

USE OF SNOW-MELT FORECASTS BY THE CORPS OF ENGINEERS FOR FLOOD CONTROL OPERATIONS ON THE RIO GRANDE

by

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The Corps of Engineers' responsibility for flood control operations is established by three principal pieces of Federal legislation:

The Flood Control Act of 1936 made the Corps responsible for flood control investigations and projects planning, construction and maintenance and operation on all navigable streams and their tributaries except the Tennessee Valley.

The Flood Control Act of 1944 established the Corps as responsible to prescribe regulations for the use of storage allocated for flood control at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purpose. This concerns projects constructed and operated by the Bureau of Reclamation and other agencies.

Public Law 99 and other special continuing authorities authorized the Corps of Engineers to participate in flood fights and rescue work during emergencies.

These laws permit the Corps to make emergency repairs and restoration of any existing flood control facility. These laws provide that the Corps shall construct the necessary projects to provide flood protection to public facilities such as highway bridges, etc. and to construct badly-needed small projects which are not covered by authorized flood control studies. Funds for operations under these continuing authorities are available through Corps-wide annual appropriations and as a result are somewhat limited in certain instances.

To show how the above obligations are met during snow-melt floods on the Rio Grande, the river basin above Elephant Butte Dam is divided into three reaches: the San Luis Valley, Espanola Valley, and Middle Valley (Reference to watershed display map, a copy of which is attached).

The San Luis Valley reach extends from the headwaters to the Colorado-New Mexico state line. The Corps has a local protection project consisting of an improved channel on Willow Creek through Creede, Colorado, and a small amount of capacity in Platoro Reservoir allocated exclusively for flood control with remainder of the reservoir capacity available by seasonal evacuation based on snow-melt runoff forecasts. The Platoro Reservoir, located on Conejos River, Colorado, was constructed and is operated by the Bureau of Reclamation. The other Corps' interests in the San Luis Valley which require snow-melt runoff forecasts are minor, consisting of the timely dispatch of an observer to the area to collect engineering data and possibly furnish assistance in a flood fight at the city of Alamosa, Colorado.

The Espanola Valley extends from Velarde, New Mexico to the head of White Rock Canyon, downstream from Espanola. This reach is subject to inundation and scour by spring flood waters. An interim degree of protection is provided at Espanola by a leveed floodway. During large floods the Corps must be prepared to assist the local interests in a flood fight at this project. The levee project was constructed or improved by the State of New Mexico.

The Middle Valley extends from Cochiti to the head of Elephant Butte Reservoir. This reach constitutes a major flood problem during snow-melt floods. Almost the entire reach consists of a leveed floodway and at this time the levees and floodway are under improvement by the Corps of Engineers and the Bureau of Reclamation. The newly-completed works and the construction activity in the floodway both emphasize the need for snow-melt forecasts.

The U. S. Weather Bureau, beginning on 1 January each year, issues the monthly publication "Water Supply Forecasts for the Western United States." I am sure all of you are familiar with these bulletins. These forecasts are presented for the complete water year and for the seasonal period, April through July. The Soil Conservation Service publication "Snow Survey and Water Supply Forecasts for Colorado and New Mexico," is also available beginning 1 January on a monthly basis, through 1 May, and semi-monthly to 15 June. The "Water Supply" forecasts by Soil Conservation Service are presented in terms of percent of normal for the season April through September, but this publication contains valuable data

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on snow depth and water content at several snow courses in the basin. For the particular purpose of regulation of the Platoro Reservoir the Bureau of Reclamation furnishes the Albuquerque District with runoff forecasts on the Conejos River, Colorado, beginning on 1 March. Beginning on about 1 April, stream gaging data are obtained from the pertinent gages in Colorado and New Mexico through the Weather Bureau office in Albuquerque. Heavy diversions are made from the Rio Grande in Colorado for irrigation during the runoff season. These diversions may materially affect flood flows in the vicinity of Alamosa, and the contribution to flood flows in the Espanola and Middle Valleys from the Rio Grande watershed in the San Luis Valley. For this reason it is necessary to obtain advance notice, if possible, from state and local representatives as to the plans for any material changes in these diversions. In addition, there is considerable storage for irrigation in reservoirs near the head waters of the Rio Grande which generally become filled during a major runoff and begin to spill at a crucial time when related to flood flows throughout the Rio Grande. The status of these reservoirs is obtained through the same state and local officials. During the runoff period the Weather Bureau provides 4-day temperature forecasts for two locations, Santa Fe, New Mexico and Alamosa, Colorado. These temperature forecasts are revised each day.

The 1 March forecasts serve primarily as a guide to estimate the amount of effort and material which will be required to conduct a successful flood fight. The Bureau of Reclamation issues a 1 March forecast for the flow of the Conejos River at Mogote for the period April through July. This forecast is used, along with a set of "rule curves," to determine the subsequent operation at Platoro Dam. If releases are required the rule curves indicate the magnitude of such releases. In the past, the Corps of Engineers has acted in an advisory capacity to the Bureau of Reclamation and the Middle Rio Grande Conservancy District for the regulation of El Vado Reservoir on the Chama River for optimum reduction of flood flows through the Middle Valley. When New Mexico is in a debit status with respect to the Rio Grande Compact, or if Project Storage in Elephant Butte and Caballo Reservoir is below 400,000 acre-feet on 1 March, the use of El Vado Reservoir for flood-control purposes requires prior unanimous consent of the Compact Commission. If flood control regulation appears desirable after the 1 March forecasts, permission is requested to operate El Vado Dam for flood control purposes at this time, and an answer can be obtained from the Commission before the spring runoff begins. The Albuquerque District supplements the official forecasts with correlation curves which cover only the balance of the spring runoff and with curves which relate peak discharge to volume of runoff. This enables us to estimate the maximum discharge rates through each of the reaches of the river, which is an aid in planning the subsequent activities.

If the 1 April forecasts indicate significant runoff it is the signal to get geared for action, as it is about this time that the spring rise begins. Flows seldom reach serious proportions before the latter half of April and usually become critical during May. On the average, the Rio Grande at the Otowi gaging station has two peaks, the first about 15 May and the second about 1 June. The first of these peaks is due mainly to contributions from the Chama River and the second is from flows which originate mainly in Colorado, but which also includes the recession of flows from the Chama River.

Snow-melt runoff from the Jemez Basin usually begins about two weeks before the Rio Grande starts to rise and flows are passed through the Jemez Reservoir until the Rio Grande below Jemez Creek approaches damaging stages, after which releases are reduced to the extent necessary to restrict the Rio Grande to non-damaging flows as long as possible.

The Albuquerque District uses its set of forecast curves in order to get an idea of the total volume of runoff to be expected at the key gaging stations as soon as the snow-course data is obtained and before the official forecasts are available from the Weather Bureau. We also have hydrographs plotted for the past twenty-five years or so, and from comparisons of the distribution of the snow pack we can estimate the pattern of the runoff.

Beginning about 1 April a program of short-term forecasting is commenced as an aid in determining the day-by-day releases to be made from the various flood-control reservoirs in the system. Daily readings from the key gaging stations in the Basin are received by the District Office from the Weather Bureau. These gage readings are converted to flows, based on the latest rating curves and shifts furnished by the Geological Survey. Past experience indicates the response of these flows to temperature changes, and by utilizing four-day temperature forecasts, furnished by the Weather Bureau, and by routing these flows downstream, Rio Grande discharges in New Mexico may be forecast as much as a week in advance with a fair degree of accuracy. Contribution by storms during this period is not easily forecasted until the flows have appeared in the river and have been recorded at one of the key gaging stations, after which they can be routed downstream, and accurate one- or two-day forecasts made for the lower stations. A continual check of the cumulative runoff is maintained for each station to determine if the peak discharge is just occurring, has occurred, or is yet to occur. A continual check must also be maintained of the amount of storage in irrigation reservoirs because sometimes peaks appear

in the river as the result of the cessation of storing water. This might occur before, during or after the natural peak of the stream and successful forecasting depends on keeping tabs on as many of the elements as possible. Another of these elements is the amount of irrigation diversions from the Rio Grande which sometimes exceed 4,000 c.f.s. in the San Luis Valley.

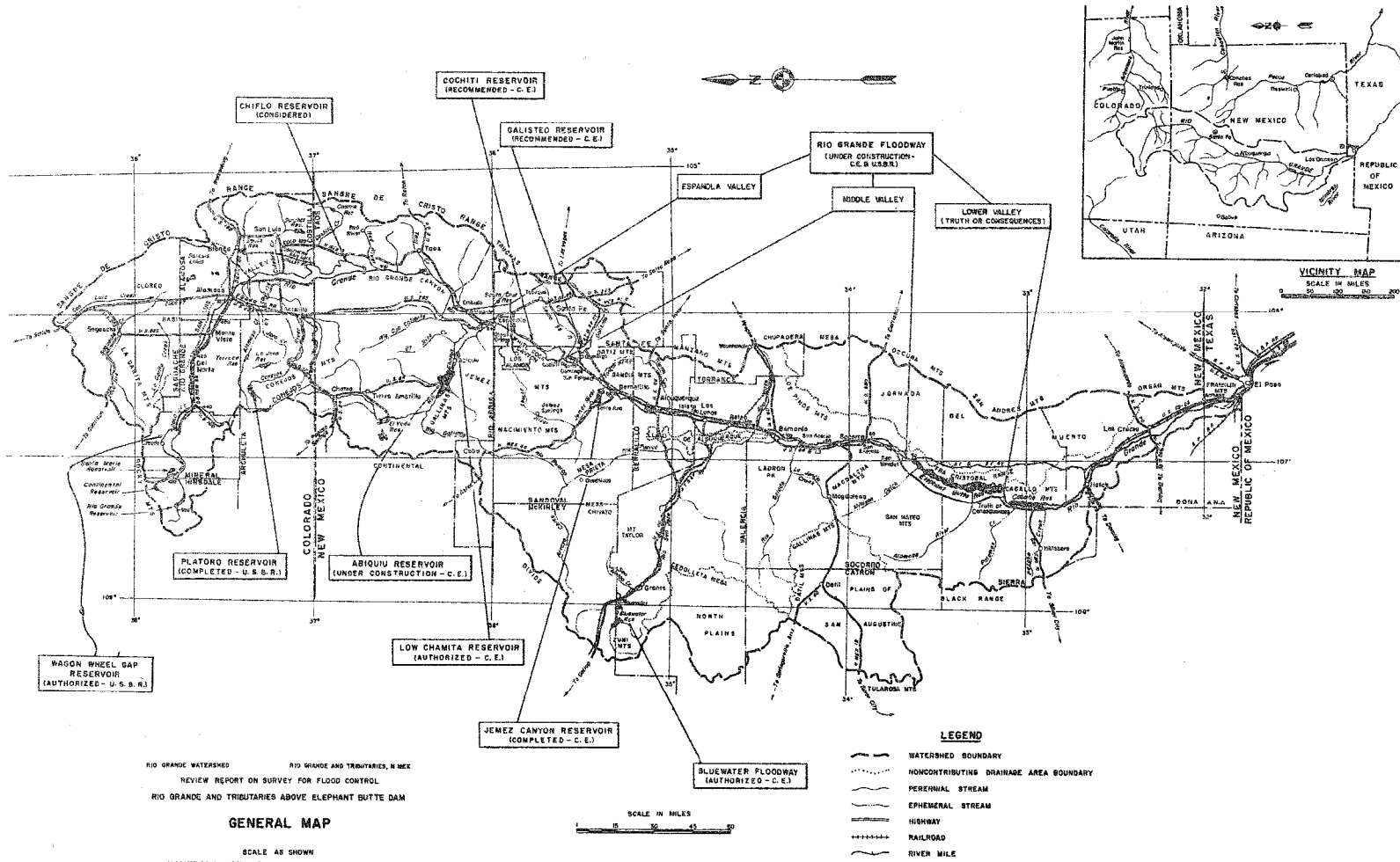
The correlations mentioned above were developed in 1952. These correlations were based on snow courses, then in existence, which had several years of record. The snow courses were weighted according to the area in the elevation band in which they were located. Those courses within each elevation band were separated as to direction of exposure and all those with the same exposure were averaged together; these averages were then averaged to give the representative water content for that elevation band. The other parameters entering into the correlation were the average antecedent precipitation during the period September through December, and the average precipitation during the balance of the spring runoff period. The precipitation stations used were those considered representative of the snow-melt runoff contributing area of the basin for which the forecast curve was made. The weighted sum of these three parameters was used as the independent variable and volume of discharge for the balance of the spring runoff season was used as the dependent variable. The points were plotted and a line of best fit was drawn. The weighting factors for the three parameters varied with the basin and with the time of the forecast, but in general the weight given the snow-cover approximately equalled the combined weight of the two precipitation factors. Use of precipitation subsequent to the time of the forecast permits the shading of the average precipitation in line with the Weather Bureau 30-day forecasts. During and subsequent to 1952, many new snow courses have been established and it is planned that next year correlations will be determined, using the additional data which have accrued since 1952. The peak-volume relationships were based on flows which were corrected for reservoir storage and so give an indication of the natural peak to be expected. Regulation of reservoirs for flood control would be planned for the maximum reduction of this peak.

It has been observed that the spring runoff begins immediately following the period for which the mean temperatures at Santa Fe average above 40° F, for at least 4 days. Comparing the flows of the Rio Grande at Otowi, it appears that prior to the peak the flows vary about 200 to 250 c.f.s. per degree change in the mean temperature at Santa Fe and lags the temperature change by about 3 to 5 days, the lag becoming longer as the snow line recedes.

I have described the use of snow-melt runoff forecasts based on the existing development in the Rio Grande watershed. These developments are subject to change considerably in the near future. In the San Luis Valley, the Bureau of Reclamation has an authorized Wagon Wheel Gap Reservoir on the main stream above Del Norte, Colorado. Wagon Wheel Gap will be a multiple purpose irrigation and flood control project with flood control allocations similar to Platoro Reservoir, except on a much larger scale. The Corps has the Abiquiu Reservoir on the Chama River under construction at this time. The Chama River is a major tributary which enters the Rio Grande in the Espanola Valley reach. The Board of Rivers and Harbors, the State of New Mexico, and the Rio Grande Compact Commission have approved or indorsed a Corps of Engineers report which would authorize the construction of the Cochiti Reservoir for flood control on the Rio Grande at the head of the Middle Valley. This report also contains a flood control reservoir on the Rio Gallisteo which would not be involved materially in snow-melt runoff. If and when the above projects are placed in operation the program for collecting precipitation, snow accumulation and stream flow data in the Rio Grande basin will need to be expanded materially. Further, the procedures of snow-melt forecast analyses will be supplemented and improved.

The above forecast analyses are made for Corps of Engineers operational needs and are subject to variation and modification. Further, due to the paucity of information, they require the application of considerable experience and judgment. For these reasons the relationship curves and charts described are not for publication or distribution.

I will close by expressing the appreciation of the Corps of Engineers for the excellent cooperation of Federal agencies in furnishing the snow-melt forecasts and stream flow, and the State and local representatives who furnish operational plans during the runoff season.



RIO GRANDE WATERSHED
 REVIEW REPORT ON SURVEY FOR FLOOD CONTROL
 RIO GRANDE AND TRIBUTARIES ABOVE ELEPHANT BUTTE DAM

GENERAL MAP

SCALE AS SHOWN
 ALBUQUERQUE DISTRICT, ALBUQUERQUE, N. MEX.
 APPROVED: [Signature]
 SPECIAL AGENT IN CHARGE
 GRADE: H.C.L.
 TYPED: J.S.B. FOR ADDRESS REPORT
 CHECKED: H.C.L. 10/15/54
 FILE NO. RGTR - RR - 1

NOTE:
 RIVER MILE 0 (ELEPHANT BUTTE DAM);
 RIVER MILE 176.4 (ABOVE THE MOUTH)