

(b) Runoff Forecasting

There is a great need for runoff forecasts in Chile, as I mentioned before. In ENDESA we have used all kinds of available data: rain records (generally of rain gages located in the Central Valley); streamflow records; and temperature records. We have used a few different methods of forecasting, principally the one established by the U. S. Weather Bureau, based on multiple correlation. In the near future we are planning to introduce the snow water equivalent data, as this data begins to be applicable.

We are not only interested in forecasting the total runoff to be produced by snow melt (from October through January or October through March in our country), but we are also concerned in forecasting flow with a short time of anticipation. This is necessary for dam operations and flood control. It is especially important for us to forecast the high flows and the lower flows. Up to this moment we have used almost exclusively a comparison of the current flow with the historical records, that in many cases have proved to be a good short procedure, especially in the cases where streams are almost entirely fed by snow.

We are looking forward to establishing more observation points in our Andes, thus being able to apply the data to obtain better forecasts.

I have been informed that during the last summer season in Chile (December through March 1957) more snow courses and shelter cabins have been installed in the mountains.

CEILINGS UNLIMITED

By

Robert W. Miller^{1/}

We are always trying to find a quicker and easier way to perform a given task. In the case of snow surveys, the helicopter would seem to be the logical solution. Helicopter snow surveys certainly aren't a recent innovation--surveys were made by helicopter in some areas at least eight years ago. Realizing this, and that there has already been much said and written on the subject, I shall not try to approach the use of helicopters as a new panacea for all snow survey operations. Rather, the intent of this talk is to pass along the results of our rather brief experiences with this type of operation in the hope that they will be of some interest and/or value to those of you who might be contemplating a helicopter snow survey program.

The use of helicopters for snow surveys is extremely logical. Many years ago when helicopters were still in their infancy, Dr. Church prophesied that the day would come when many snow courses would be taken with the aid of helicopters. Almost as soon after World War II as helicopters became commercially available, the helicopter companies began promoting their use for snow surveys. In 1947, a contract was negotiated between an aircraft company and the U. S. Geological Survey in Washington for helicopter snow survey work. At that time, it was stated the helicopter could probably handle courses up to 11,500 feet. Four years and numerous helicopter improvements later, they decided the limit was nearer 6,500 feet. The State of California entered the helicopter snow survey picture on an emergency basis for a brief period in 1952. The results left much to be desired. The conclusion, at the end of approximately two weeks and about \$9,000, was that for high elevation operation and for range the helicopter just didn't have it. It should be pointed out, however, that this was an emergency operation. As such, there was no time for such details as caching fuel supplies. In addition, the entire operation was carried out during extremely adverse weather conditions.

By the summer of 1956, helicopters seemed to have improved to the point where they might be practical. At least the situation seemed to justify a re-evaluation. The results of this re-evaluation seemed to be that from the point of view of time saved, effort saved, and possibly even

^{1/} Hydraulic Engineer, Department of Water Resources, State of California, Sacramento, California.

money saved, the helicopter had something to offer. In cooperation with the Kern County Land Company, a trial program was set up on the Lower Kern River Watershed for the four sets of surveys during the 1957 snow survey season. At about the same time, the Southern California Edison Company and the Pacific Gas and Electric Company were independently setting up trial programs on the San Joaquin and Kings Rivers. In all three cases, negotiations were satisfactorily completed, and a helicopter snow survey program went into operation.

Now, with most of the survey season behind us, we have arrived at a number of conclusions. Possibly the best way to present these is by comparison with the same surveys as taken on foot.

First, consider the time element. Time saved is undoubtedly the most important advantage of a helicopter survey. In our case, the Lower Kern survey previously took eight to ten days on foot for ten courses. This year, with the aid of the helicopter, in April we took ten courses in one day. The Southern California Edison Company and the Pacific Gas and Electric Company experienced similar time savings.

Second, we have ease of operation. This is the rather obvious advantage, that it is easier to be deposited right at the snow course than ski in to it. In the case of our Lower Kern survey, it avoids a really tough trip that necessitated the snow surveyors slugging it out against a variety of ever-changing travel conditions that included mud, snow, rocks, and bare ground.

Third, consider relative costs. On our particular operation, we will save money this year by using the helicopter. The price basis for our surveys consisted of a base price plus an additional \$30 per course. In the case of our April survey of ten courses, total helicopter charges came to \$600.00. On foot, the same survey would have cost about \$500.00. However, we save approximately \$600.00 in cabin-stocking costs when the helicopter is used, which more than balances the slightly lower figure for the foot surveys.

Fourth, the safety situation. As of this date, our limited experience would hardly justify any conclusions on this point. However, we believe that with the pilots and equipment we are using, the helicopter snow survey is quite safe.

We must also consider the disadvantages of helicopters. With their current state of development and high cost, the helicopter certainly is not the answer everywhere. With normal conditions and a reasonably large landing area, we feel that 10,000 feet is about the practical elevation limit for operations at this time. The cost of helicopter snow surveys precludes their use for taking courses where the trip involves less than three days. This is an arbitrary figure, but we feel it is a good base for consideration. A further disadvantage of helicopter operations is that they are so strongly dependent on good weather. Generally speaking, foot surveys can continue in weather that grounds helicopters, and this is especially true when there is a wind condition. However, the helicopter has one advantage over foot surveys during a period of adverse weather; the helicopter can get in and complete the surveys in one day of good weather between storms.

In setting up a helicopter operation, there are a number of minor points that we feel are worth mentioning.

First, is the matter of contracts: A price arrangement of a base price plus a per course charge is thought to be preferable to an hourly rate. The arrangement of an hourly rate with a minimum daily guarantee makes it almost impossible to determine ahead of time what the total costs will be. The daily guarantee can be extremely expensive in the case of bad weather.

Second, if possible, a test run to all courses should be made prior to the survey season. This test run serves a number of purposes:

- a. It serves to locate courses and establish that landings can be made.
- b. It provides an altitude operation check.
- c. It establishes if landing area improvements are necessary and with enough time to make them prior to the survey season.
- d. It makes it possible to determine the best refueling procedures and to cache gas prior to the surveys, if necessary.

A third point is the matter of optimum crew size. This season we made surveys with three men and the pilot--with two men and the pilot--and also with just one surveyor and the pilot. We now feel that unquestionably the optimum crew size is to have one surveyor and the pilot with the pilot acting as the second man of the survey crew.

The foregoing discussion includes the most pertinent of our thoughts, conclusions, and recommendations regarding helicopter operations at this time. In summary, it could well be stated that it is our feeling that helicopters have made their place in snow surveys and that we would expect this position to expand.

HELICOPTERS - FROM THE FIELDMAN'S VIEWPOINT

By

Willard W. Dean^{1/}

Travel on foot to isolated mountain snow courses and streamflow measuring stations has largely been made obsolete during the past 20 years by the use of mechanized over-snow vehicles for traveling over snow such as the Tucker Sno-Cat, the M-7, the Frandee Sno-Shu, the Weasel, the snow plane, the motorized toboggan, and others. Planes like the Supercub have been used at some locations where landings on skis are possible. From the fieldman's viewpoint, however, the helicopter is the best mode of over-snow transportation of this kind yet developed.

All of these vehicles have eased the work of the snow surveyor and stream gager. All have helped him to concentrate more on hydrologic data collection and less on the struggle over the snow to the point of measurement. Under the proper conditions the helicopter can now carry the fieldman and his equipment quickly to many stream gaging stations or snow courses with a minimum of effort on his part.

Use of the helicopter does not imply that snow tractors will soon be junked as many trips will continue to be made on the ground. Foot travel will be necessary on ground over which the snow tractor cannot operate or where the helicopter cannot land. In using any form of mechanical transport, the fieldman may some day find that mechanical failure forces him to proceed on foot.

Helicopters have been used in stream gaging from time to time since the late 40's when the Tacoma District of the Geological Survey began using helicopters for transport to snow courses and possibly there was some earlier usage. The Salt Lake City District is using a helicopter to go to remote gaging stations below 10,000 feet in the Wasatch Mountains. This year in California helicopters are being employed for the first time to carry hydrographers to 12 gaging stations operated for several cooperating agencies in the Kern, Kings, Stanislaus, and American River basins.

Helicopters have given very good results to date, and their use has been justified on an economic basis alone. The rather high cost of operation has been equalled by the saving in salary and per diem of personnel and operation costs of the snow tractor. Other gains such as improvement in the fieldman's morale and the better utilization of technical manpower are most important. No longer do hydrographers sometimes struggle in a snow tractor for three or four days to reach one or more gaging stations, and then need an equal amount of time to rest up before they are ready for field work again.

The Menlo Park District has chartered a Bell G-2 model helicopter with a 260 horsepower Lycoming engine. The cost is \$100 per hour of flying time. The district guarantees a minimum amount of flying time and no charge is paid for standby time. A charge of 25 to 32 cents per mile each way is paid for moving the ship by trailer from airport to the operating base - the point on a plowed road nearest to the group of gaging stations.

By using Weather Bureau short range forecasts little trouble has been experienced with weather conditions. A tentative day is scheduled for flying and firmed up 24 hours in advance. Good flying weather is essential.

The winter is usually a comparatively slack period for agricultural helicopter work and there

^{1/} Hydraulic Engineer, U. S. Geological Survey, Sacramento, California.