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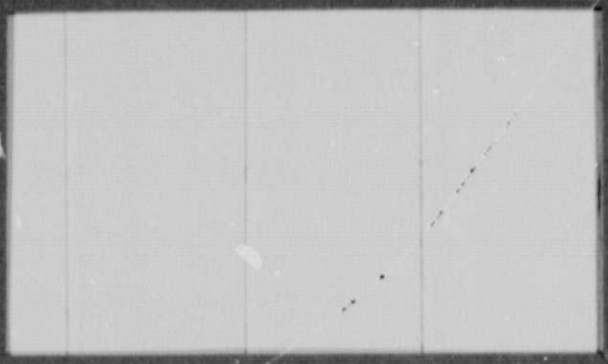
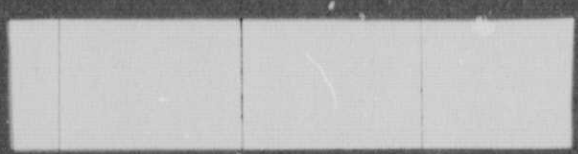
SDSU-RSI-74-2





SDSU-RSI-74-2

Field Investigation Report

Remote Sensing For Evaluating Post-Disaster Damage Conditions

The Pierre, S.D. Tornado July 23, 1973

by

Alvin E. Rusche and Victor I. Myers

A Report to National Aeronautics and Space Administration
NASA Grant NGL 42-003-007

Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

August 1974

INTRODUCTION

Disasters occur without warning. The natural reaction following a disaster is to assess the damage, take care of emergency situations, and proceed as quickly as possible with clean-up operations. These reactions are certainly normal and should not be changed. However, in the pressure and confusion of post-disaster decision making, the management tool of remote sensing is seldom used.

The damage caused by a disaster will not of course always be of sufficient extent to make remote sensing techniques useful. Damage confined to a small area can effectively be assessed by ground observations. An aerial panoramic view of large areas of damage, however, has obvious advantages over the limitations of ground viewing. In addition to providing an overall view for damage assessment and a quick-look for coordinating initial actions required for restoration of vehicular traffic, utilities services clean-up operations etc., remote sensing data also serves the important purpose of recording the post-disaster situation on film for future study, review and planning.

It is with these thoughts in mind, that this report of remote sensing coverage following a tornado in Pierre, South Dakota, is written.

Disaster Situation

At about 3:45 P.M. on Monday, July 23, 1973, a tornado struck the city of Pierre, South Dakota. The tornado emerged from a heavy rain-shower area southwest of the city, descended over the river and moved northerly along Williams Street. (see enclosure 1). Approximately 20 city blocks were affected by the storm, with major damage occurring in the six block area bounded by Williams Street, Willow Avenue, Missouri Avenue and Second Street.

Although the damage was limited to a small area, it was quite severe. Fortunately, there were few injuries, and most of those which did occur were not serious. Initial dollar-cost damage estimates to property, mostly residential, were placed at about $165,000.

Immediate action by clean-up crews and extensive participation and cooperation by the local citizens enabled clearing of major debris

and restoration of local traffic by Tuesday morning.

The Remote Sensing Mission

On the morning following the storm, the Remote Sensing Institute aircraft was flown to Pierre to photograph the damaged area. Aerial photography was collected at 1500 feet above ground level. Four 70 millimeter (2 3/4 inch format) cameras were used containing the following film and filter combinations:

Film Type	Filter	Comment
2402	58	Black and white film with green filter
2448	HF3	Color film with haze filter
2443	15 and 40M	Color infrared film with blue cutoff and color correction filter
2424	89B	Black and white infrared film with infrared pass filter

The interval of exposure was set to permit stereo viewing of the forward overlap. Six overflights were made, three for vertical aerial photography and three for oblique views obtained by exposure during turn and banking maneuvers. The vertical photography was flown on headings as follows:

(1) southeasterly ($\approx 150^{\circ}$)
(2) northwesterly ($\approx 310^{\circ}$)
(3) north-northeasterly ($\approx 30^{\circ}$)

While the aircraft was being refueled at Pierre, part of the aircraft crew went to the site where the tornado struck to photograph the damage from the ground. These 35 millimeter slides were used in conjunction with the aerial vertical and oblique photography to add another dimension to the photographic coverage for current evaluation and recording the damage

for future reference.

The photography was processed at the Remote Sensing Institute photo lab and was forwarded to the Civil Defense Office in Pierre on July 26, 1973. (see enclosure 2)

Evaluation of Mission

Weather conditions were ideal for aerial data collection on the day following the tornado and excellent photographic coverage was obtained. The damaged area is clearly evident as shown on the color photographs in figure 1. These photographs are arranged for stereo viewing. The altitude of 450 meters (1500 feet) above ground was optimum for this mission, but a higher altitude might be required if it were necessary to obtain more broad coverage without making a number of parallel runs.

Figure 1.

Roof damage, object dislocation, destroyed structures and scattering of debris can be easily identified on these vertical photographs. Note that the debris has already been cleared from the streets, even though the data collection mission was flown the day following the tornado damage.

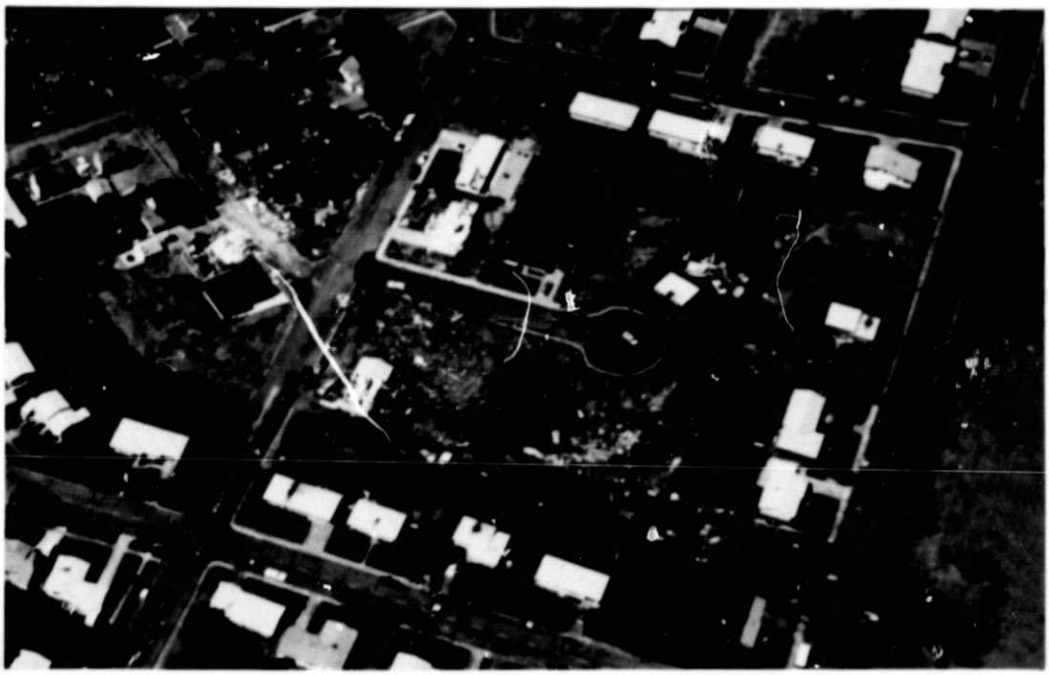


Figure 2.

The oblique photograph in Figure 2 provides additional information to the photo interpreter in that the vertical sides of structures can be seen and evaluated for damage. Heavy tree cover within a damaged area could make this type of imagery difficult to obtain. In that case, ground photography may be necessary to observe damage to verticle structures.

The series of ground photographs displayed in figure 3 are keyed to an enlarged vertical view of part of the damaged area. These photos are useful for further documenting the extent of destruction.

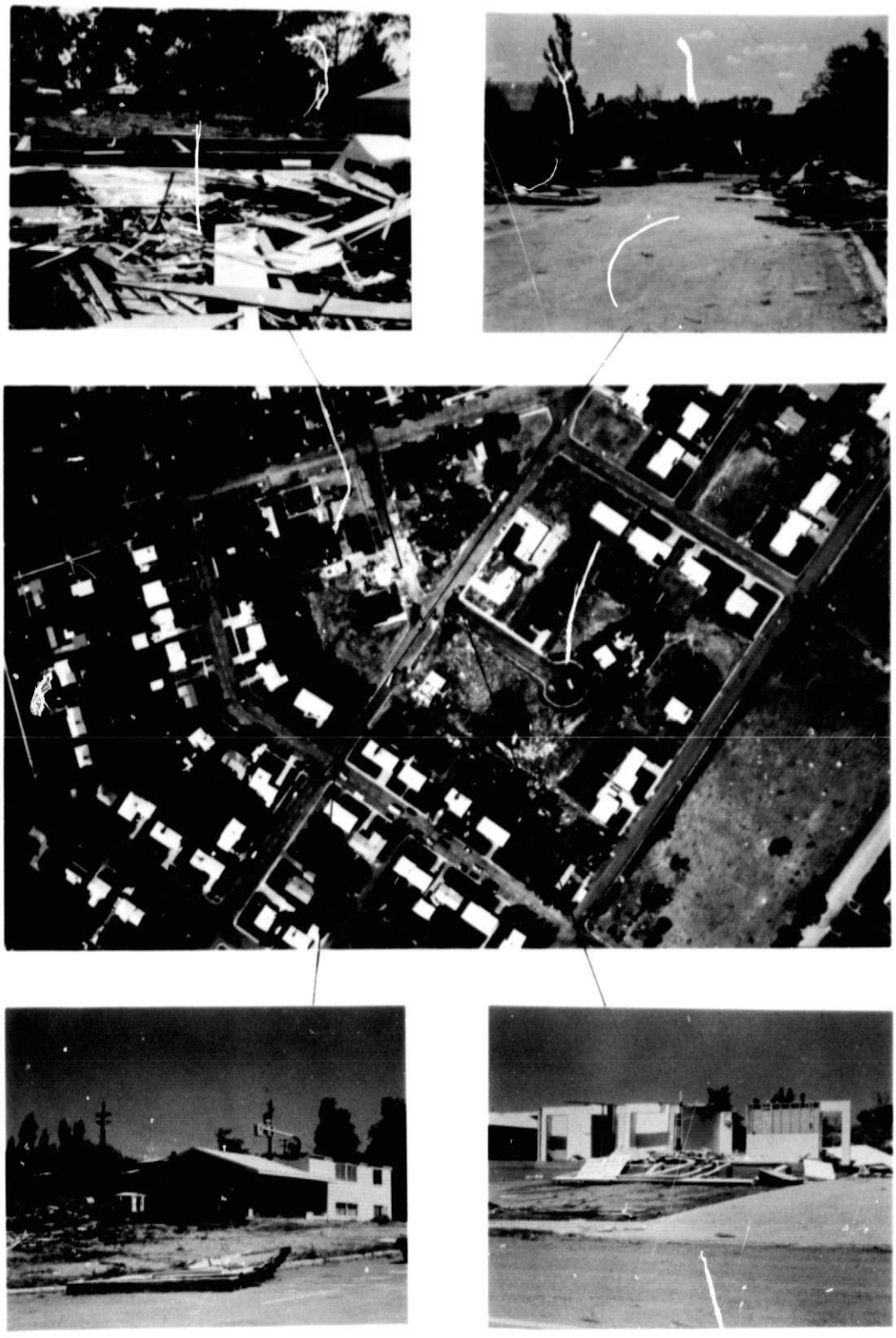


Figure 3.

Figure 4 shows small pieces of debris which were propelled by the tornado winds with sufficient force to penetrate the side of a building.

Figure 4.

Conclusions and Recommendations

In this instance, since the damage occurred late in the afternoon and was limited to a very small area, debris was partially cleared and nearly normal traffic and utilities services were restored prior to possible aerial data collection. However, had the area of damage been more extensive, as in the case of the Rapid City Flood, aerial coverage would have been much more useful for directing debris clearance, traffic routing, utility damage evaluation, etc. Even in this case, the recipients of the imagery have found it to be very beneficial in determining the scope of damage and for briefing various groups concerning the extent of the storm. (see enclosures 3 and 4).

It is imperative that data be collected as soon as possible following a disaster in order to maximize its benefits for post-disaster clean-up and recovery operations. Those who are in a position of responsibility for immediate action following a disaster are understandably pre-occupied with many problems at such a time. Therefore, it is important to establish and maintain a close liaison with whomever may have that responsibility, and to discuss with them the various types and scales of remote sensing

data, their approximate cost and their probable benefit to post-disaster damage assessment. Funds should be authorized for expenditure on post-disaster data collection and analyses. Having been pre-briefed on remote sensing capabilities and costs, planners could implement the data collection effort quickly following the damage occurrance in order to achieve its maximum advantage.

Use of Remote Sensing Imagery for Damage Assessment

The obvious use of remote sensing information following a disaster is to obtain a quick-look at the overall damage. Following the quick-look assessment, the imagery can be used for many additional purposes. Among these uses are to identify various conditions so that action can be initiated for:

1. Restoration of lines of communication such as roads, streets, telephone lines and airport facilities.
2. Elimination of health hazards such as ponded water, exposed breaks in sewer and water lines, broken electrical lines, damaged sewage treatment areas, etc.
3. Assessment of property damage for mortgage and insurance purposes.
4. Establishment of overall damage cost to support emergency funding requests.
5. Determination of temporary housing needs.
6. Location of central points for disaster aid stations.
7. Observation of vegetation destruction to determine reseeding and replanting requirements.
8. Recommendations for rezoning to avoid similar damage in case of future flooding.
9. Assessment and impact of crop damage.
10. Determination of crop spraying or reseeding requirements.
11. Determination for the requirement for alert messages to surrounding areas in the case of crop disease or insect infestation.

day. The inflammation and drainage subsided completely, and the devices remain in use six months post implantation (Fig 6).

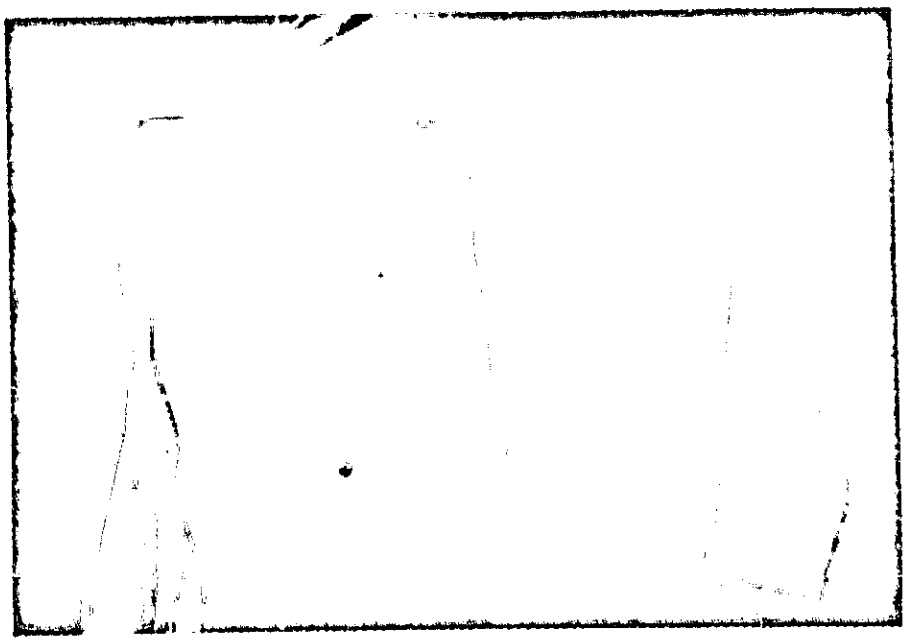


Fig 6--Carbon devices implanted in the skin over pain points for electrical stimulation to block pain.

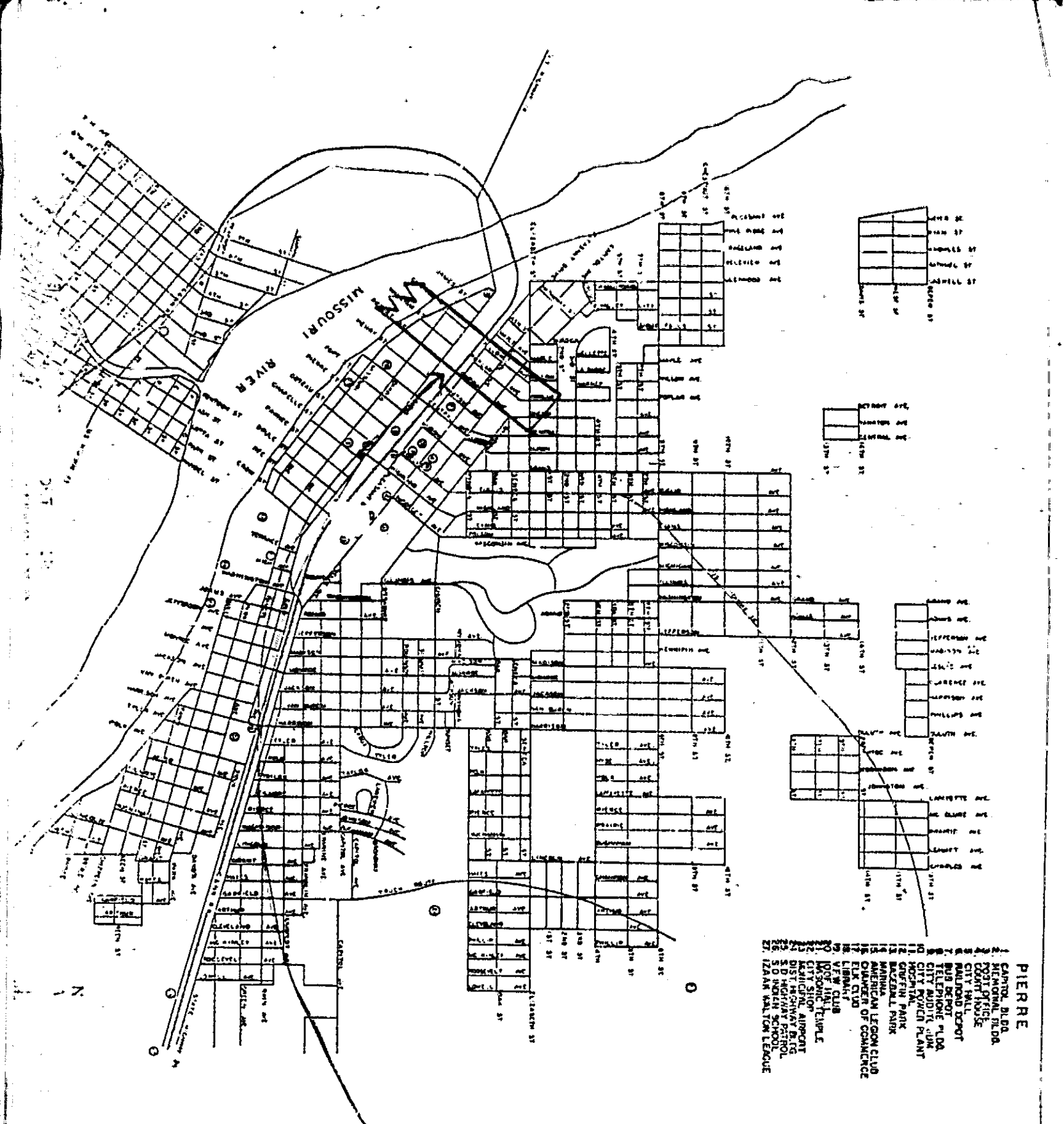
Five other applications using the same devices have been done for muscle stimulation and for the control of pain. Currently, all skin interfaces remain without gross infection.

APPROACH 2

This type of device has been implanted in one volunteer. It overlies the peroneal nerve just anterior to the neck of the fibula. Its purpose is to test the efficiency of stimulating the dorsiflexion musculature of the right foot for correction of drop foot secondary

Crop Damage Due to Insect or Disease Infestation

Research is continuing to determine the feasability of and best methods to accomplish early detection and extent of damage due to these causes. Ground observers can easily observe this type of damage at close range, but to determine the extent of damage within fields and over broad areas is difficult other than by spot sampling or by estimation. Refined remote sensing techniques should be developed to improve these kinds of damage assessment.



DAMAGE AREA - PIERRE TORNADO
JUNE 23, 1973

Enclosure 1

July 28, 1973

Mr. John Powell
Assistant Director
Civil Defense
Pierre, South Dakota 57501

Dear Mr Powell:

As I promised you over the phone, we are sending some photographs showing areas damaged by the July 24 tornado in Pierre. Also as we agreed, one of us in the Institute will contact you early next week so that we can correlate our remote sensing information with your ground survey data.

Since we did not have immediate knowledge of the tornado we did not fly the area until noon the following day. Aircraft engine trouble in Pierre delayed our return to Brookings until late Tuesday evening. My point is that if we were involved in a co-ordinated, planned disaster evaluation operation, we could have had complete aerial coverage available for interpretation within five or six hours.

I am sending two sets of eight prints each (four color infrared and four regular color). Two of the photos, frames 6 and 7 as labeled on the reverse side, can be viewed in stereo. The remaining two prints of each type are aerial oblique coverages which include almost all of the damage/area in each view. Perhaps you would like to forward one set of prints to someone such as Bob Hardwick for his use and evaluation.

I will contact you early next week.

Sincerely yours,

Victor I. Myers
Director

VIM/raa
Enclosure

Enclosure 2

STATE OF SOUTH DAKOTA

OFFICE OF THE ADJUTANT GENERAL

STATE CIVIL DEFENSE

STATE EMERGENCY OPERATIONS CENTER

STATE CAPITOL BUILDING

PIERRE, SOUTH DAKOTA 57501

MAJ GEN DUANE L. CORNING
DIRECTOR
THE ADJUTANT GENERAL

30 July 1973

Victor I. Myers, Director
Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

Dear Mr. Myers:

Thank you very much for the copies of photos taken by your Institute showing the damaged areas in Pierre on the July 24, 1973, tornado.

I am sorry that we did not advise you so that you had immediate knowledge of the tornado, however, we will certainly attempt to do this in all future incidents such as this and hopefully allow you more planning time for accomplishing such a mission.

These photos are very beneficial in determining the scope of damage and you can be assured that we appreciate it immensely.

Sincerely,

JOHN F. POWELL
Deputy Civil Defense Director
for South Dakota

JFP/st

Enclosure 3

STATE OF SOUTH DAKOTA

OFFICE OF THE ADJUTANT GENERAL

STATE CIVIL DEFENSE

STATE EMERGENCY OPERATIONS CENTER

STATE CAPITOL BUILDING

PIERRE, SOUTH DAKOTA 57501

RICHARD F. KNEIP
GOVERNOR

MAJ. GEN. DUANE L. CORNING
DIRECTOR
THE ADJUTANT GENERAL

19 November 1973

Mr. Victor Myers
Remote Sensing Institute
Harding Hall
South Dakota State University
Brookings, South Dakota - 57006

Dear Mr. Myers:

After the Black Hills flood of June 9, 1972, your Institute compiled a document of photos valuable in damage assessment immediately after the flood and important in delineating the flood plain area for long-range flood plain management.

Again as a result of a small tornado in Pierre this year the imagery provided assisted a great deal in identifying the path of and damage caused by this incident.

As a result of these two specific cases, and the uses to which the photos assisted in damage assessment, identification of the hazard areas and long-range planning, we would hope that your Institution could continue to provide this service in the event of future disasters.

Sincerely,

JOHN F. POWELL
Deputy Civil Defense Director
for South Dakota

JFP/st

Enclosure 4