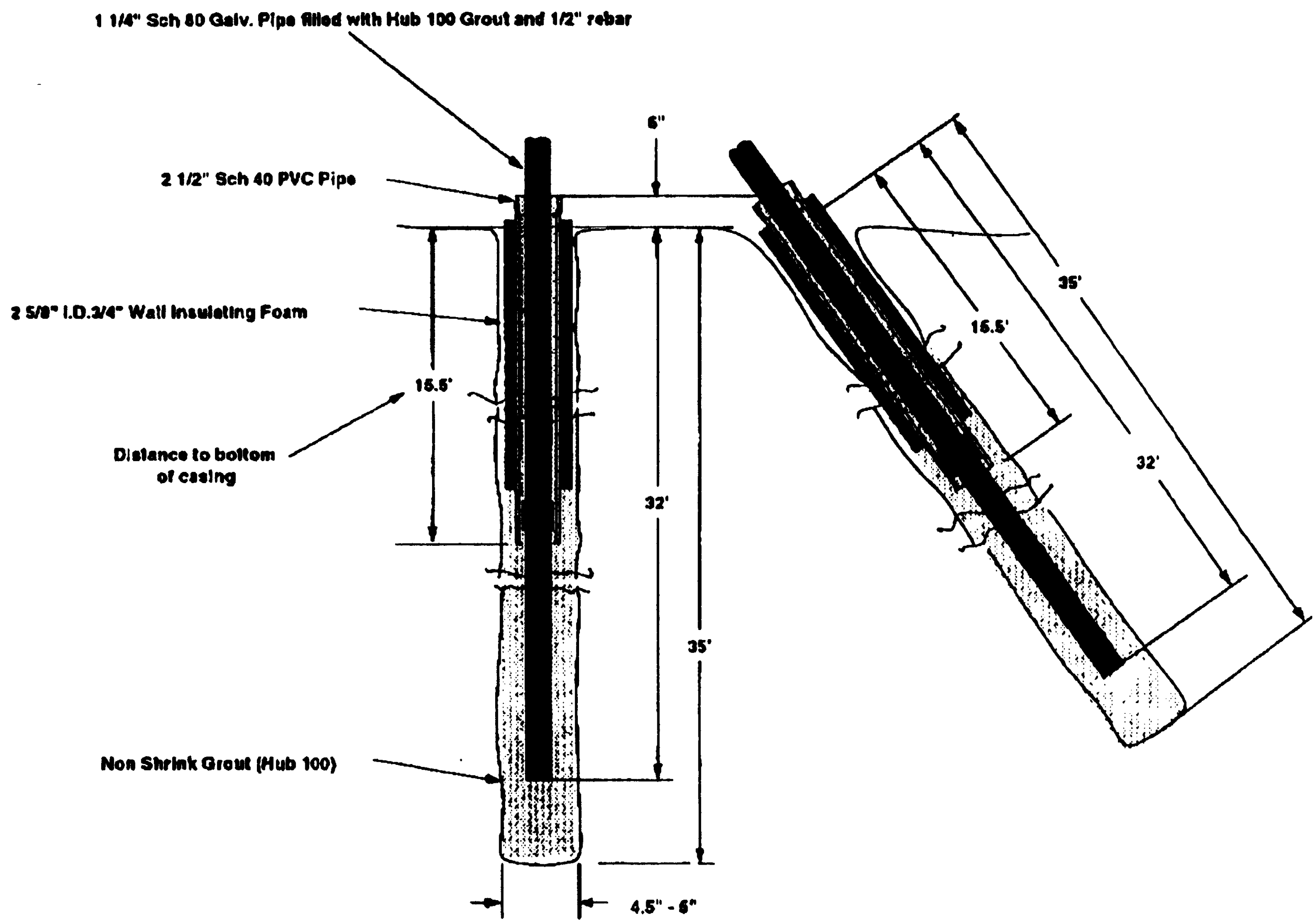
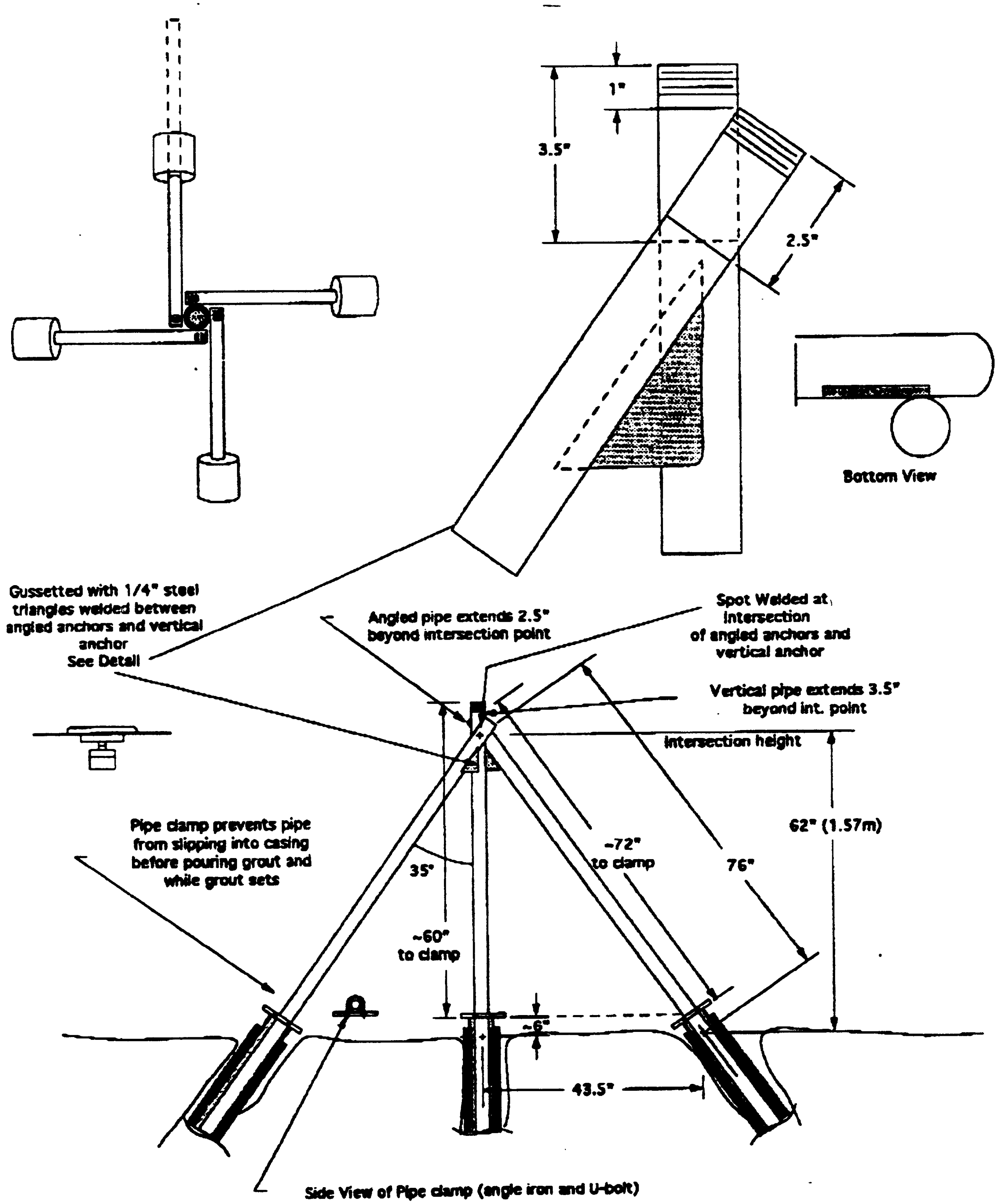


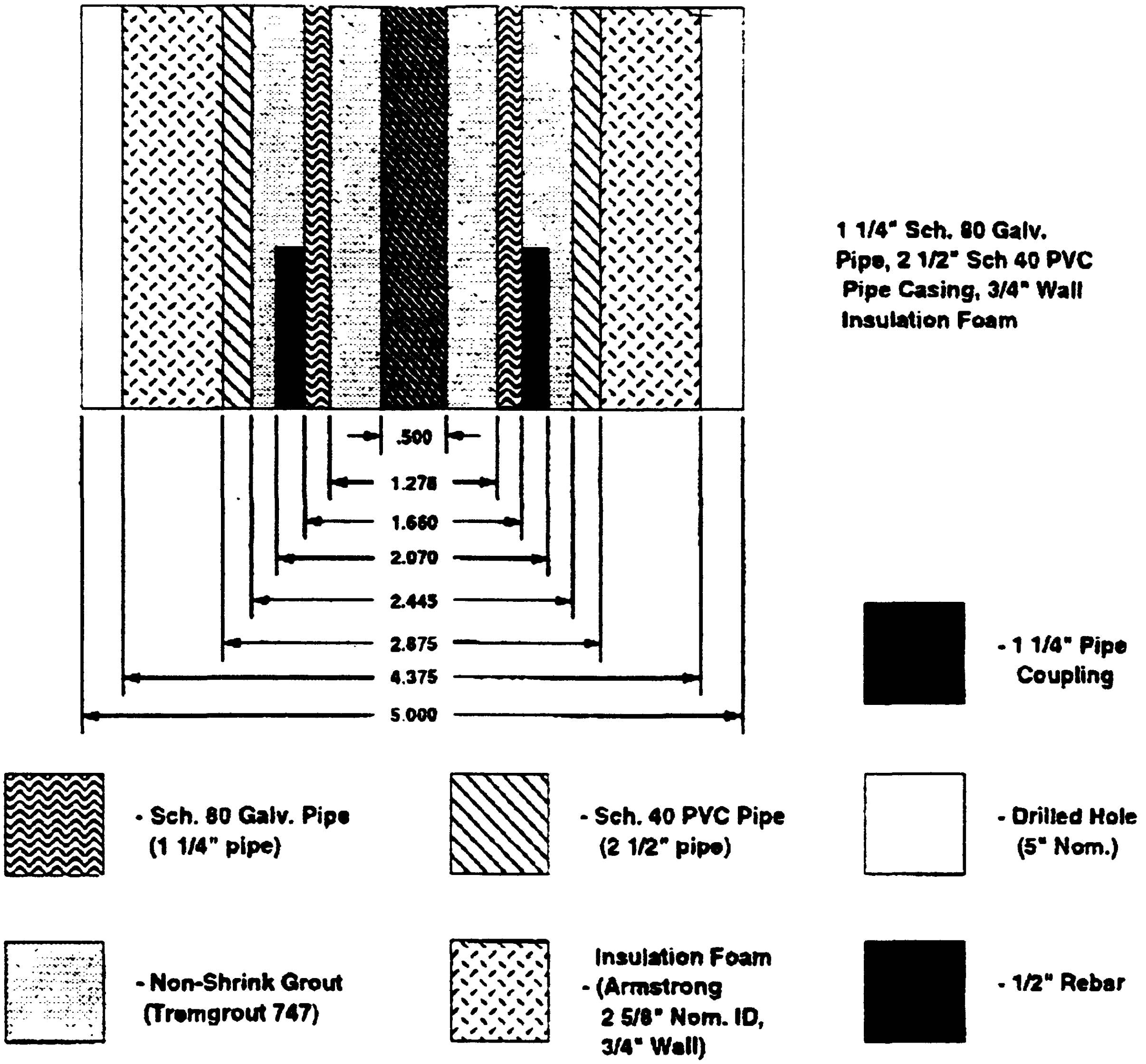
Note: All pipe assemblies 1 1/4" Sch 80 Pipe
with standard Sch. 40 couplings
All casings 2 1/2" Sch. 40 PVC Pipe with
3/4" wall insulating foam

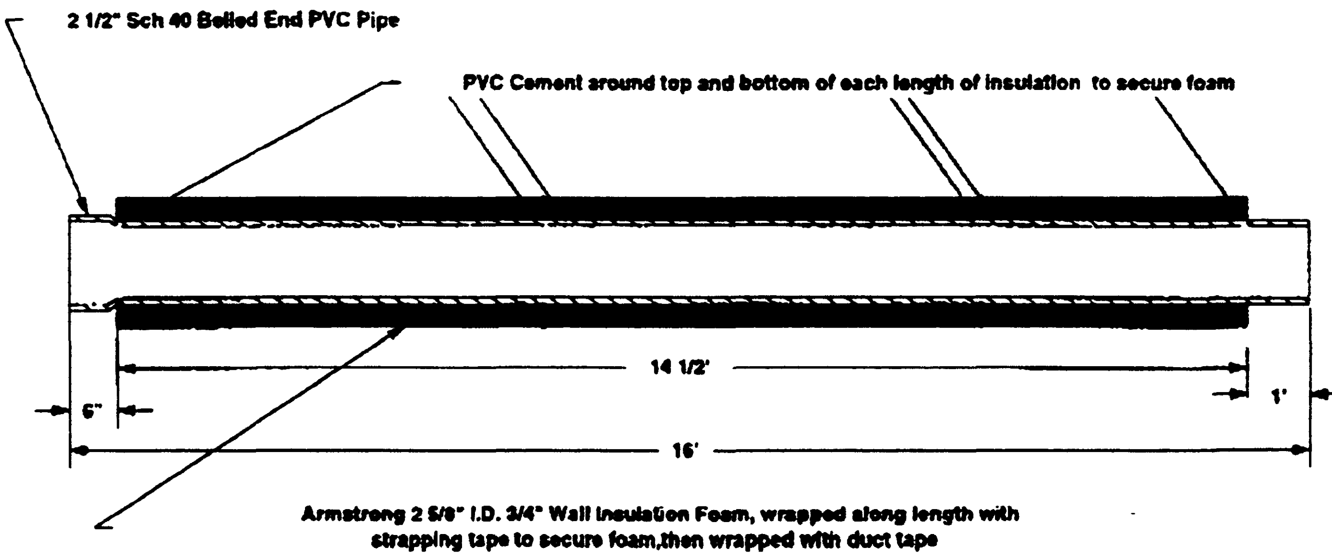
University of California IGPP 0225 La Jolla, California 92093 **Piñon Flat Observatory**		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg
		TITLE **Subsurface Assembly Plan**
DRAWN BY Paul Zimmer	DATE 1/19/95	DRAWING NUMBER **GPS-LA-1**
Do Not Scale This Drawing	SCALE	



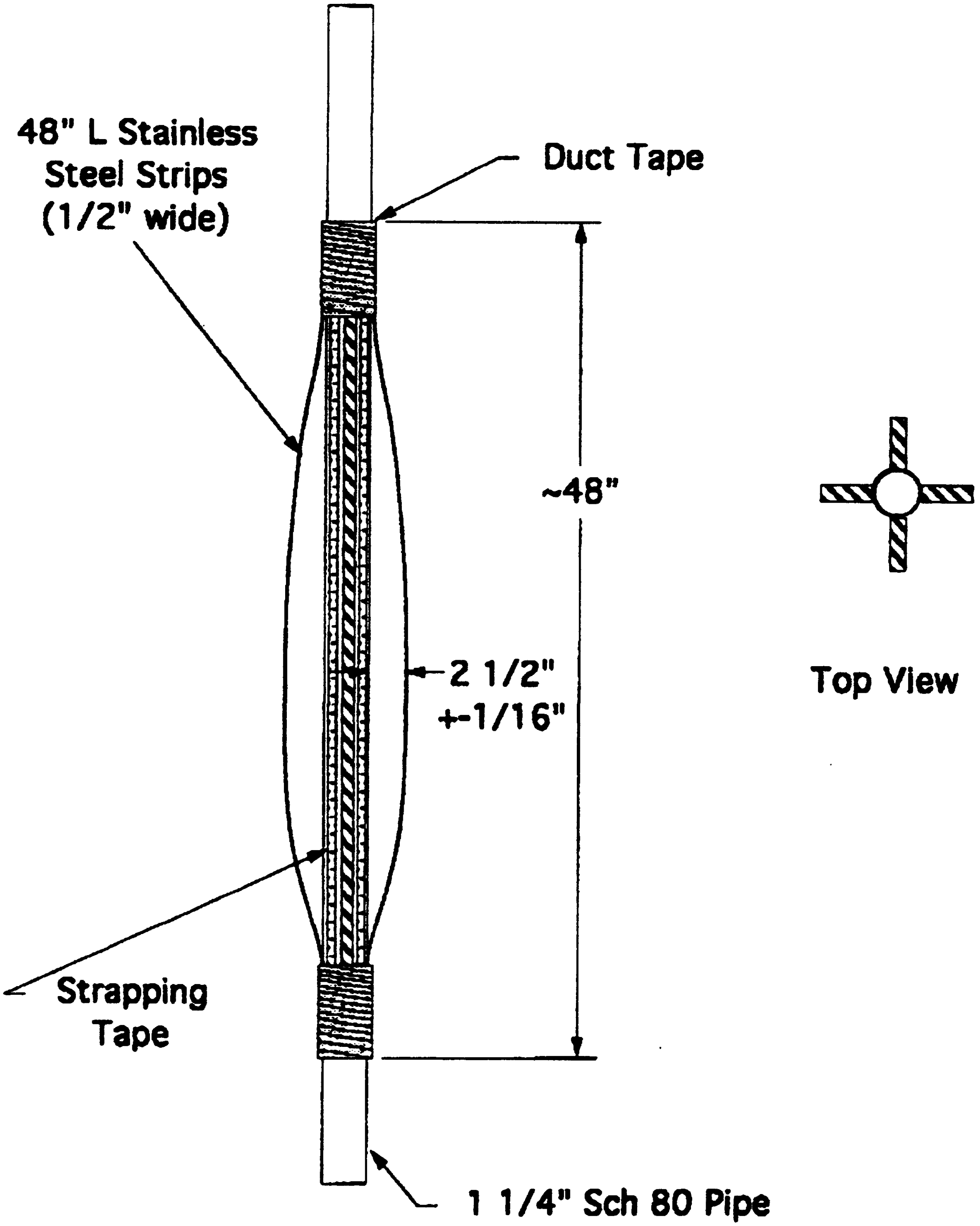
University of California IGPP 0225 La Jolla, California 92093 Piñon Flat Observatory		TITLE	Surface Assembly Plan
DRAWN BY Paul Zimmer	DATE 1/18/95	DRAWING NUMBER	GPS-LA-2
Do Not Scale This Drawing	SCALE 1"=8"		

12-OCT-95

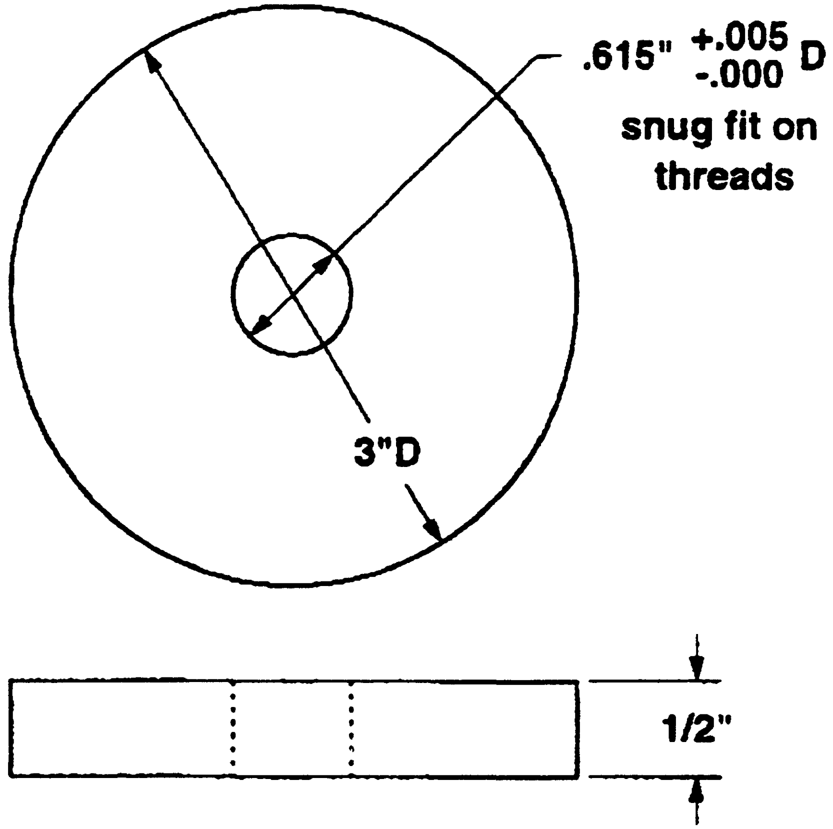




University of California IGPP 0225 La Jolla, California 92093 Piñon Flat Observatory		TITLE	Casing Preparation
DRAWN BY Paul Zimmer	DATE 1/18/95	DRAWING NUMBER	GPS-LA-3
Do Not Scale This Drawing	SCALE		



University of California IGPP 0225 La Jolla, California 92093 Piñon Flat Observatory		TITLE Borehole Pipe Centralizer Plan
DRAWN BY Paul Zimmer	DATE 1/19/95	DRAWING NUMBER GPS-LA-4
Do Not Scale This Drawing	SCALE 2"=1'	

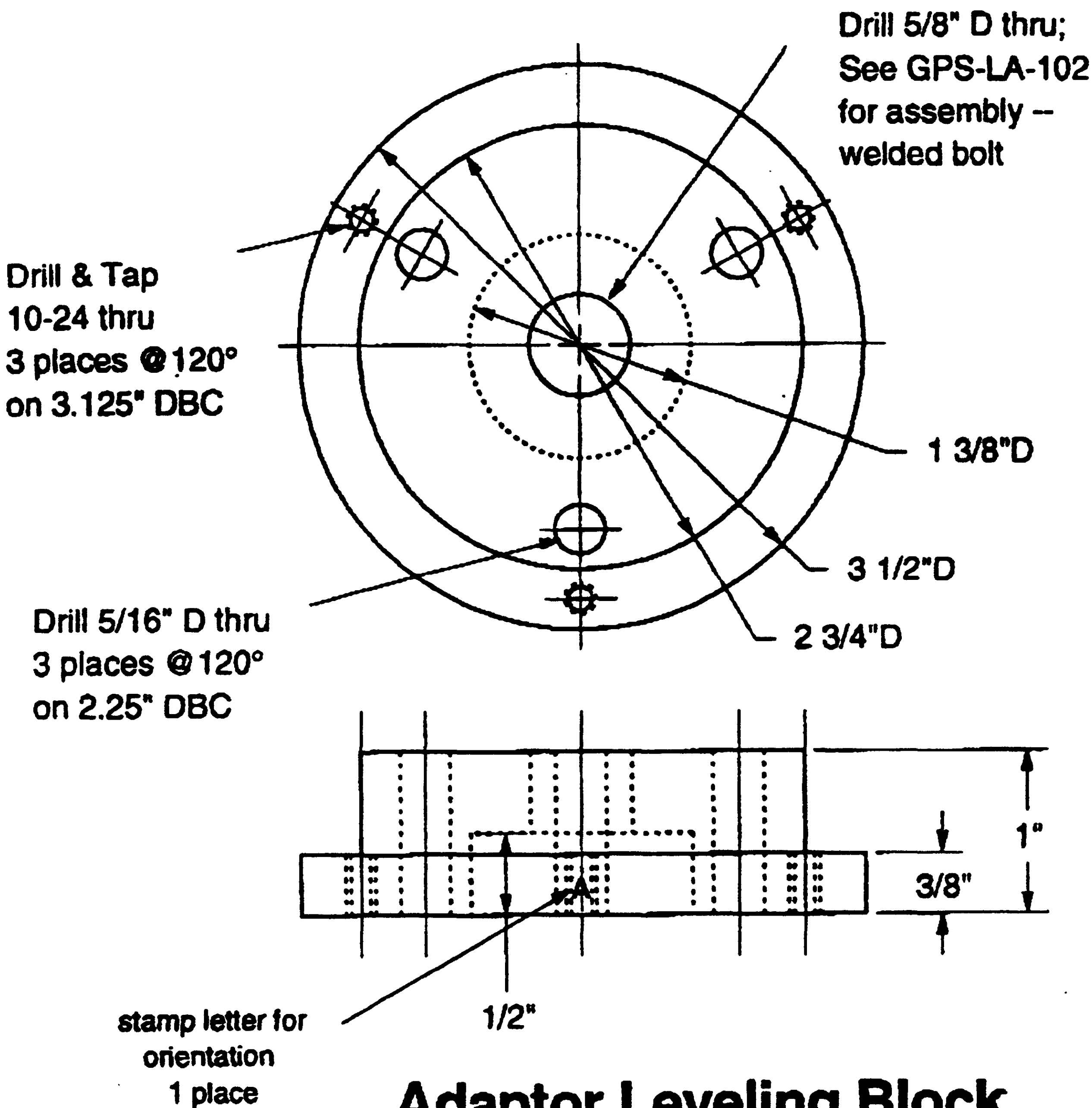


Washer

Mat'l: 304/316 Stainless

1 req'd per unit

University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Mounts		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Washer
DRAWN BY C. B. Hollinshead	DATE 11Apr95	DRAWING NUMBER GPS-LA-21
Do Not Scale This Drawing	SCALE 1"= 1"	



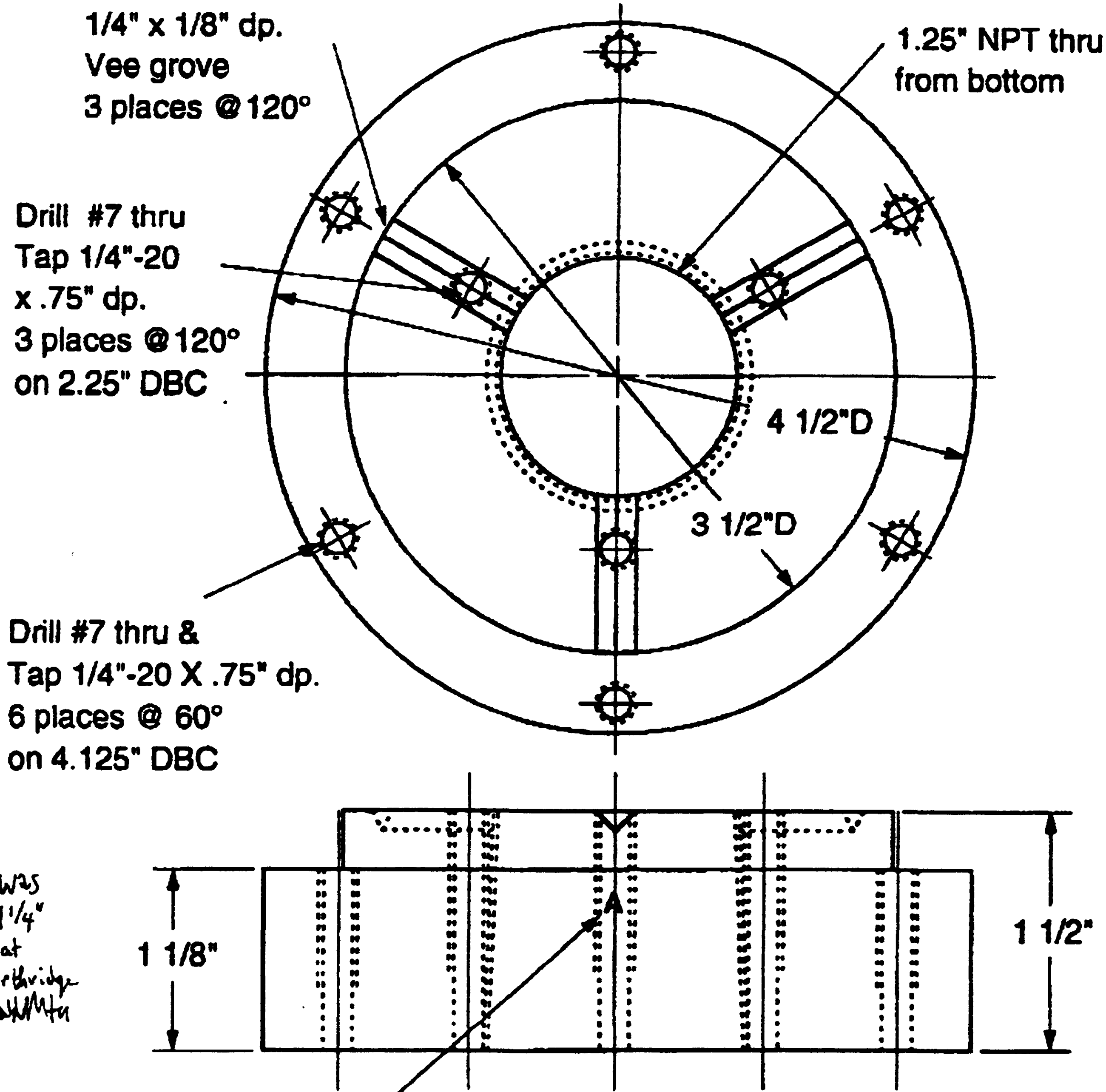
Adaptor Leveling Block

Mat'l: 304/316 Stainless

1 req'd per unit

University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Mounts		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Leveling Block
DRAWN BY C. B. Hollinshead	DATE 11Apr95	DRAWING NUMBER GPS-LA-22
Do Not Scale This Drawing	SCALE 1" = 1"	

30-Oct-95

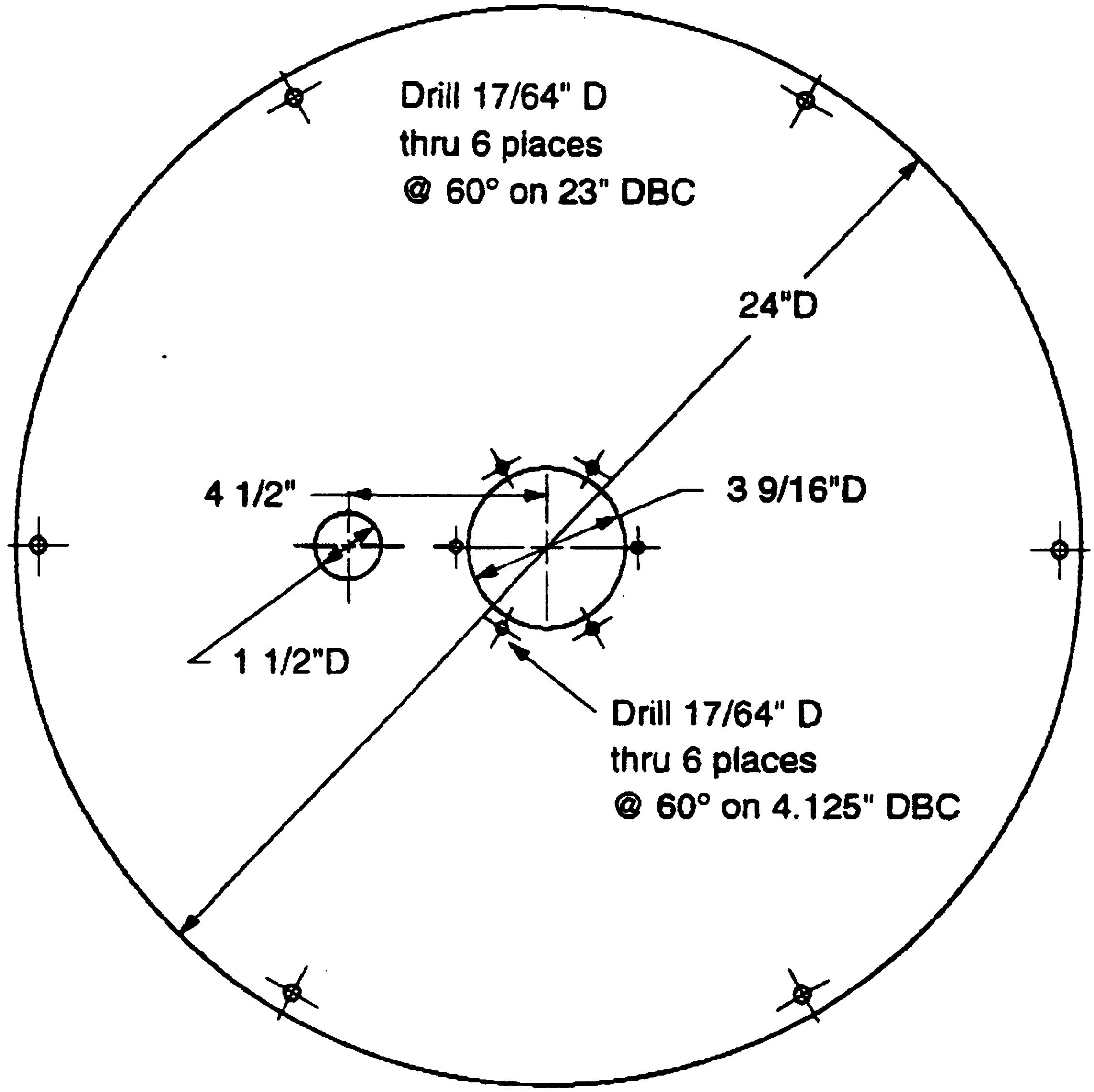


Adaptor Base

Mat'l: 304/316 Stainless

1 req'd per unit

University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Mounts		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Adaptor Base	
DRAWN BY C. B. Hollinshead	DATE 11Apr95	DRAWING NUMBER	GPS-LA-23
Do Not Scale This Drawing	SCALE 1" = 1"		

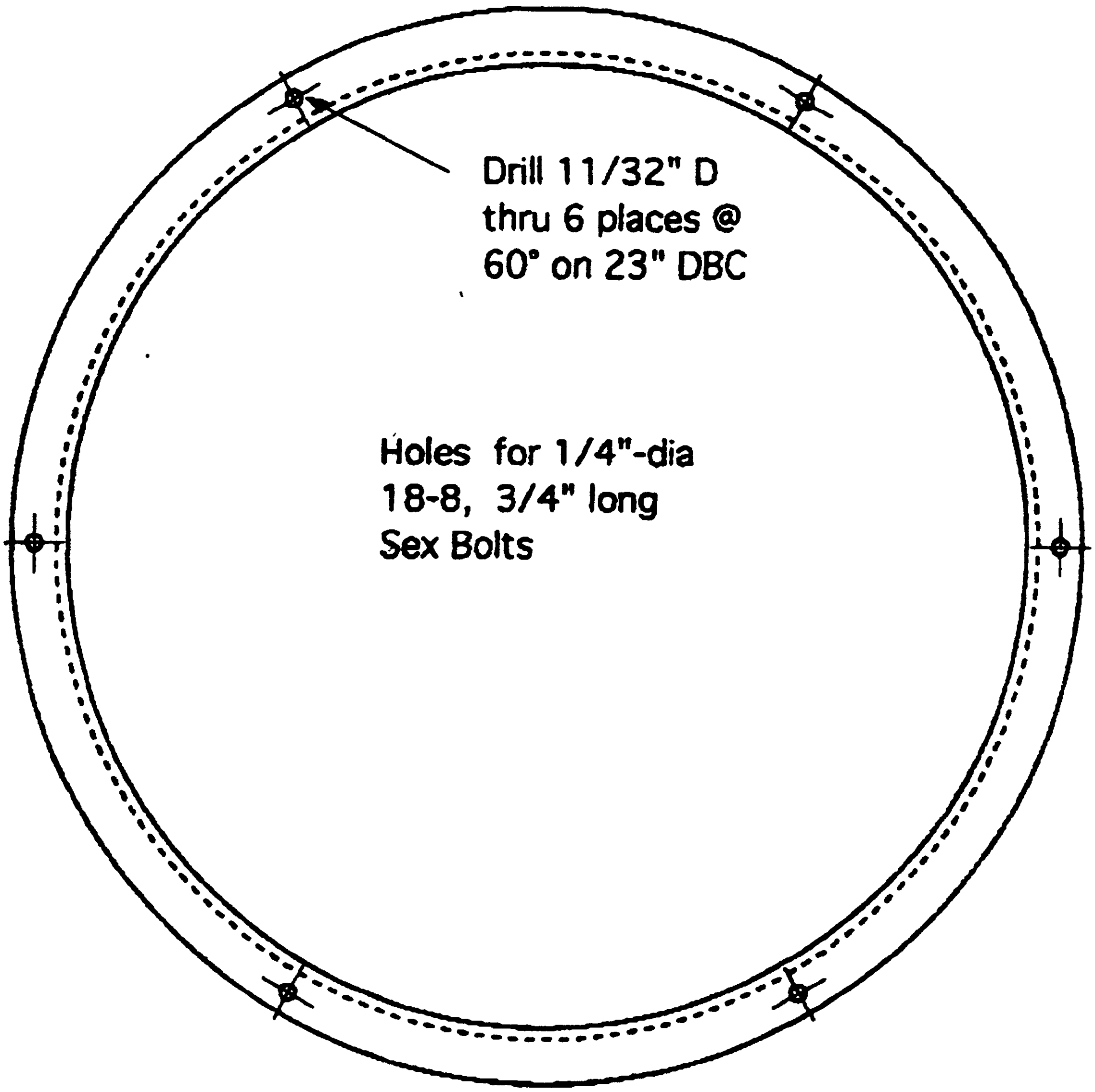


Plastic Base

Mat'l: 3/8" Lexan

1 req'd per unit

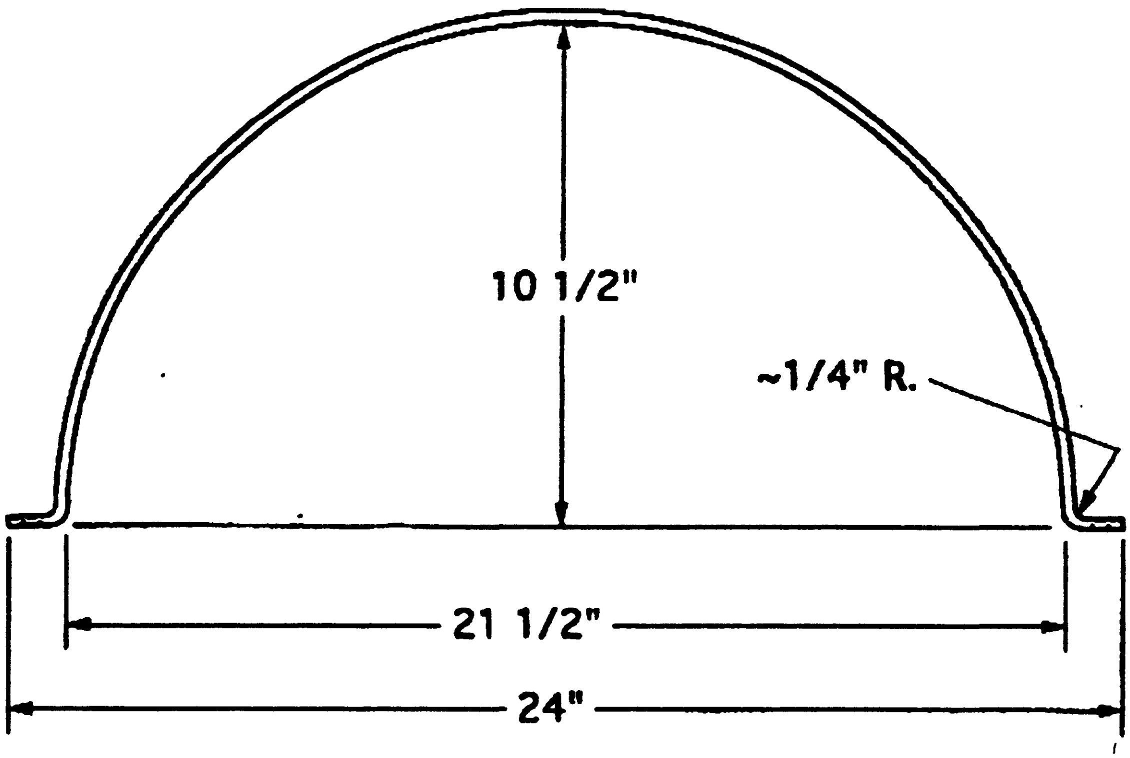
University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Mounts		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Plastic Base	
DRAWN BY C. B. Hollinshead	DATE 12Apr95	DRAWING NUMBER	GPS-LA-24
Do Not Scale This Drawing	SCALE 1"= 4"		



Modified Plastic Dome

Mat'l: 1/4" Opaque White Acrylic
1 req'd per unit

University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Mounts		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Modified Plastic Dome
DRAWN BY C. B. Hollinshead	DATE 11Apr95	DRAWING NUMBER GPS-LA-25
Do Not Scale This Drawing	SCALE 1"= 4"	



Note: Extrude Acrylic into approx. hemisphere to the specifications shown above, with lip as shown

Plastic Dome

Mat'l: 1/4" Opaque White Acrylic

University of California IGPP 0225 La Jolla, California 92093 GPS Antenna Mounts		Tolerances +/- (unless specified) x/x .x .xx .xxx angular 1/64" .1" .01" .005" 1deg TITLE Plastic Dome Side View
DRAWN BY Paul Zimmer	DATE 20 Apr. 95	DRAWING NUMBER GPS-LA-25.5
Do Not Scale This Drawing	SCALE 1"= 4"	

Parts List for GPS Antenna mount

Part Description	# req'd	Refer to Drawing No.
Washer	1	GPS-LA-21
Adaptor -- Upper half	1	GPS-LA-22
Adaptor -- lower half	1	GPS-LA-23
Plastic Base	1	GPS-LA-24
Modified Dome	1	GPS-LA-25
10-24 x 0.5" SS set screw (w/ rounded ends)	3	GPS-LA-102
1/4"-20 x 1.75" SS soc cap	3	GPS-LA-102
1/4"-20 x 0.75" SS hex bolt	6	GPS-LA-102
1/4"- 18-8 SS Sex Bolts - 3/4" lg (McMaster Carr #90650A102, p. 2378, cat. #99)	6	GPS-LA-103
5/8"-11 x 2.5" SS bolt	1	GPS-LA-102
5/8"-11 SS nut	1	GPS-LA-102