

Cloud Seeding Suspension Criteria in the State of Utah



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Summary

“*Cloud Seeding*” or “*Weather Modification*”, as defined in the cloud seeding reports of the Utah Division of Water Resources (DWR), means all intentional acts undertaken to artificially distribute hygroscopic and ice nuclei into selected clouds to augment precipitation, mitigate hail or disperse cold fog. “Cloud seeding project” means a planned project to evaluate meteorological conditions, perform cloud seeding operations, and evaluate results. Cloud seeding in Utah typically refers to enhancement of precipitation by artificially stimulating clouds to produce more rainfall or snowfall than they would naturally. Cloud seeding is a complex process consisting of interactions between multiple atmospheric, hydrological, and human induced factors that have direct and indirect effects on snowpack, snowmelt, and snow-dominated streamflows. There are no documented reports or published journal articles that clearly guide the derivation of cloud seeding suspension criteria and the indices currently used in the State of Utah. Therefore, this document will also function as a foundation document for cloud seeding suspension activities and provide the basis for future updates and improvements to suspension criteria in the future.

This report documents proposed Snow Water Equivalent (SWE) indices-based cloud suspension criteria derived from seasonal streamflows and observed SWE values of SNOTEL stations in cloud seeding projects in the State of Utah. The objectives of this report are: (1) review and summarize the cloud seeding suspension criteria practiced in Utah and neighboring states of Utah such as Colorado, California, and Nevada; (2) evaluate the existing SWE based indices and establish a relationship between the SWE and streamflow in the cloud seeding projects; and (3) update and recommend cloud seeding suspension criteria in the project areas.

Statistical methods were adopted to establish relationships between SWE values and observed streamflows (here defined as critical flow). The critical flows represent the 95th percentile cumulative volume of the annual seasonal streamflow (April to July). The data used to calculate the seasonal cumulative volume for each of the basins were extracted from the USGS website (mostly daily flow from 1979 to 2017). The SNOTEL stations considered in this study are located within the catchment of each river basin, have long historical observational data records available, and have been continuously updated by the NRCS. The results of the SWE indices-based criteria derived from this study are similar to the existing SWE-based suspension criteria adopted in Utah. For example, currently a cloud seeding project in Utah is flagged for possible suspension if SWE values observed from one or more SNOTEL sites in a given basin exceeds 200% of the average on January 1, 180% on February 1, 160% on March 1, or 150% on April 1. The calculated average suspension criteria from this study are 230%, 197%, 183%, and 178% for January 1, February 1, March 1, and April 1, respectively. Unlike the existing practice of taking a single percentage value for the entire state, it proposes basin/project specific SWE instantaneous value for each month and