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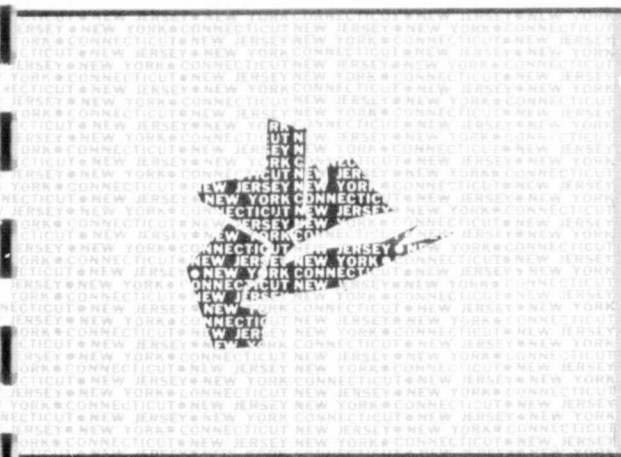

INVESTIGATION OF SKYLAB IMAGERY for REGIONAL PLANNING

TRI-STATE REGIONAL PLANNING COMMISSION

CONNECTICUT • NEW JERSEY • NEW YORK

DECEMBER 1975

Investigation of Skylab Imagery

for

Regional Planning

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NAS 9-13266

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December, 1975

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle Investigation of Skylab Imagery for Regional Planning			5. Report Date Dec. 1975 6.
7. Author(s) William Harting			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Tri-State Regional Planning Commission One World Trade Center, 82 Floor New York, New York 10048			10. Project/Task/Work Unit No. 11. Contract/Grant No. NAS 9-13266
12. Sponsoring Organization Name and Address NASA - Lyndon B. Johnson Space Center Technical Support Procurement Branch Houston, Texas 77058			13. Type of Report & Period Covered Final Sept. 1973 14.

15. Supplementary Notes

16. Abstracts

Skylab earth terrain camera infrared imagery is of excellent quality and can be used to delineate vacant and developed land, limited access and most arterial highways and significant water bodies in the regional planning context.

Skylab multispectral imagery can be used for detecting, mapping and measuring surface water bodies. General development patterns for pictorial representation can be made. Delineation of developed from undeveloped land cannot be made for inventory purposes. Most major highways and some arterial routes can be observed and mapped.

17. Key Words and Document Analysis. 17a. Descriptors

vacant land - susceptible for future development

developed land - land containing streets, structures and other committed land - such as parks.

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 34
	20. Security Class (This Page UNCLASSIFIED	22. Price

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ABSTRACT

It is feasible to use earth terrain camera imagery to detect four land uses--vacant land, developed land, streets and water--for general regional planning purposes. Sufficient detail cannot be obtained in all land use categories to incorporate the findings into a land use inventory for predictive models.

Multispectral imagery is suitable for detecting, mapping and measuring water bodies as small as two acres. Sufficient information can be extracted to prepare graphic and pictorial representations of the general growth and development patterns but cannot be incorporated into an inventory file for predictive models.

The predictive models require small area data particularly for the critical land use category of vacant. This must be measured to a two acre level and that the overall confidence level of all the land use areas be in the 90% to 95% level.

INTRODUCTION

The Tri-State Regional Planning Commission is the official planning agency of the Tri-State Region, which includes 12 counties in New York, 9 counties in New Jersey and 6 planning regions in Connecticut. It also serves as a central supporting resource for subregional and local planning.

The Commission has prepared a number of regional plans and development guides dealing with such subjects as highways, mass transit and open space. The basis for these plans was extensive inventories taken in 1963. The land use inventory

required a field survey involving 900 people, took six months to acquire the data and over a year to process and tabulate it. The inventories are presently updated by using Black/White aerial photographs at a 1:4800 scale and supplemented by information supplied by participating agencies. This requires substantial amounts of manual labor (including inherent human error), is time consuming and very costly.

The objective of this project was to ascertain the feasibility of using SKYLAB imagery to detect and monitor four specific features of the earth's surface: vacant land, developed land, streets and water; and to incorporate the findings into a land use inventory for predictive forecasting models.

PROCEDURE

Two methods of image analysis were originally planned to be used--visual interpretation and automatic scanning devices. However, only the visual interpretation was used because a review of existing procedures, techniques and equipment for scanners indicated that "unique signatures" could not be obtained from existing devices. "Unique signatures" means that a specific grey scale digital value cannot be assigned to a specific land use, such as developed land, in all cases. Pursuing this method would be costly and could not be accomplished within the time allowed.

DATA REVIEW

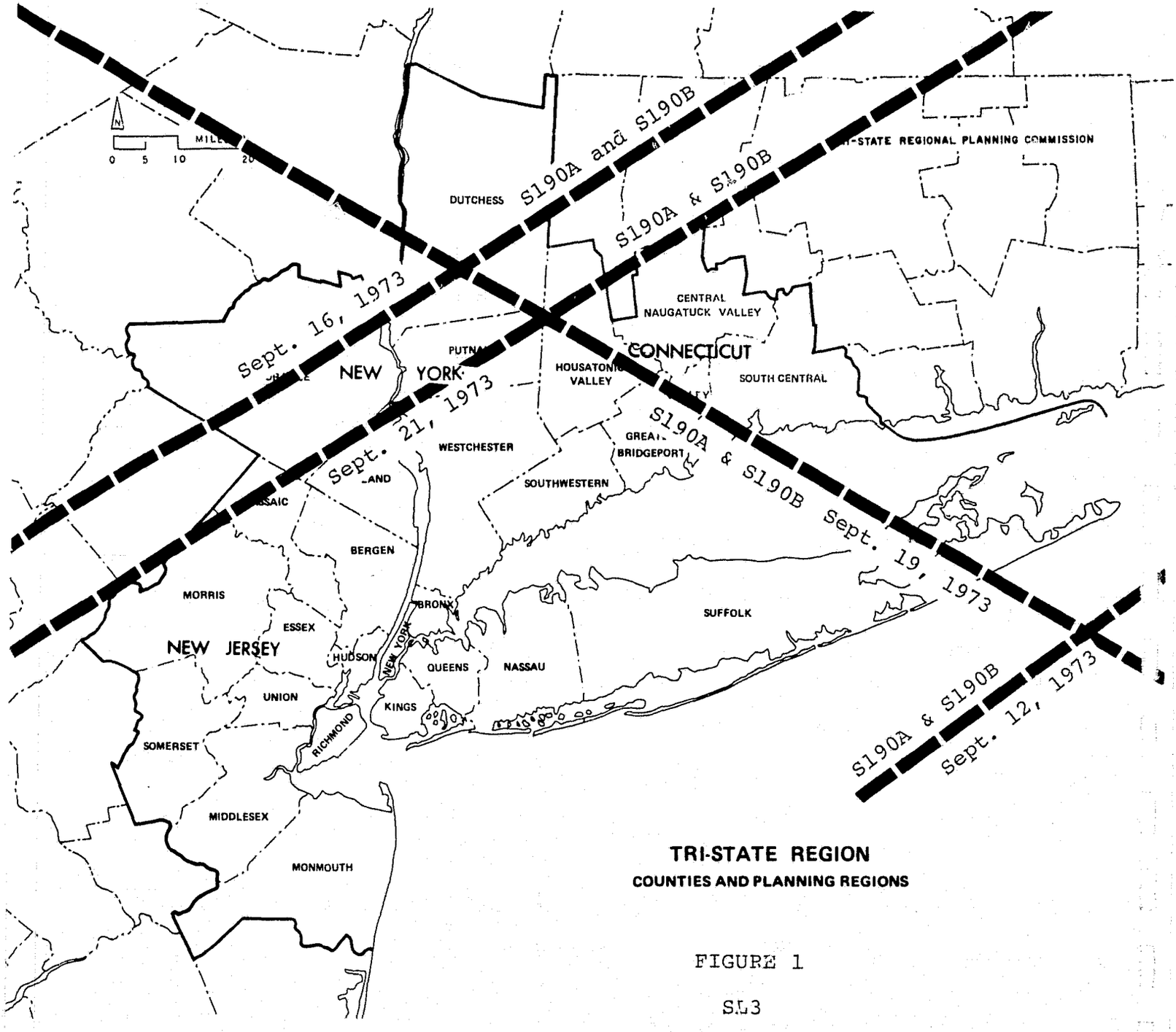
Data in the form of negatives and transparencies was received from four passes of the Skylab 3 mission (Figure 1). S190B (earth terrain camera) infrared and aerographic color images were from the passes on Sept. 19 & 21, 1973. S190A images (multispectral photographic camera) were supplied from the passes of Sept. 12, 16, 19 and 21, 1973. All images were of excellent quality. Supporting technical specifications were also supplied.

VISUAL PHOTO INTERPRETATION

Two frames, RL87-299 and RL88-276, were selected for S190B earth terrain camera review (Figure 2).

Frame number 301, taken on Orbit 52, Sept. 21, 1973, was selected for the multispectral camera investigation (Figure 3). The coverage in this frame provides the full range of land use characteristics that would be encountered in the planning process--that is, high density urban (New York City) to densely wooded open space (Harriman State Park). Several types of images were used.

1. Contact prints were made from the 9" x 9" Black/White negatives of frames 43-301, 44-301, 47-301 and 48-301. See Appendix.
2. Enlargements to 1:250,000 scale were made of the above frames. See Appendix.
3. Observations on the color IR frame, 45-301, and the high resolution color, 46-301, were made using transparencies.



TRI-STATE REGION
COUNTIES AND PLANNING REGIONS

FIGURE 1

SL3

SKYLAB COVERAGE PASSES

SEPTEMBER 1973

Transparencies are not included in report.

It is important to state the definitions of terms used for regional planning purposes.

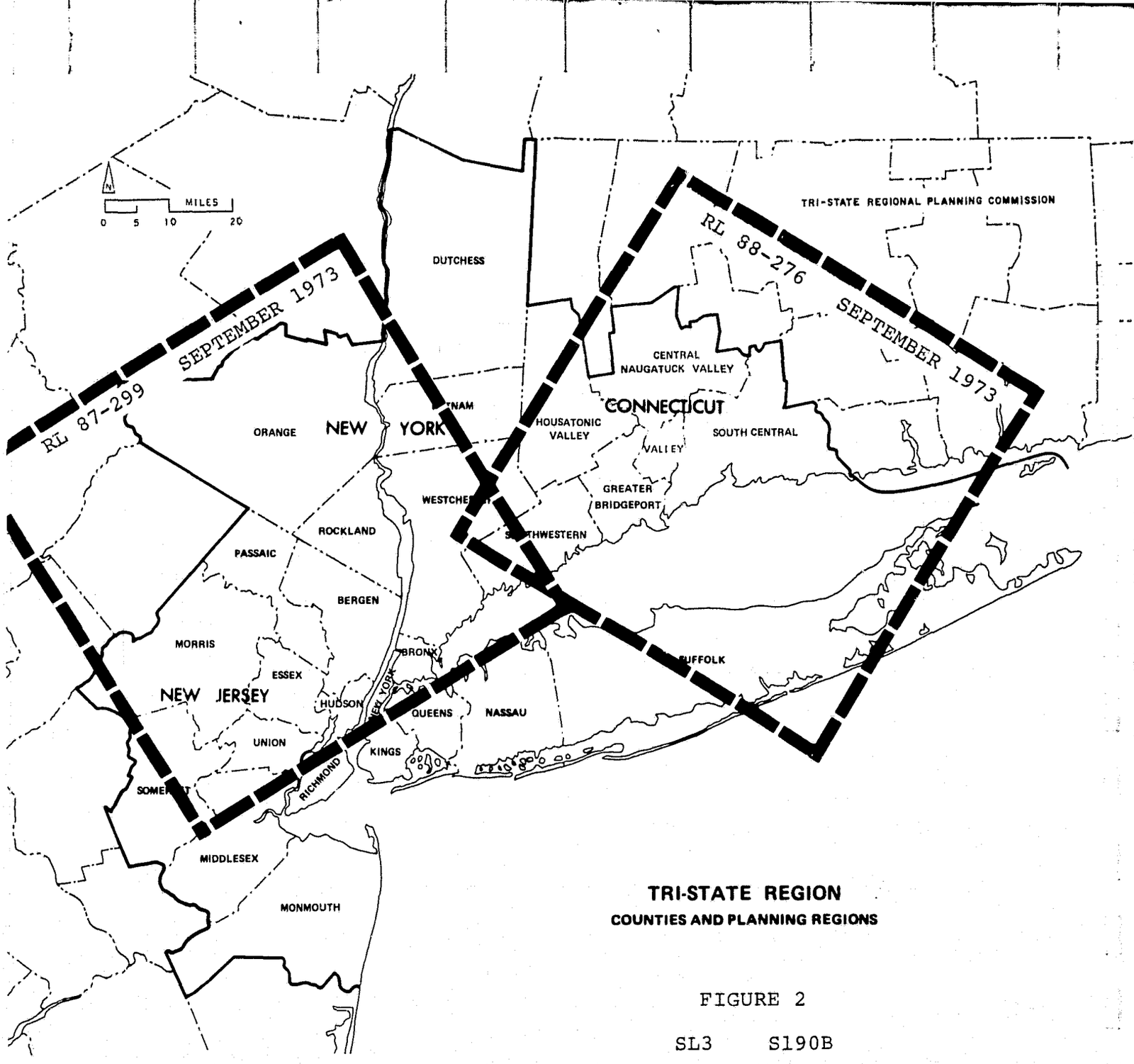
Undeveloped or vacant land is defined as those areas which are susceptible for development. Land which does not contain structures or streets would be the prime requirement. Included in this definition is land which has a natural ground cover, (wooded) or is used as agricultural land. Land in between partially developed areas is also defined as vacant.

This is a common condition in suburban areas and is critical for planning purposes. Excluded from the vacant category are parks and watershed land. The property lines cannot be differentiated from vacant land on photos and so must be delineated separately using other source data.

Developed land is an area that has structures, both residential and nonresidential, and streets. Included in the definition is that land adjacent to the existing structures which is not subject to additional construction.

For purposes of planning, streets are broken down into three categories--limited access, arterial and local. Limited access highways and major arterials are of primary importance in regional planning. Local streets are considered part of other types of developed land.

Water refers to rivers, streams, lakes, reservoirs and ponds which form political or land use boundaries and affect navigation, flooding, water supply or recreation.



TRI-STATE REGION
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FIGURE 2

SL3 S190B

EARTH TERRAIN CAMERA STUDY AREA

EARTH TERRAIN CAMERA

S 190 B SL3 FRAME RL87-299 INFRARED COLOR

(See Appendix, Exhibit A)

Images taken with the earth terrain camera are of excellent quality and have very high resolution. Individual features as small as 30 ft. can be seen.

Undeveloped or Vacant Land

The false color image gives an excellent representation of all types of open lands.

Homogeneous wooded areas are easily seen and can be outlined and measured. Parks in urban areas, which have a significant amount of trees, stand out.

Agricultural lands have varying shades of pink but are distinctive. The individual parcels are uniform in color although the shade will vary from parcel to parcel depending on the vegetative cover.

Vacant parcels of land in between developed parcels are a characteristic of suburban development. Since the color of this image varies from magenta (vacant) to light cyan (developed) the blend of the two indicates varying degrees of partially vacant land. The individual parcels are not visible but an estimate of the percent vacant can be made.

Developed Land

Developed land, which has structures and streets, appears as a light cyan. The denser the development the darker the color. This is very apparent in the midtown and downtown

portions of Manhattan and in the central business districts of the cities. Heavy concentrations of nonresidential buildings, like industrial parks, also have darker shades of cyan. Varying shades of cyan indicate various intensity of development. Age of development has an effect on the color in the suburban areas. In older suburbs the street pattern and structures are not as obvious since they are obscured somewhat by tall, full leaved trees. In the newer suburbs the street pattern is more discernible since the structures are further apart, the trees are not as tall and the soil still shows the effect of being disturbed. It is not within the scope of this investigation to put definitive values on the age of development.

Streets

The street patterns are easily discernible when they are in a rectangular grid formation, such as Manhattan and much of New York City. They are not too visible in the older suburbs but the curvilinear pattern of recent development is quite clear. Major highways and most arterial routes can be delineated.

Water

Excellent for mapping water bodies of two acres or more as well as streams as small as 50 ft. in width.

S 190 B SL3 FRAME RL-88-276 AERIAL COLOR

(See Appendix, Exhibit B)

The resolution of this aerographic color image is very good but the overall blue cast is not suitable for this purpose.

Undeveloped or Vacant Land

Wooded areas can be detected and outlined especially if they are 10 acres or more.

Agricultural lands are also detectable, mostly by their color, shape and uniform texture over the parcel area.

Vacant areas in the urban and older suburban areas are not easily recognized because they tend to blend with the developed areas.

Vacant areas in the newer suburbs can be observed.

Developed Land

The sharpness of the image plus the color and development pattern contribute toward making this feature visible. Intensely developed and newly developed suburban areas are easily detected. Older suburbs intermingled with undeveloped areas are difficult to separate.

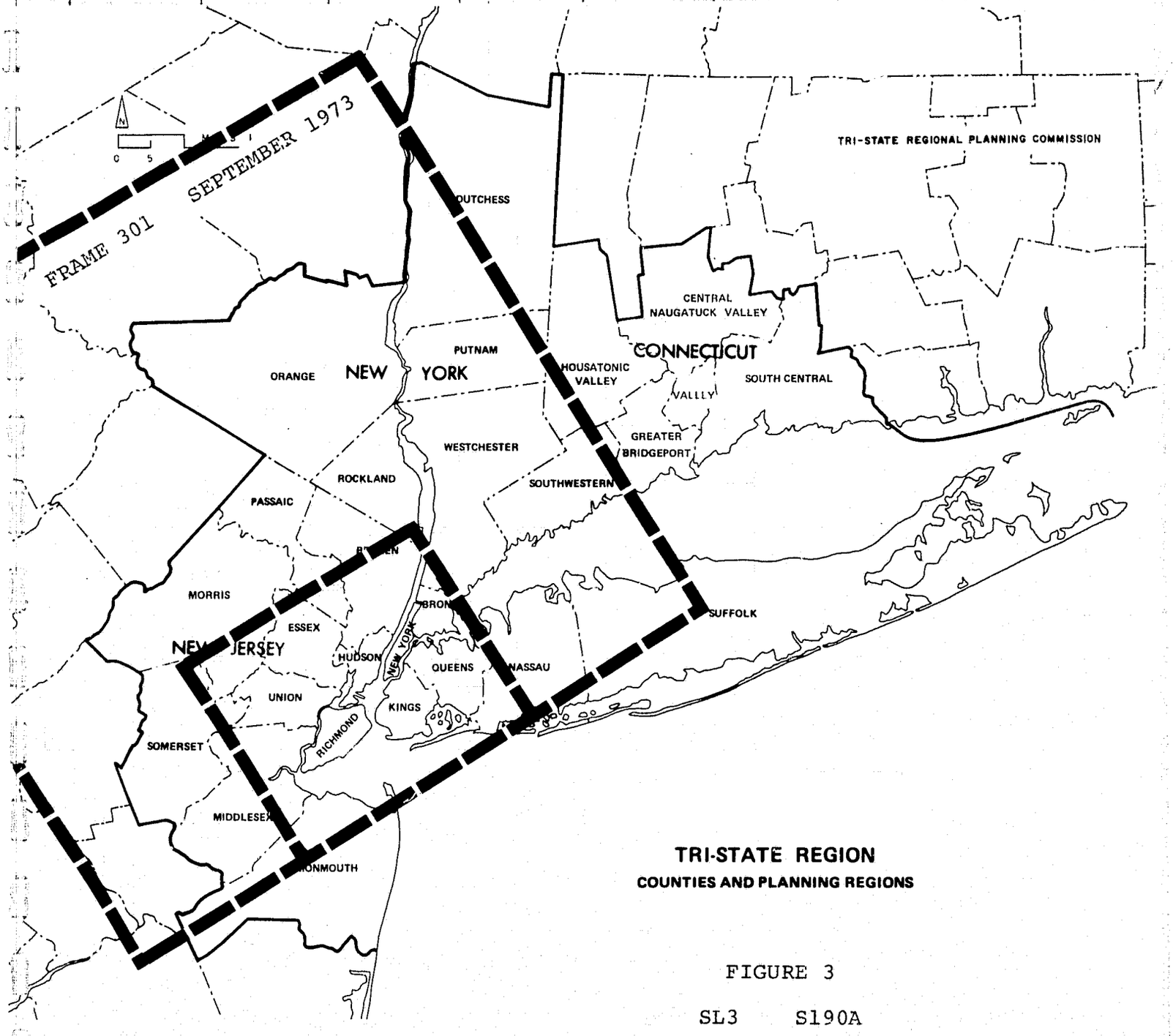
Newly developed areas are distinctively light in color -- a feature which shows considerable promise. Periodic overflights could be used as an indicator of change in development pattern.

Streets

Concrete highways are particularly visible as are routes with strip development along the roadside. Asphalt pavement is not detectable except for major highways of six or more lanes. Local street patterns can be discerned in some cases by the development configuration, but in general this image is not suitable for street inventory purposes.

Water

The overall blue cast of the image does not provide enough contrast between land and water.



TRI-STATE REGION
COUNTIES AND PLANNING REGIONS

FIGURE 3

SL3 S190A

MULTISPECTRAL CAMERA STUDY AREA

(Inset denotes enlargement area)

MULTISPECTRAL CAMERA

STATION 1 SL3 FRAME 43-301 .7-.8 u

(See Appendix Exhibit C and D)

Undeveloped or Vacant Land

The spectral range of this image has very limited use for defining undeveloped land within the Tri-State definition. Undeveloped areas are the lightest grey tone value. The lightest shades naturally predominate in the rural, wooded areas. In the urban areas, parks, cemeteries and golf courses can be distinguished because of the contrast with the darker shades of high density development. The least definition of undeveloped land occurs in the suburban areas. There is very little difference in the grey scale values to distinguish developed from undeveloped. There are several reasons:

1. Suburban areas have spread out development with a relatively large proportion of grass and trees interspersed between the structure and the houses.
2. Vacant areas are irregular in shape. These characteristics tend to make the two land use types blend together rather than give the desired distinction between them. A clear delineation is necessary to permit areas to be outlined and measured.

Developed Land

Intensely developed land, such as Manhattan, Brooklyn, Newark, Paterson and other major cities, can be detected on this image. Heavy concentrations of strip development are also evident. However, the same problem of separating developed from undeveloped land in suburban areas exists.

Streets

Most streets cannot be clearly observed using this particular imagery. Some major highways can be seen, particularly if they have been newly constructed.

Water

This imagery is very good for observing water bodies. Ponds and lakes as small as four acres are clearly visible. This is a very valuable aid in geographically locating prominent features and grid lines.

STATION 2 SL3 FRAME 44-301 .8-.9 u

(See Appendix, Exhibit E and F)

This imagery incorporates the same characteristics as 43-301. It is good for separating land from water but graininess prevents clear delineation of undeveloped land, developed land and streets.

STATION 3 SL3 FRAME 45-301 .5-.8 u (See Appendix, Exhibit G)

This imagery was investigated by using a 9 x 9 inch infrared color transparency. The scale was determined to be 1:700,663.

Undeveloped or Vacant Land

The primary characteristic of vacant land is vegetation. The magenta range of the false color infrared accentuates this feature. The wooded areas were the darkest red, the cultivated farms were pink and fertilized golf courses showed a bright red. These areas could be delineated on an overlay and used for graphic presentation. Problems are encountered when the cultivated areas are intermingled with sparsely developed areas. Delineating one from the other is difficult. Inclusion into the land use inventory file would require accurate land area measurements. The small scale of imagery, plus the graininess of infrared, does not yield sufficiently accurate results at the square mile level.

Developed Land

Developed land appears in the cyan range. Densely settled areas stand out very distinctly. As with undeveloped land, it can be outlined on an overlay for graphic presentation. The intermingling problem of cultivated areas with sparsely settled areas is also the same as the undeveloped land.

Streets

This particular imagery has mixed results for observing streets. Limited access highways and some major routes in rural and sparsely settled suburban areas could be detected. Newly constructed roads were clearly shown. In the urban and densely settled areas they blended into the background. Type and width of pavement and contrast with background are the critical factors contributing to visibility. Concrete surfaces thru wooded areas are the most visible. Asphalt surfaces of six lanes or more thru wooded areas are also visible. Local streets blend in with the background and cannot be delineated.

Water

Major rivers, lakes and reservoirs can be readily observed. Smaller streams and ponds are not clearly visible. This particular image is not recommended for delineating water since images in the .7 to .9u range do a far better job.

STATION 4 SL3 FRAME 46-301 .4-.7 u (See Appendix, Exhibit H)

This image was reviewed as a 9 x 9-inch transparency. It has a blue cast characteristic with some red observable in rural areas.

Undeveloped or Vacant Land

The darkest areas are water. The next darkest areas are wooded lands which can be detected when there is a sizeable homogeneous grouping. Agricultural areas appear in the lighter tones and are sometimes mixed with red tones. The tonal qualities are about the same as those for developed areas; however, the agriculatural areas tend to be uniform in color within each parcel (farm) whereas the developed areas are mottled.

Very light areas—bordering on white—have been observed as being undeveloped. The light areas fall into three broad categories -- major highways and other large surfaces made of concrete, soil disturbed areas and newly developed areas.

The soil disturbed areas are of particular concern. They represent a change in the land cover and could be an aid in monitoring land use development. However, most of the time they cannot be separated from previously developed areas. The distinction between the two is necessary since one is undeveloped and the other is already developed.

Developed Land

Developed land shows up in the lighter tones with a mottled texture. The densely settled urbanized areas can be easily discerned. Much of the closely knit suburban area can also be discerned. Trouble arises when developed land is interspersed between open or agricultural land. Clear boundary definitions cannot be accurately established to outline and measure them for input to an inventory file.

It should be noted that in many instances the curvilinear pattern of suburban development can be easily seen.

Streets

The major concrete highways can be clearly delineated, especially in rural areas. In urban areas they tend to blend with the background but still can be discerned. Asphalt pavements are not readily observable. Expressways such as the Garden State Parkway and the New Jersey Turnpike are paved with asphalt. They are visible when they have more than six moving lanes of traffic and when they are situated in open areas.

Local streets blend with the urban fabric.

Water

Major rivers and lakes are readily observed. Small lakes and reservoirs of ten acres are also visible.

This particular image is not recommended for delineating water since images in the .7 to .9u range do a far better job.

STATION 5 SL3 FRAME 47-301 .6-.7 u

(See Appendix, Exhibits J and K)

This image is closest to a standard black/white aerial photograph of those investigated. The contrast is high and there is some graininess.

Undeveloped or Vacant Land

When the image is enlarged to a scale of 1:250,000, homogeneous wooded areas as small as 10 acres can be defined.

Disturbed soil areas are difficult to separate from newly developed areas because of the high contrast and graininess. This also applies to the delineation of farmland.

Developed Land

Intensely developed areas are easily defined.

The close knit curvilinear suburban development can be clearly seen and delineated. Problems are encountered in outlining low density development in wooded or heavily vegetated portions.

Streets

Major highways and many arterial routes can be detected. The rectangular street patterns of the cities and the curvilinear pattern associated with suburban development are visible. However, the resolution is not good enough to define the local streets.

Water

Water bodies are visible and are an aid in geographically locating many features.

STATION 6 SL3 FRAME48-301 .5-.6 u

(See Appendix, Exhibits L and M)

Ground features are not clearly discernible. Low contrast blends the various features together.

Undeveloped or Vacant Land

Large wooded or vegetated areas can be observed but their boundaries are not sharp and cannot be accurately outlined.

Lack of sharpness also makes agricultural land undefinable.

Developed Land

Intensely developed lands like the large wooded areas can be observed but their boundaries cannot be accurately outlined.

Streets

Image quality does not permit delineation of streets and roads other than major highways.

Water

Large lakes, reservoirs and rivers are visible and serve as an aid in geographically locating land features.

CONCLUSIONS AND RECOMMENDATIONS

The most suitable Skylab image for regional planning purposes was the color infrared obtained by the earth terrain camera (S190B). The resolution was high enough to discern patterns of development, major highways and significant water bodies. The false color accentuated the vegetation, which is indicative of vacant land. However, land use areas could not be consistently measured at the two acre level or meet the 90 percent confidence requirement needed for use in predictive computer models.

The aerographic color image of the earth terrain camera (S190B) has limited use for regional planning purposes. It is not suitable for delineating water, streets and some types of vacant land because of lack of contrast and the blue cast. Newly or recently developed areas are visible by virtue of their distinct white color. To separate the newly developed from those previously developed would require comparison of images from two different time periods. This was not possible on the Skylab mission.

Visual photo interpretation of multispectral images can be used for detecting water bodies and general patterns of developed and undeveloped land. Generalized maps can be prepared for pictorial presentation.

Water bodies of two acres and more can be detected and measured. Other land uses, such as undeveloped, developed land and streets can be visually detected only at the ten acre level.

Visual observation is an acceptable method for determining land use; however, machine methods would be preferable.

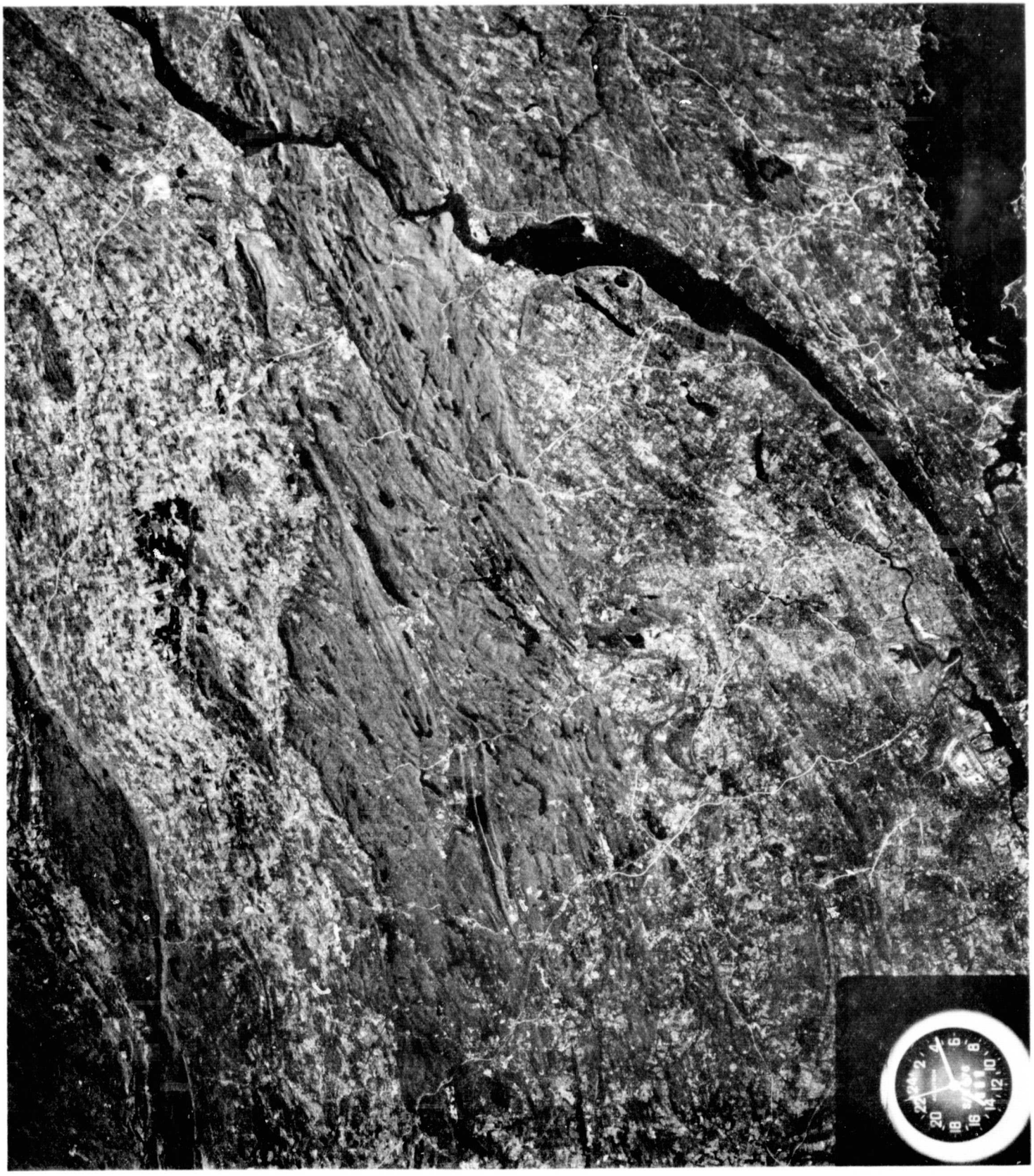
To be an effective, on-going tool in the planning process, the following items are recommended:

- ground resolution of 5 meters
- annual acquisition of data
- processing capability of digital data on small computers
- unique signatures for all Level II, Geological Survey Circular 671, land uses
- delivery of data to user within one month of acquisition date.

APPENDIX

Exhibit A	S190B	SL3	RL87-299 (1:474,320 B/W print of infrared color transparency
Exhibit B	S190B	SL3	RL88-276 (1:474,320) B/W print of color aerographic transparency
Exhibit C	S190A	SL3	43-301 B/W print (1:700,663)
Exhibit D	S190A	SL3	43-301 B/W print (1:250,000)
Exhibit E	S190A	SL3	44-301 B/W print (1:700,663)
Exhibit F	S190A	SL3	44-301 B/W print (1:250,000)
Exhibit G	S190A	SL3	45-301 (1:700,663) B/W print of intrared color transparency
Exhibit H	S190A	SL3	46-301 (1:700,663) B/W print of aerial color transparency
Exhibit J	S190A	SL3	47-301 B/W print (1:700,663)
Exhibit K	S190A	SL3	47-301 B/W print (1:250,000)
Exhibit L	S190A	SL3	48-301 B/W print (1:700,663)
Exhibit M	S190A	SL3	48-301 B/W print (1:250,000)

1:474,320 Exhibit A



1:474,320 Exhibit B

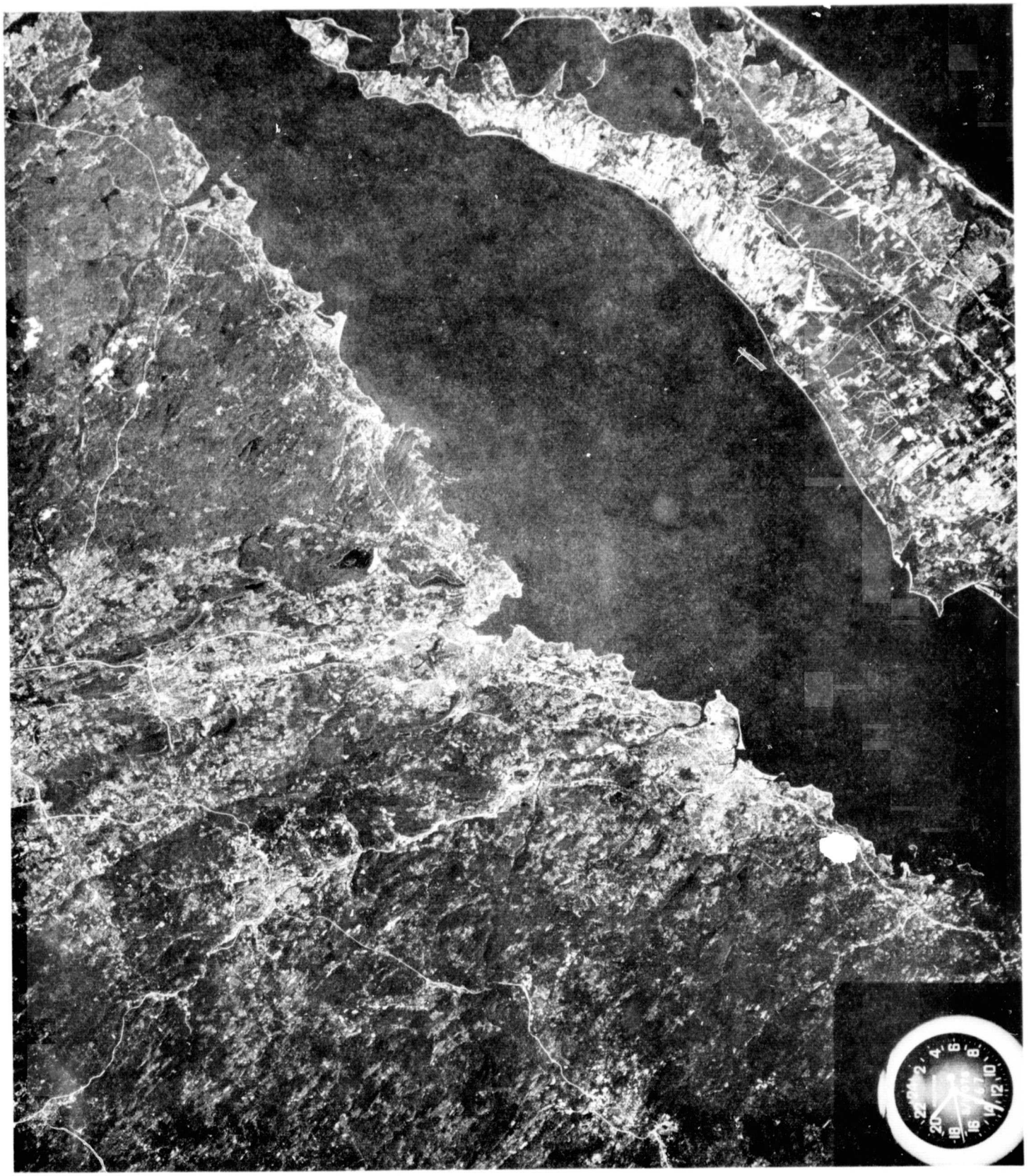


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Exhibit C

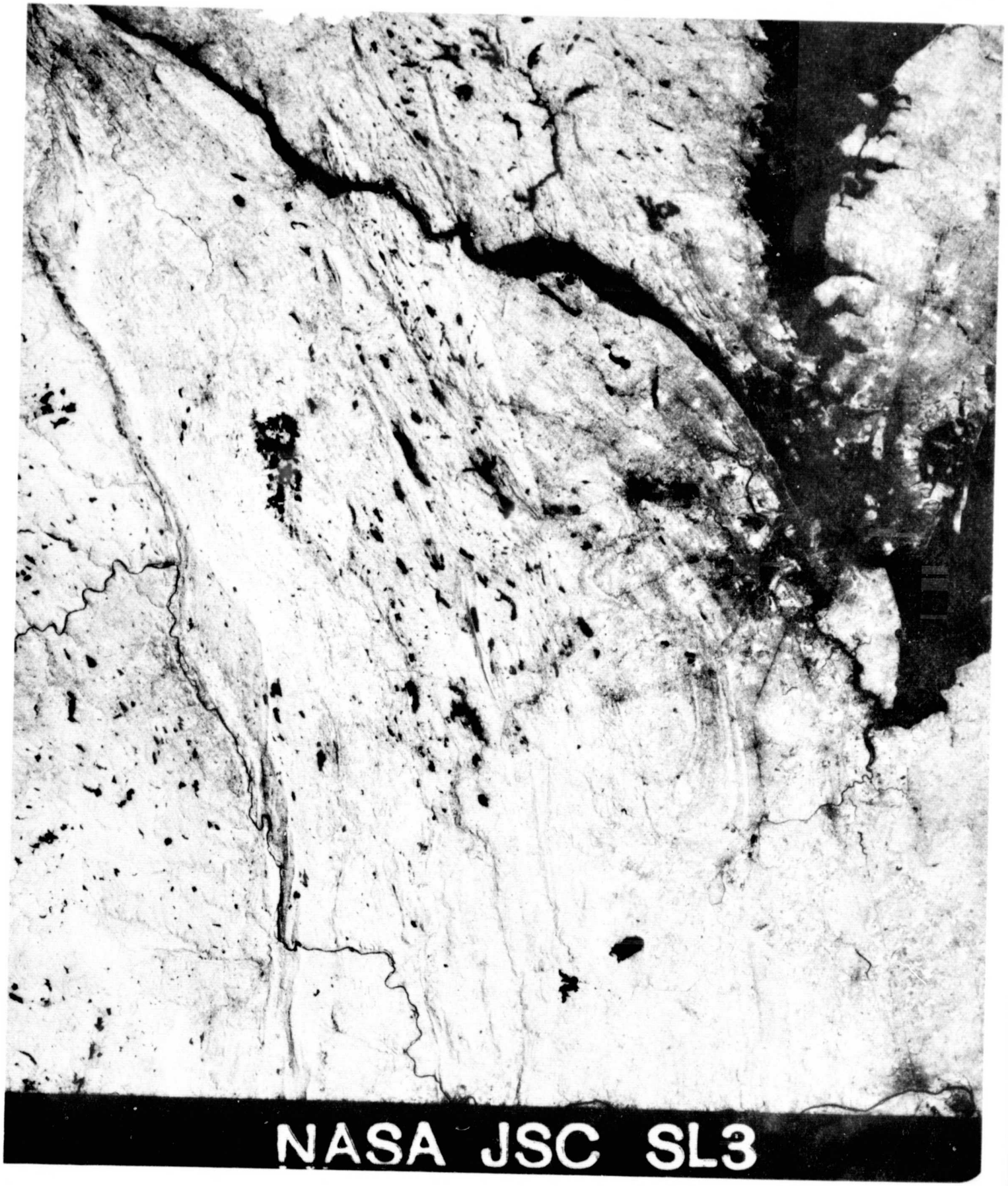

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Exhibit D

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Exhibit E

301

NASA JSC SL3
RL 44 SEP 73

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Exhibit F

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Exhibit G

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Exhibit H

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Exhibit J

NASA JSC SL3
RL 47 SEP 73

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Exhibit K

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Exhibit L

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