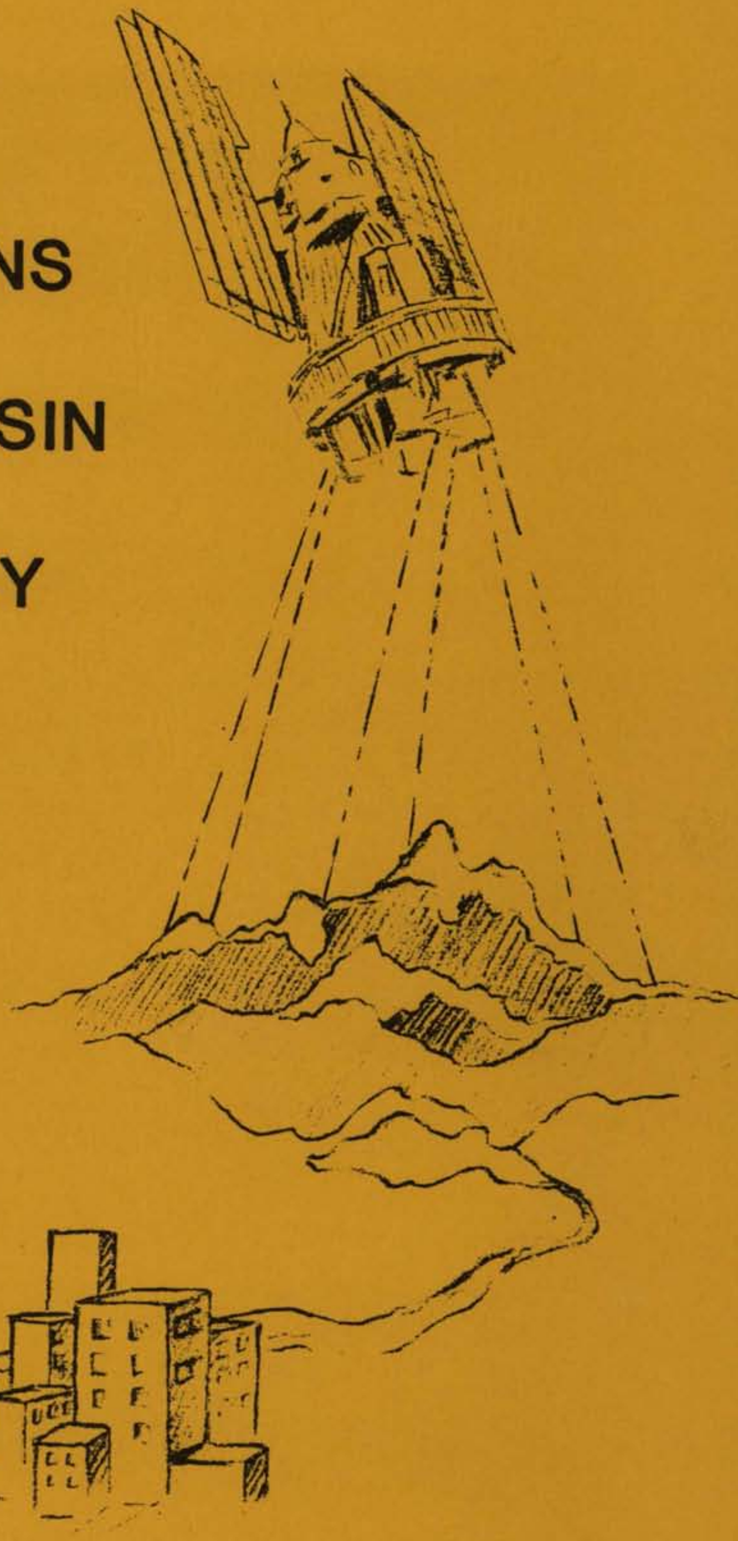
IDENTIFICATION OF SNOW COVER DEPLETION PATTERNS IN THE BOISE RIVER BASIN USING SATELLITE IMAGERY



by

Dr. Leroy F. Heitz

Assistant Professor

of

Engineering Science

Idaho Water and Energy Resources Research Institute

University of Idaho

Moscow, Idaho

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ABSTRACT

The purpose of this research was to develop snow covered area maps for the Boise River Basin in Idaho. Landsat satellite imagery was used as the basic data source for the development of these maps. The snow covered area information on the Landsat imagery was transferred to 1 to 250,000 scale U.S. Geological Survey topographic maps using optical projection techniques with the aid of the zoom transfer scope.

This research is the first phase of a larger project in which snow covered area maps will be used to enhance the predictive capability of the SSARR model. This model is used by the Walla Walla District of the U.S. Army Corps of Engineers as a river flow forecasting model for the Boise River Basin. In past years there has been some problems with the predictive capabilities of the model during later stages of spring snow melt runoff. It is felt that an improved model could be developed by comparing model predicted with actual snow covered areas and snow line elevations.

This report outlines the required future studies and identifies the budget requirements to make these refinement studies.

INTRODUCTION

In August of 1983, the Walla Walla District of the U. S. Army Corps of Engineers entered into a contract with the University of Idaho to provide snow covered area maps of the Boise River Basin in Idaho. These maps were to be developed from Landsat satellite imagery available from the U.S. Geological Survey's EROS Data Center in Sioux Falls Sd.

The required imagery was purchased in September of 1983 and a set of 32 snow covered area maps was developed in the fall Of 1983 and spring of 1984. These maps were developed using 9 in by 9 in satellite images. The maps were all drawn to a scale of 1-250,000. The enlargement from basic satellite imagery film positive to 1-250,000 scale map was done using the zoom transfer scope.

The remainder of this report describes the acquisition of the satellite imagery, the development of the snow covered area maps and future research possibilities using these snow covered area maps.

STUDY BACKGROUND

The Walla Walla District of the U.S. Army Corps of Engineers along with other agencies, is responsible for reservoir operations in the Boise Basin. District personnel presently uses a sophisticated runoff model (SSARR) to predict snow melt runoff into the river system. This model is extremely valuable in determining reservoir operation plans. In the past, there appears to be certain areas within the basin where the patterns of snow cover depletion do not follow that which is predicted by the SSARR model. These discrepancies between model and real world cause the model to predict flows that are unrealistic compared to observed values.

These erroneous predictions usually are most troublesome during the critical final reservoir refill period. Prediction errors during this period of time could result in the reservoirs of the system under filling or having to resort to possible surcharging or unnecessarily high flows in the lower portions of the Boise River system. Each of these could result in undesirable economic and political effects.

The purpose of this project will be to investigate the snow cover deletion patterns in the Boise River Basin to determine what changes could be made to the SSARR model so that more accurate flow predictions can be made during the critical final refill period. This report will describe in detail the first phase of this work which deals with gathering snow covered area satellite imagery and developing this imagery into snow covered area maps. There will also be sections dealing with future uses of the snow cover depletion data for enhancing the SSARR model's predictive capabilities.

ACQUISITION OF DATA

The snow covered area maps that were drawn for this project were developed from satellite imagery collected by the Landsat series of satellites. The Landsat satellite series has consisted of four satellites Landsat 1 thru Landsat 4. Landsat 1, the first in the series became operational in July 1971. Since that time there has been at least one or two of the Landsat platforms operational at any one time.

The U.S. Geological Survey is in charge of managing the image information that is gathered by these satellites. The EROS Data Center at Sioux Falls, South Dakota has the primary responsibility of creating usable imagery from the satellite gathered data. They are also charged with the dissemination of this information to the public. The EROS Data Center is an extremely well organized information dissemination organization and if a systematic approach is applied those wishing to use satellite imagery should be favorably impressed with this organization. The following steps outline the procedures for acquiring the data used for this study. Similar steps should be taken by anyone wishing to use satellite imagery for any reason.

The first information that was determined is the location of the area for which imagery was desired in reference to the paths which the satellite traverse in their particular orbits. EROS Data Center provided what is called a path and row map for the Landsat satellite series. This map (NOAA Form 34-1205) shows the flight paths for each of the Landsat satellites and it provides a path and row grid system for locating the center points of available imagery. A template is also provided so that the coverage of each individual scene can be identified. Landsat 1,2, and 3 data for the Boise Basin is contained in Path 44, Rows 29 and 30. Landsat 4 data is contained in Path 41, Rows 29 and 30.

Once the path and row points were identified the next step was to contact the EROS Data Center and relay the information on path and row desired and other information such as what periods of time the imagery is desired, and what degree of cloud cover is acceptable. Criteria for the Boise Basin imagery was based on a 1 April thru 30 June time period with a maximum acceptable cloud cover of 80%. Personnel at EROS Data Center then made a computerized search of the available data and provided a computer printout which listed imagery type (Landsat 1 thru 4), the scene identification number, quality of the imagery, cloud cover in percent, exposure data and a microfilm accessing number. This information was provided for all available scenes that fell within the path and row, time and cloud cover constraints that were previously identified.

After reviewing the listing of available imagery, there was still some uncertainty about which scenes to purchase. The effect of high percentages of cloud cover on image usability was of particular concern. To resolve this, a trip was made to the EROS Data Center to actually preview the scenes before purchases were made. The EROS Data Center maintains a microfilm library which when used with the computer printout made previewing of the imagery very simple.

Once the desired imagery was identified the next step was to determine what type of image product was desired and which band or bands would be the most useful for this particular project. Both black and white and color imagery is available. This imagery can be purchased in various formats such as film positive or negative and also printed on paper. It was determined that black and white film positives would be most usable for the snow covered area mapping. Which multi spectral scanner (MSS) band to order was also an important consideration. A review of previous work in this area revealed that band 5 was probably the best for delineating snow covered area with band 4 being the second best for this type of task. (Foster, 1983). After determining the final desired product the next step was to actually order the imagery. EROS Data Center has a standard form for this purpose (NOAA Form 34-1201 and 34-1200).

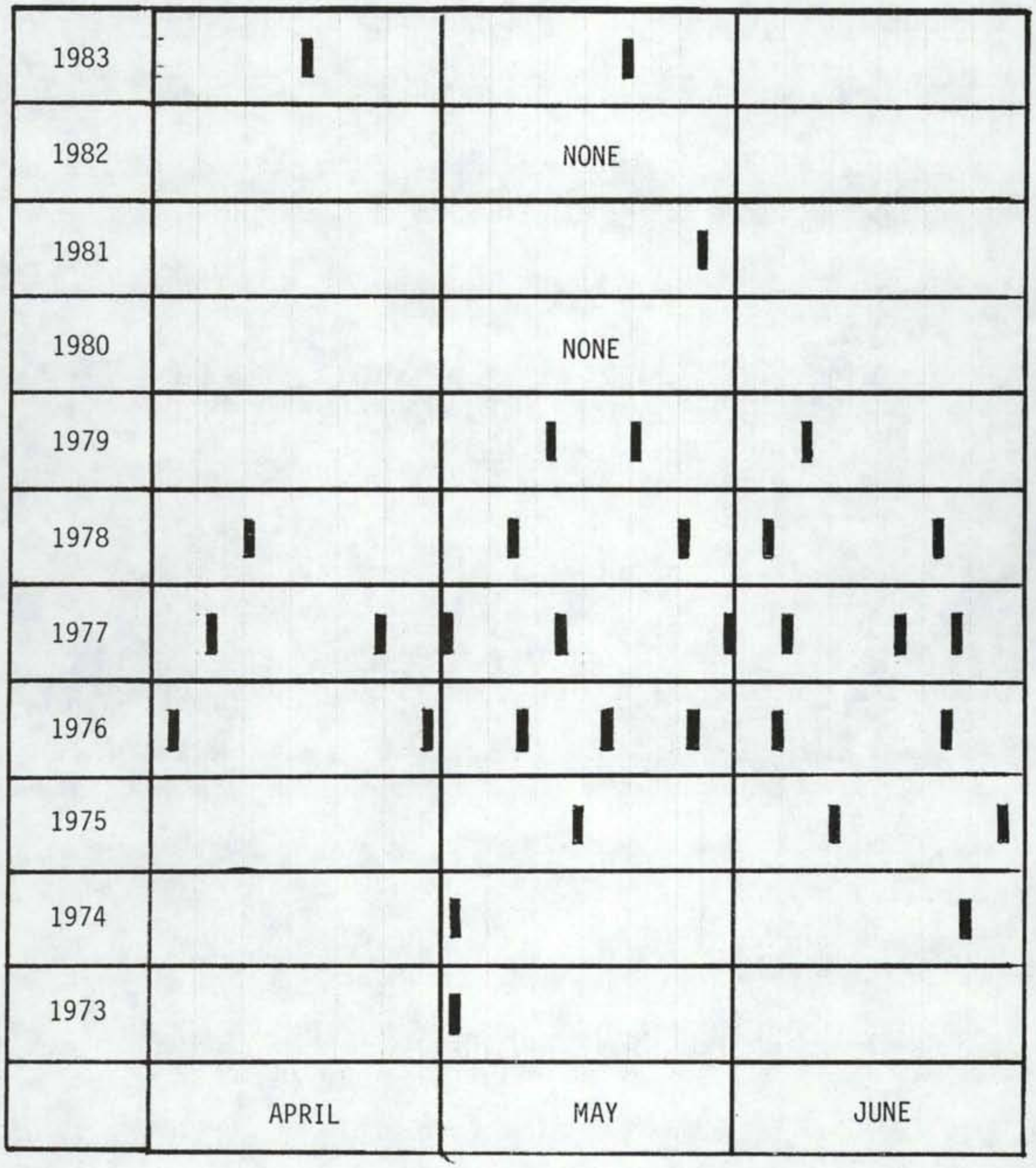
Table 1 shows a listing of the scene dates of the imagery that was purchased. Figure 1 shows the imagery dates plotted on a time line so that comparisons can be made of data availability for different years.

TABLE 1
DATES WHEN SNOW COVERED AREA
MAPS ARE AVAILABLE

* * * * * * 1983 * * * * * *
1. 19 MAY
2. 17 APR
* * * * * * 1981 * * * * * *
3. 28 MAY
* * * * * * 1979 * * * * * *
4. 08 JUN
5. 21 MAY
6. 12 MAY
* * * * * * 1978 * * * * * *
7. 22 JUN
8. 04 JUN
9. 26 MAY
10. 08 MAY
11. 11 APR
* * * * * * 1977 * * * * * *
12. 24 JUN
13. 18 JUN
14. 06 JUN
15. 31 MAY
16. 13 MAY
17 01 MAY
18. 25 APR
19. 07 APR
* * * * * * 1976 * * * * * *
20. 23 JUN
21. 05 JUN
22. 27 MAY
23. 18 MAY
24. 09 MAY
25. 30 APR
26. 03 APR
* * * * * * 1975 * * * * * *
27. 29 JUN
28. 11 JUN
29. 15 MAY
* * * * * * 1974 * * * * * *
30. 25 JUN
31. 02 MAY
* * * * * * 1973 * * * * * *
32. 02 MAY

Figure 1

DATES WHEN
SNOW COVERED AREA MAPS
ARE AVAILABLE



SNOW COVERED AREA MAP

DEVELOPMENT

In order for the information on snow cover that was available on the satellite imagery to be useful, it had to be transferred to maps of standard U.S.Geological Survey topographic map scale. It was determined that maps of 1-250,000 scale would be used for this project. These maps represented a scale that was both large enough so that the entire basin could be drawn on a workable size sheet yet the scale was small enough so that details in the basin would not be lost.

The imagery available from the Landsat series of satellites is not geometrically to the same scale on all points of the scene. In order to achieve a scale adjustment of the imagery to a constant 1 to 250,000 scale the zoom transfer scope was used. The zoom transfer scope is an optical projection devise that allows the projection of one image onto another. In this case the satellite imagery was projected on to a standard 1-250,000 scale U.S. Geological Survey topographic map of the Boise Basin.

The inconsistent scale of the satellite imagery was corrected by using the stretch feature of the zoom transfer scope. This feature allows the scale of the projected image to be changed in two different axis directions. This

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stretching was continued until physiographic features such as streams or mountain tops on the projected image matched those on the topographic map. While the procedure sounds relatively simple the actual process of matching map scales is very tedious and time consuming.

After the scales of the satellite imagery and the topographic map were made to coincide, the next step was to actually map the location of the snow line. This was accomplished by simply tracing the projected snow line location on to the topographic map. The tracing was done on a mylar overlay.

In most cases the high contrast between snow covered and snow free areas made the snow line tracing task relatively simple. In some cases, though, cloud cover obscured portions of the snow line. In these cases the obscured snow line was estimated and shown as a dotted line on the tracing. Another problem that arose was trying to differentiate between snow covered and snow free area when the snow covered areas contained patches of partially snow free areas. In these cases the best guess of complete cover snow line was estimated. A complete set of snow covered area tracings for the dates shown in Table 1 and Figure 1 will be furnished to the U.S. Army Corps of Engineers as agreed in the contract for this project.

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FUTURE STUDIES

The first phase of this project, which was described earlier in this report, is really only the beginning point in solving the runoff prediction problems for the Boise River system. In order to solve these problems, further studies using the snow covered area maps developed during the first phase of the study will be required.

The first part of the required future work will involve dividing the snow coved area maps into sub basins that correspond to those presently used in the existing Boise River SSARR model. Next the snow covered area and average snow line elevation will be determined for each of the sub basins for each date that the snow maps are available. Percent of snow covered area for the entire basin and for each sub basin will be determined from this data.

It will be attempted to develop a set of typical snow covered area maps that would illustrate where the snow pack would be located for average 10, 15, 20, 25, and 35 percent snow covered area conditions. These typical condition maps would be developed from the snow covered area maps completed during the first phase of this project.

Next a set of simplistic snow covered area maps will be developed. These simplistic maps will be based on area elevation data. The 10, 15, 20, 25, and 35 percent snow covered area snow line will be defined by simply following the contour that has the specified percent area contained above that particular elevation. Since the SSARR model depends heavily on this simplistic viewpoint of snow covered area, any discrepancies between the simplistic maps and the maps developed from the actual imagery may indicate problem areas in the modeling process.

The percent of total April through July runoff and accumulated runoff in acre feet will be tabulated for each of the dates that snow covered area maps are available. A measure of accumulated heat will also be tabulated. This relationship will be based on the maximum and minimum temperature and some base temperature eg. 32 deg. F. Studies of the fifteen minute temperature data available from the U.S. Bureau of Reclamation and the Snotel snow water equivalent data should indicate what kind of relationship to use as a measure of the accumulated heat factor. A tabulation of percent of total April thru July accumulated heat will also be made. Tables 2 and 3 are examples of the types of data tables that will be generated as a result of this part of the study.

At this point some relationships between percent snow covered area, percent runoff, and percent of accumulated heat should begin to become apparent. Various correlation techniques will be used in an attempt to quantify these relationships.

Figure 2 is a flow chart of the work that must be completed in order to accomplish the goals identified above.

TABLE 2
SAMPLE OF ENTIRE BASIN
SNOW DEPLETION DATA

DATE	SNOW COVERED AREA Mi^2	AVERAGE SNOW LINE ELEVATION Ft MSL	AVERAGE SOUTH SLOPE SNOW LINE ELEVATION Ft MSL	AVERAGE NORTH SLOPE SNOW LINE ELEVATION Ft MSL	PERCENT SNOW COVERED AREA %	PERCENT 1 APR - 1 JUL RUNOFF %	TOTAL RUNOFF 1 APR - 1 JUL Acre ft	ACCUMULATED HEAT 1 APR TO DATE Deg Days	PERCENT OF TOTAL 1 APR - 1 JUL ACCUMULATED HEAT %

TABLE 3
SAMPLE OF SUB-BASIN
SNOW DEPLETION DATA

(ONE TABLE FOR EACH SSARR SUB-BASIN)

DATE	SNOW COVERED AREA Mi^2	AVERAGE SNOW LINE ELEVATION Ft MSL	AVERAGE SOUTH SLOPE SNOW LINE ELEVATION Ft MSL	AVERAGE NORTH SLOPE SNOW LINE ELEVATION Ft MSL	PERCENT SNOW COVERED AREA %

FIGURE 2
FLOW CHART FOR
PHASE II
IDENTIFICATION OF
SNOW COVER DEPLETION PATTERNS
USING SATELLITE IMAGERY

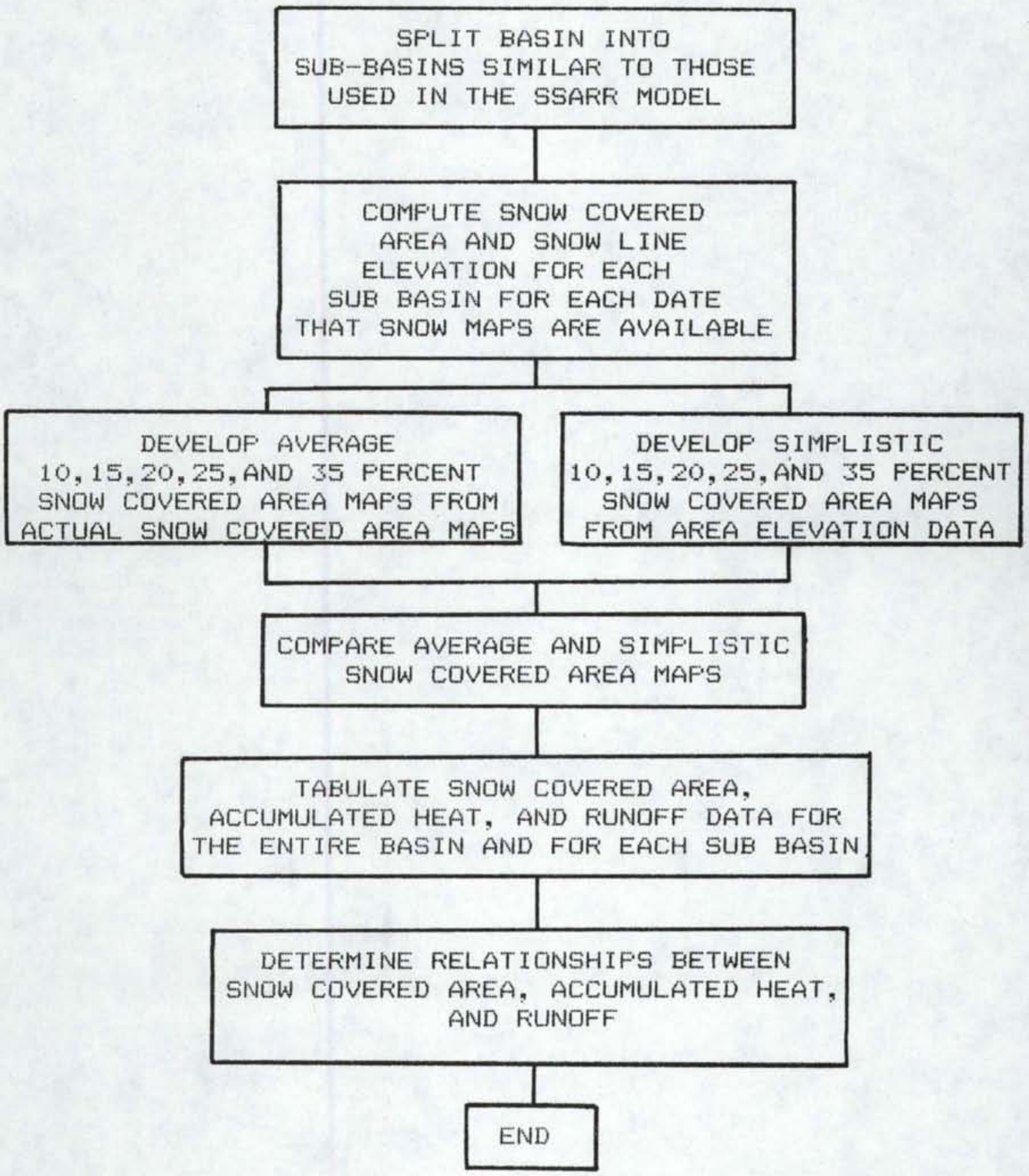

Table 3 identifies the budget requirements to accomplish the work outlined above and in Figure 2. It is felt that if the project could be initiated by september 1984, a completion date of December 1985 would be reasonable.

TABLE 4

PRELIMINARY BUDGET FOR
PHASE II
IDENTIFICATION OF
SNOW COVER DEPLETION PATTERNS
USING SATELLITE IMAGERY

I.	Salaries		
	1. Professional		9935.38
	2. Grad Students		-0-
	3. Technicians		-0-
	4. Irregular Help		960.00
	TOTAL SALARIES		10895.38
II.	Employee Benefits	23% Staff 8% IH and Grads	2361.94
III.	Other Expenses		
	1. Publication		100.00
	2. Computer		250.00
	3. Telephone		50.00
	4. Supplies		100.00
	TOTAL OTHER EXPENSES		500.00
IV.	Travel		250.00
		SUBTOTAL	14007.32
V.	Indirect	42.5% of SUBTOTAL	5953.11
VI.	TOTAL		19960.43

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