The Flood of 1997

FINAL REPORT:
An Analysis of Snowpack Water Content and Precipitation Changes in the Waterbasins of Western Nevada and the Effect on Runoff and Stream Flows
December 16, 1996—January 6, 1997

JANUARY 1997
[Revised and Updated: May 1997]

Nevada Division of Water Planning
Department of Conservation and Natural Resources

Notes to the Reader

This analysis report on "The Flood of 1997" is intended to provide insights into the extreme flooding conditions which affected the Lake Tahoe and Truckee, Carson, and Walker River Basins in western Nevada beginning on January 1, 1997. These events resulted in the Nevada counties of Churchill, Douglas, Lyon, Mineral, Storey, and Washoe, and the Independent City of Carson City being declared as federal disaster areas. This analysis provides insights and comparisons with respect to changes in precipitation and changes snowpack water content over specific time periods within the overall event period of December 16, 1996 through January 6, 1997. These time periods were chosen to isolate the effects of prior heavy snowfall in late December 1996 and the effects of subsequent heavy, warm rains which began on December 30, 1996, and lasted through January 3–5, 1997. Should you have comments regarding these dates and/or events, or additional information pertaining to this analysis, please contact:

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Publications in the Division of Water Planning's Nevada Water Basin Information and Chronology Series

Carson River Chronology
Truckee River Chronology
Walker River Chronology

[NOTE: The most current versions of these Nevada river chronologies are also available on the Internet through the Nevada Division of Water Planning's Home Page address listed above.]

Acknowledgments

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Introduction

The flood event of January 1997 represented one of the most significant and most devastating floods in recorded history within the waterbasins of western Nevada. The flood event was basically a rain-on-snow and wet mantle (rain on saturated soils) flood event, worsened by the extreme warmth of the tropical rain system which entered the Sierra Nevada Mountains by December 30, 1996 and lasted through January 3-5, 1997.

The extreme warmth of these rains effectively melted much of the accumulated snowpack below 7,000 feet in elevation and also produced heavy rainfall even up to 10,000 feet, preventing significant snowpack accumulation, or rainfall absorption, even at those higher elevations. As a consequence, a significant portion of the rainfall at all elevations went to available runoff, which, in combination with the water lost from the depletion of the snowpack, amplified the effects of the flooding.

This analysis on "The Flood of 1997" is intended to provide insights into the origins and causes of the January 1997 flood event and to analyze why the event produced such extreme levels of runoff in the river systems of these western Nevada water basins.

The report is organized into ten separate sections: (1) Summary; (2) Notes on the January 1997 Flood Event Analysis, and on Accompanying Appendices, Data Tables, and Graphs; (3) Analysis of the January 1997 Flood Event; (4) Supplemental Flood Analysis: An Approximation of "Natural" (Hypothetical) Truckee River Peak Flows at Reno, Nevada, and Comparisons to the Record Flood of 1955; (5) Appendix A—Northern Nevada Principal Watershed Maps, River Flow Schematics, and NRCS SNOTEL Sites, and Nevada Hydrographic Basins; (6) Appendix B—Lake Tahoe Basin SNOTEL Site Tables and Graphs; (7) Appendix C—Truckee River Basin SNOTEL Site Tables and Graphs; (8) Appendix D—Carson River Basin SNOTEL Site Tables and Graphs; (9) Appendix E—Walker River Basin SNOTEL Site Tables and Graphs; and (10) Appendix F—NWS Precipitation Tables and Graphs. All data is provisional and subject to later revision.

The Flood of 1997

Western Nevada and the Sierra Nevada Mountains

Date of Presidential Declaration: **January 3, 1997**
Disaster Number: **FEMA-1153-DR-NV**
Type of Disaster: **Ongoing severe storms, flooding, and mud and landslides**
Initial Incident Period: **December 20, 1996–January 3, 1997**
Amended Incident Period: **December 20, 1996–January 17, 1997**
Period of this Analysis: **December 16, 1996–January 6, 1997**
Initial Designated Nevada Counties: **Douglas, Lyon, Storey, Washoe, and the Independent City of Carson City**
Amended Declaration: **January 15, 1997**
Added Designated Nevada Counties: **Churchill and Mineral**

Nevada Waterbasins Impacted:

Lake Tahoe Basin (as the Upper Truckee River Basin)
Truckee River Basin
Carson River Basin
Walker River Basin

Summary

The flood event of January 1997 represented one of the most significant and most devastating floods in recorded history within the waterbasins of western Nevada. The flood event was basically a rain-on-snow and wet mantle (rain on saturated soils) flood event, worsened by the extreme warmth of the tropical rain system which entered the Sierra Nevada Mountains beginning on December 30, 1996, and lasted through January 3, 1997. The warmth of these rains effectively produced heavy rainfall even above 10,000 feet in elevation and largely prevented significant snowpack accumulation, or rainfall absorption, even at those higher elevations. As a consequence, a significant portion of the rainfall at all elevations went to available runoff.

The flood event and its origins centered around two primary events: (1) late December 1996 storms originating in the Gulf of Alaska which produced extensive snowpack buildup in the Sierra Nevada Mountains and the valleys below during the period of December 20 through December 23, 1996, and again, to a lesser extent, over the period of December 27 and December 28, 1996; and (2) warm, torrential tropical rains beginning on the last days of 1996 and continuing into early 1997 and precipitating from an extremely wet system of storms originating in the central Pacific region near Hawaii (i.e., the "Hawaiian Express", the "Hawaiian Hoser", or the "Pineapple Connection"). This storm system precipitated heavy rainfall in the Sierra Nevada Mountains beginning on Monday,

December 30, 1996 and lasting through Friday, January 3, 1997. The effects of this severe storm system, which produced rainfall at virtually all elevations, tended to move south down along the Sierra Nevada Mountains, bringing on delayed rain and flooding conditions from the Lake Tahoe Basin to the Truckee River Basin, then to the Carson River Basin and finally to the Walker River Basin.

Due to the heavy snows and abundant snowpack water content accumulation realized during the period of December 20 through December 28, 1996, the subsequent warm rains not only produced considerable quantities of direct runoff, but snowmelt runoff as well. The melting of virtually all of the snowpack at elevations generally below approximately 7,000 feet greatly added to the available runoff from direct precipitation and significantly worsened the effects of the flood event. The heaviest rainfall recorded at monitored Natural Resources Conservation Service (NRCS) SNOTEL (snowpack telemetry) sites was at Squaw Valley (Gold Coast) at just over 22 inches during only a 3–4 day period. This rainfall, combined with nearly 3 inches of snowpack meltdown, produced 25 inches of total available runoff from this location, resulting in a raging torrent in Squaw Creek, which directly enters into the upper Truckee River below the Lake Tahoe Dam.

While the flood's effects through Reno and Sparks in the Truckee River Basin may not have attained the definition of a "100-Year Flood Event," few would seriously debate the fact that a new record flood event was only prevented by the judicious and timely regulation of upstream reservoirs by the U.S. District Court Federal Water Master in Reno, Nevada. The critical regulating structures include Stampede Dam and Boca Dam on the Little Truckee River, Prosser Dam on Prosser Creek, and Martis Dam on Martis Creek. Except for Boca Dam and Reservoir, which was completed in 1939, the other regulating dams and reservoirs, particulary Stampede Reservoir with a maximum holding capacity of some 226,000 acre-feet, were not available for such flood-prevention purposes in 1950 or 1955, flood years which generally constitute the most devastating prior flood event periods.

There is little question, however, that had ample storage capacity not been available in these regulating reservoirs and along the principal tributaries of the Truckee River, the devastating effects of the current flood event would have been significantly worse and undeniably exceeded the record flows of any prior flood event. [For a more extensive analysis of this concept, see "Supplemental Analysis: An Approximation of "Natural" (Hypothetical) Truckee River Peak Flows at Reno, Nevada, and Comparisons to the Record Flood of 1955" which follows this analysis.]

The potentially devastating effects of this flood event may be assessed by evaluating the outflows of the normally inconsequential tributary streams entering the upper Truckee River between Tahoe City and Truckee, California. Due to the lack of any retaining structures, none of these outflows were regulated during this storm event. Flows along the initial 15-mile stretch of the Truckee River increased from a peak rate of flow of approximately 2,500–2,600 cubic feet per second (cfs) at the outflow of the Lake Tahoe Dam at Tahoe City to nearly 12,000 cfs at Truckee, California. However, due to an extensive system of dams on principal tributary streams, over the next 25 miles of the Truckee River's reach, Truckee River rates of flow increased to just over 18,000 cfs by the time they reached Reno, Nevada.

Flows at the USGS Reno gaging station, located 400 feet downstream from the Kietzke Lane Bridge, peaked at 18,200 cfs on the morning of January 2, 1997, below the record of 20,800 cfs set in 1955 (making this event at this location less than a 50-year flood event). However, the river stage (height) at Reno reached 14.91 feet, 2.0 feet over flood stage (12.0 feet) and higher than 1950's stage of 13.83 feet. Further downstream, the river's effects were noticeably more severe, primarily due to extensive flood waters entering the Truckee River from Steamboat Creek. Flood conditions in Steamboat Creek, which flows north along the eastern side of the Truckee Meadows, effectively isolated the residential community of Hidden Valley by flooding this area's two primary access routes.

Despite the fact that the flow at the USGS Reno gage only reached 18,200 cfs, this rate of flow was nonetheless sufficient to create extensive havoc throughout Reno and Sparks, particularly below this gaging station location. Of particular note was the flooding of the Reno Hilton Hotel and Casino RV park and Hilton pond, and across the Truckee River from the Reno Hilton the inundation of Sierra Pacific Power Company's Glendale water treatment plant, the flooding of the Reno–Tahoe International Airport, the extreme erosion of the Truckee River's banks between the Rock Street and East McCarran Avenue bridges, the extensiveness of the flooding in the Sparks industrial area, and the river's record stage at Vista below Steamboat Creek.

In the Lake Tahoe Basin, the heavy snowfall accumulated from the two prior snowfall events, combined with warm torrential rains over a relatively short period of time, resulted in an outpouring of runoff which fed nearly 136,000 acre-feet of water into Lake Tahoe over a six-day period from the morning of Monday, December 30, 1996, to the morning of Sunday, January 5, 1997 (over 166,000 acre-feet to include concurrent lake outflows at the Lake Tahoe Dam). In a normal water year, the Lake Tahoe Basin produces approximately 530,000 acre-feet of water. As a result of this storm event, over a period of only six days the Lake Tahoe Basin produced nearly one-third of its annual average ("normal" water year) water production.

In contrast to the more regulated Truckee River, limited tributary and mainstem storage capacity in the Carson River Basin and the Walker River Basin produced new record flows along virtually all reaches of these river systems. Relatively heavy snowpacks in Washoe Valley, Carson Valley, and particularly Eagle Valley (Carson City), combined with heavy mountain runoff, produced severe flooding in these areas, sending flood waters over U.S. Highway 395 in Pleasant Valley, Washoe Valley, and Carson Valley and thereby severing the main highway connection between Reno, Carson City, and Minden–Gardnerville.

In the Carson River Basin, significant flooding occurred in the Carson Valley from essentially southwest of Gardnerville, Nevada, all the way to where it exits Carson Valley and enters Eagle Valley to the north. Along the Carson River system, record stream flows were recorded at Markleeville, California, and further downstream at Gardnerville, Nevada, both located on the Carson River East Fork, and at Woodfords, California, on the Carson River West Fork. Neither of these forks have any significant upstream regulation flow capabilities.

In the Walker River Basin, record flows on the West Walker River washed out U.S. Highway 395 along an eight-mile stretch through the Walker Canyon between Walker and Sonora Junction, both located in Mono County, California. Flood waters emerging from the Walker Canyon also flooded the community of Walker, washed away a two-mile segment of Nevada State Route 208 through Wilson Canyon between Smith and Mason valleys and, when combined with the flood waters of the East Walker River, caused extensive flooding in Mason Valley and particularly within the City of Yerington.

While perhaps not the worst flood of record in all waterbasins and along all river reaches, this event will certainly be remembered for its severity, its suddenness, its brevity, and the widespread damage and socioeconomic disruption it produced throughout the watersheds of western Nevada. Without the ability to regulate Truckee River inflows from the river's principal tributaries the flooding impacts downstream in the Truckee Meadows and in the cities of Reno and Sparks, Nevada would certainly have been far more severe than they were and undoubtedly would have exceeded any prior recorded flood event. The impacts of "The Flood of 1997" will necessitate considerable assessment, reassessment, and additional planning and mitigation to preclude or minimize future such events.

The Flood of 1997

Notes on the January 1997 Flood Event Analysis, Appendices, Data Tables, and Graphs

Appendix A of this analysis of *The Flood of 1997* contains an assortment of western Nevada watershed maps, river flow schematics, and a map showing the Sierra Nevada Mountain Natural Resources Conservation Service (NRCS) SNOTEL (snowpack telemetry) measuring sites used in this analysis. Also presented in Appendix A is a listing of Nevada's fourteen (14) hydrographic regions (waterbasins or watersheds) and a more detailed table showing physical characteristics of the hydrographic areas and sub-areas contained in the Nevada (only) portions of the Truckee, Carson, and Walker River Basins. A combined watershed map produced by the U.S. Geological Survey (USGS), Water Resources Division, Carson City, Nevada, is provided for the Truckee River Basin (including the Lake Tahoe Basin), the Carson River Basin and the Walker River Basin.

More extensive separate maps, also produced by the USGS, are provided for the Lake Tahoe Basin (as the upper Truckee River Basin) and the Walker River Basin. River flow schematic diagrams produced by the USGS, which show the relative locations of USGS gaging stations, are provided for Lake Tahoe and the upper Truckee River system down to the Farad gaging station near the California-Nevada state line. Other river flow schematics cover the remainder of the Truckee River system from the USGS Farad gaging station down to Pyramid Lake, the Carson River system, and the Walker River system. A portion of the NRCS SNOTEL site location map is provided detailing those monitoring sites in western Nevada and eastern California which are analyzed in this report.

All source data relative to Sierra Nevada Mountain accumulated precipitation and accumulated snowpack water content was obtained from the NRCS, U.S. Department of Agriculture (USDA), Reno, Nevada, and was collected by their SNOTEL electronic telemetry snowpack (snow "pillow") and precipitation measuring systems. These data, representing accumulated snowpack water content (in inches) and accumulated total precipitation, are for the water year beginning October 1, 1996. Data on stream flows and river stage levels was provided by the USGS and the U.S. District Court (Federal) Water Master's office in Reno, Nevada, for various streamflow gaging stations. These gaging stations measure only the height, or stage, of the river at a particular location relative to a specific base level, or datum; rating tables are then used to translate this river stage information into a flow (measured in cubic feet per second) and, based on a time factor (i.e., day, month, year), into a runoff or discharge amount (measured in acre-feet per a given time period).

Upper Truckee River reservoir stage, spill, and water release information was provided by U.S. Bureau of Reclamation (USBR), Lahontan Basin Area Office, Carson City, Nevada. Lake Tahoe surface elevations and water release figures at the Lake Tahoe Dam at Tahoe City, California, was provided by the Federal Water Master's office in Reno, Nevada. Precipitation data for other monitoring sites and estimated stream flow data was provided by the National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA), Reno, Nevada.

All data used in this analysis are provisional and subject to revision. Precipitation and snowpack water content data were selected for analysis by the Nevada Division of Water Planning (NDWP) for NRCS SNOTEL monitoring sites within four (4) principal western Nevada waterbasins to include the Lake Tahoe Basin (comprising the upper portion of the Truckee River Basin), and the Truckee, Carson, and Walker River Basins. These watersheds constituted the primary areas of most severe storm and flood activity and encompass the Nevada counties of Douglas, Lyon, Storey, and Washoe and the Independent City of Carson City. A Presidential disaster declaration for these counties was made on January 3, 1997. This declaration was later amended on January 15, 1997, to additionally include the Nevada counties of Churchill and Mineral. These two counties include the terminus locations of the Carson and Walker rivers, respectively. The disaster declaration number (contract number) assigned to this disaster declaration was FEMA-1153-DR-NV, and covered the amended time period of December 20, 1996 through January 17, 1997.

NRCS SNOTEL sites were specifically chosen for this analysis so as to provide snowpack water content and precipitation data for both upper Sierra Nevada Mountain elevations sites, i.e., between 9,000 and 10,000 feet above mean sea level (MSL), and for lower level sites located between 6,000 and 7,000 feet MSL. Analysis of the data of the lower elevation SNOTEL sites was particularly important in assessing the contribution of the melting snowpack to increasing the level of available runoff beyond that expected from the actual level of direct precipitation. The analysis of the data of the higher elevation SNOTEL sites indicated at what point the snowpack at these locations could no longer absorb the heavy rainfall.

Data and analysis tables for the four principal water basins of northwestern Nevada—the Lake Tahoe Basin (Appendix B, Tables 1A and 1B), the Truckee River Basin (Appendix C, Tables 2A and 2B), the Carson River Basin (Appendix D, Tables 3A and 3B), and the Walker River Basin (Appendix E, Tables 4A and 4B)—provided valuable information regarding the sources, phases and effects of the heavy snow and flood events of late December 1996 and early January 1997. Tables 1A, 2A, 3A, and 4A are summaries of changes in precipitation, changes in snowpack water content, and available runoff for each waterbasin for the periods of December 16–23, 1996, and December 31, 1996–January 6, 1997. Tables 1B, 2B, 3B, and 4B provide the more detailed source data for these summary tables.

The overall flood "event" may be timed to have actually started around December 20, 1996, with the commencement of heavy snowfall in the Sierra Nevada Mountains, and lasted through about January 3–5, 1997 when the heavy rains slackened and most rivers in western Nevada returned to within their natural banks. An additional period of snow accumulation also occurred over the period of December 27–28, 1996, further adding to the available snowpack water content throughout the Sierras and the lower elevation valleys. These three periods of precipitation—two initial heavy snowfall events and one heavy rainfall event—may be clearly seen from the precipitation table and graphs covering the time period of Friday, December 20, 1996, through Monday, January 6, 1997, contained in Appendix F. This data was provided by the National Weather Service (NWS).

The analysis tables include four separate time periods. Changes in accumulated snowpack water content relative to changes in accumulated precipitation were analyzed to assess the potential, or available, water runoff from the early 1997 storm and flood event. This analysis assumes that the difference between the total precipitation accumulated during a given time period, less snowpack water content accumulation, or plus snowpack meltdown (i.e., water lost by the snowpack), approximates the total available runoff from the storm event. A further assumption is that the time periods analyzed are short enough and the soils sufficiently saturated (a wet mantle event) so that the effects of evaporation and soil absorption are relatively insignificant. By this analysis, the net effects of precipitation and changes in snowpack water content may be used to approximate actual total available runoff levels.

It should be noted that the runoff figures derived by this analysis represent the maximum potential, or total available runoff from the storm event, whether from direct precipitation or from a combination of precipitation and snowpack water content release. Studies by the NRCS have indicated that up to 80 percent of total precipitation on saturated soils results in direct or effective runoff. Consequently, available runoff during the 1997 flood event resulted in effective or direct runoff of probably no more than 80 percent of the total runoff available. However, due to the extreme saturation of both the snowpack and soils during this particular event, it is most likely that effective runoff was not much less than 80 percent of available runoff.

The underlying data for this analysis consisted of readings of accumulated snowpack water content and accumulated precipitation taken on four (4) consecutive Mondays beginning on December 16, 1996, and continuing through January 6, 1997. These time periods were chosen so as to isolate the effects of the initial heavy snowfall (December 20, 1996, through December 23, 1996) from subsequent snow and rain events in the second analysis period. The second period chosen for analysis captured the effects of heavy, warm rains beginning on December 30, 1996, and continuing through Friday, January 3, 1997. The second snowfall event, which occurred during the period of December 27–28, 1996, was captured by the analysis period of December 23, 1996 to December 30, 1996.

The data and analysis tables for each western Nevada water basin are presented in summary form, Table 1A (Lake Tahoe Basin), Table 2A (Truckee River Basin), Table 3A (Carson River Basin), and Table 4A (Walker River Basin), and in a more detailed analysis format, Tables 1B, 2B, 3B, and 4B. The summary analysis tables deal only with the time periods of December 16, 1996, through December 23, 1996, and December 30, 1996, through January 6, 1997, which capture both the initial heavy snowfall event and the heavy rainfall event, respectively. The summary table for each waterbasin shows only the changes in precipitation, changes in snowpack water content, and the net effects of these changes on available runoff by SNOTEL site.

The detailed analysis format tables for each waterbasin are divided into three parts. The first part of these tables deals with the time period of Monday, December 16, 1996, through Monday, December 23, 1996, and analyzes the changes in accumulated snowpack water content and changes in accumulated precipitation of primarily a snow accumulation event, i.e., the increase in water content within the snowpack. This analysis clearly shows the extensive buildup of the snowpack's water content relative to period precipitation throughout the waterbasins of western Nevada. The second part of the detailed analysis table deals with changes over the time period of Monday, December 30, 1996, through Monday, January 6, 1997, and deals primarily with the effects of *both* additions to and losses from accumulated snowpack water content at various elevations, as well as corresponding changes in accumulated precipitation. This event was primarily a rain-on-snow and rain on saturated ground (wet mantle) event.

The second part of the detailed analysis table is the most important in assessing the effects of changes in precipitation and changes in snowpack water content on the flooding which began on the Truckee River on Wednesday, January 1, 1997, and peaked at 8:00 a.m. on Thursday, January 2, 1997, in Reno at approximately 18,200 cubic feet per second (cfs), reaching a stage of 14.91 feet (2.91 feet above flood stage). Due to the southward motion of this overall storm system, the flooding effects along the Carson and Walker Rivers were typically delayed by 2–3 days from the peak of the flood stage along the Truckee River system. Peak flows along these more southern river systems were generally reached between Friday, January 3, and Sunday, January 5, 1997.

The third part of the detailed analysis tables deals with hydrologic changes in the waterbasins over the entire period, covering changes in accumulated snowpack water content and accumulated precipitation from Monday, December 16, 1996, to Monday, January 6, 1997. This analysis section is probably not as revealing as the other sections, but nonetheless provides a broader and more comprehensive view of the effects on snowpack water content vis-à-vis changes in precipitation.

Interpretation of Tables

Several factors should be considered with respect to the interpretation of the tables, the distinct time periods of analysis, and the resultant graphs for each NRCS SNOTEL site. First, it is assumed that for a given SNOTEL monitoring site, at any given time period the level of accumulated snowpack water content (measured in inches) cannot exceed the corresponding level of accumulated precipitation (also measured in inches). [Note: Accumulations are measured from October 1, 1996.] That is, precipitation captured within the snowpack cannot exceed total precipitation falling on the snowpack. It follows that the change in accumulated snowpack water content between any two time periods must never exceed the corresponding change in accumulated precipitation for that site.

For some SNOTEL monitoring sites the above assumptions did not hold: accumulated snowpack water content exceeded accumulated precipitation and/or the change in accumulated snowpack water content exceeded the change in accumulated precipitation. These discrepancies were attributed primarily to measurement problems and the characteristics of heavy storm events. For example, high winds and blowing heavy, wet snow are typical conditions which would tend to prevent all of the snow from being trapped and accurately recorded in the SNOTEL site's precipitation tube. This condition was particularly evident in the first analysis period of December 16, 1996, through December 23, 1996, when there was heavy snowfall and strong winds.

Of special importance in this analysis and table presentation, for both the summary tables and the more detailed analysis tables, are the numbers recorded under the table heading "Precipitation/Snowpack Difference." These figures represent the difference between the change in accumulated precipitation (i.e., increase) over two time periods for a particular SNOTEL site and the corresponding change in accumulated snowpack water content. If, for example, the change in precipitation was 2.0 inches and the corresponding change in snowpack water content was +1.0 inch, then theoretically, 1.0 inch of the change in precipitation must have gone to either evaporation, soil absorption, or become available for runoff. If we assume that evaporation is negligible (due to the time period involved) and the soil was already at saturation, then the excess unabsorbed (in the snowpack) precipitation must go primarily to available runoff.

Similarly, if the change in precipitation was 2.0 inches and the corresponding change in snowpack water content was -1.0 inch (i.e., the snowpack melted and/or lost water content), then theoretically, 3.0 inches (2.0 inches of precipitation and 1.0 inch of melted snowpack) must have gone to available runoff. To a large extent, this was the case for "The Flood of 1997," whereby the meltdown of the snowpack, particularly at elevations below approximately 7,000 feet MSL, significantly contributed to already high levels of precipitation and resultant available runoff. At the higher elevation SNOTEL sites, snowpack water content typically showed very little change despite the intensity of the rainfall, thereby indicating that a significant portion of the precipitation (i.e., rainfall) falling at even these higher elevations was passed through the snowpack and contributed directly to available runoff.

With respect to the accompanying graphs, each NRCS SNOTEL site was analyzed using five graphs. The first graph, "Snowpack Water Content and Total Precipitation (Inches)," shows comparative levels of accumulated snowpack water content and accumulated precipitation on each of the four (Monday) dates: (1) 12/16/96; (2) 12/23/96; (3) 12/30/96; and (4) 01/06/97. Here, as a test of reasonableness, the bar representing accumulated snowpack water content for each date should never exceed the bar for comparable accumulated precipitation for reasons already noted. The second graph, "Ratio of Snowpack Water Content to Total Precipitation (Percent)," presents this same information in ratio (percentage) form, measuring the accumulated snowpack water content as a percent of accumulated precipitation on these four same dates. Here, ratios of accumulated snowpack water content to accumulated total precipitation of over 100 percent are, of course, not realistic and tend to indicate, most typically, equipment limitations with respect to the measurement of the "true" level of accumulated precipitation.

The third graph, "Estimated Total Available Runoff by Time Period (Inches)," measures the net, or available runoff for each SNOTEL site by accounting for the change in accumulated precipitation and the concurrent effects of either snowpack buildup (subtraction from available runoff) or snowpack depletion (additions to available runoff). These available runoff amounts cover the three time spans of: (1) 12/16/96 through 12/30/96 (a particularly heavy snowfall event with corresponding additions to snowpack water content); (2) 12/23/96 through 2/30/96 (an additional, albeit lesser intensity snowfall event again showing additions to snowpack water content); and finally (3) 12/30/96 through 01/06/97 (a particularly severe rainfall event showing high levels of precipitation versus gains in snowpack water content additions).

This graph of estimated runoff clearly shows that while during the first two time periods, the snowpack was capturing a significant portion of precipitation (thereby adding to its water content), during the last time period, water content was either not building significantly in the snowpack (at the higher elevation SNOTEL sites) or water was rapidly coming out of the snowpack (at the lower elevation SNOTEL sites).

The fourth graph, titled "Composition of Total Available Runoff (Inches)— 12/30/96–01/06/97," shows the contribution of total available runoff attributable to direct precipitation and the available runoff due to snowpack water content accumulation or depletion. This graph shows that during the heavy rainfall event of Monday, December 30, 1996 through at least Thursday, January 2, 1997, relatively little precipitation went towards the addition of accumulated snowpack water content at the higher elevation SNOTEL sites. By contrast, lower elevation SNOTEL sites showed significant runoff due to heavy precipitation and the depletion of the existing snowpack.

The fifth graph, "Percent of Normal—Snowpack Water Content/Total Precipitation (Percent)," shows the percent of normal readings for both the accumulated snowpack water content and the accumulated precipitation as of the four (Monday) dates. This graph shows the significant increases in accumulated snowpack water content between the dates of 12/16/96 and 12/23/96 as a percent of normal for those dates, and, most especially, the dramatic declines in accumulated snowpack water content as a percent of normal between the dates of 12/30/96 and 01/06/97, particularly at the lower elevation SNOTEL sites.

The Flood of 1997

Analysis of the January 1997 Flood Event

Typically, flood events in the western Nevada watersheds in the winter are caused by three general situations: (1) rain-on-snow; (2) rain on frozen ground; or (3) rain on saturated soils (wet mantle event). When working in combination, such conditions can prove extremely serious with respect to worsening the potential flooding effects of a rainfall event. The 1997 flood event and prior existing contributing events which affected the waterbasins of western Nevada in late December 1996, and early January 1997, included heavy snowfall and snowpack build up in late December 1996, which was then followed by heavy warm rains on both saturated snow and soils in early January 1997. The snowpack meltdown and subsequent runoff was exacerbated by the extreme warmth of the rain, which had tropical origins.

Several factors contributed to the 1997 flood event: (1) heavy, pre-existing snowpack from two previous cold storm events; (2) saturated soils due to two previous relatively wet years; (3) relatively high levels of precipitation over a relatively short period of time; (4) the warmth of the rain which resulted in the significant or complete meltdown of the relatively heavy snowpack at elevations generally below 7,000 feet above mean sea level (MSL); (5) precipitation in the form of uncommonly warm rain at high elevations resulting in relatively slight additions to snowpack water content as compared to corresponding levels of precipitation, thereby indicating that most of the rainfall, even at these upper elevation Natural Resources Conservation Service (NRCS) SNOTEL (snowpack telemetry) sites, went directly to available runoff. These factors turned the 1997 storm event into one of the most devastating and costly flood events in recorded Nevada history.

[1] Relatively High Levels of Precipitation

Precipitation in the form of rainfall was relatively heavy and relatively brief. For most of the western Nevada water basins, heavy precipitation lasted from late Monday, December 30, 1996, to early Thursday, January 2, 1997. During this period of time, precipitation, primarily in the form of rainfall at all elevations up to at least 10,000 feet MSL, recorded at Natural Resources Conservation Service (NRCS) SNOTEL (snowpack telemetry) sites in the Lake Tahoe Basin ranged from over 7 inches (Heavenly Valley) to nearly 16 inches (Echo Peak). [See Appendix B, Table 1A and Table 1B, Part II.]

In the Truckee River Basin precipitation varied from nearly 10 inches (Truckee #2) to over 22 inches (Squaw Valley Gold Coast). [See (Appendix C, Table 2A and Table 2B, Part II.] In the Carson River Basin precipitation varied from 4.5 inches (Monitor Pass) to nearly 17 inches (Ebbetts Pass). [See Appendix D, Table 3A and Table 3B, Part II.] And in the Walker River Basin , precipitation amounts varied from 3.6 inches (Lobdell Lake) to 15.4 inches (Leavitt Lake). [See Appendix E, Table 4A and Table 4B, Part II.]

[2] Snowpack Meltdown

The significant meltdown of much, if not all of the extensive snowpack at elevations typically below 7,000 feet MSL, contributed significantly to the levels of available runoff and downstream flooding. From the waterbasin tables, it may be seen that throughout the western Nevada waterbasins, lower elevation NRCS SNOTEL sites lost significant amounts of the existing snowpack water content over the period of Monday, December 30, 1996, through Monday, January 6, 1997. This loss of accumulated snowpack water content added to the effects of concurrent precipitation and directly contributed to significantly higher levels total available runoff. Due to the time duration involved and the already saturate soils after two relatively wet years, we may reasonably exclude the effects of evaporation and soil absorption in this analysis.

Within the Lake Tahoe Basin, loss of snowpack water content at certain NRCS SNOTEL sites below 7,000 feet MSL contributed an additional up to 50 percent of the available runoff from the precipitation alone. For example, melting snowpack boosted total available runoff at the Fallen Leaf SNOTEL site (6,300 feet MSL) from 11.8 inches from direct precipitation to 17.0 inches of total available runoff. Similarly, at the Tahoe City Cross SNOTEL site (6,750 feet MSL), 10.9 inches of direct precipitation was boosted to 15.6 inches due to snowmelt.

The meldown of the snowpack within the Lake Tahoe Basin directly contributed to the rapid rise in Lake Tahoe during the storm period, necessitating the Federal Water Master to open all 17 gates of the Lake Tahoe Dam at Tahoe City. In fact, as a precautionary measure, these gates had been opened December 11, 1996, after a previous storm event in early December. As a result of the heightened inflow to Lake Tahoe, and despite maximum water discharges being made from the lake, the surface elevation of Lake Tahoe still rose from 6,228.28 feet MSL at 8:00 a.m. on Monday, December 30, 1996, to 6,228.92 feet MSL by 8:00 a.m. on Thursday, January 2, 1997, an increase in lake volume of approximately 78,120 acre-feet in just a three-day period. Without the concurrent water releases at the Lake Tahoe Dam, the lake's volume would have increased an additional 93,000 acre-feet. The lake continued to rise until it reached a peak surface elevation of 6,229.39 feet MSL at 8:00 a.m. on Sunday, January 5, 1997, equating to an approximate increase in Lake Tahoe's water volume of 135,490 acre-feet over only a six-day period. When accounting for a concurrent outflow of between 2,500 cfs and 2,600 cfs from the Lake Tahoe Dam, total inflows over just six days exceeded 166,000 acre-feet.

In the Truckee River Basin, the Truckee #2 SNOTEL site (6,400 feet MSL) lost 30 percent of its snowpack water content over the period of Monday, December 30, 1996, to Monday, January 6, 1997. This reduction in snowpack water content of 3.9 inches, when combined with direct precipitation (rainfall) of 9.6 inches, resulted in a net available runoff of 13.5 inches. This effect actually underestimates the rapidity of the runoff since by early Thursday, January 2, 1997, the precipitation at this site had turned from rain to snow, thereby again building up the snowpack and its water content. Consequently, the runoff period was of this heavy rainfall event was primarily concentrated around 3-4 days of late 1996 and early 1997. This runoff was unmoderated as no dam or retention structures exists between Tahoe City, California, and the Truckee Meadows (Reno and Sparks) in Nevada.

The contribution of the partial "meltdown" of the Sierra Nevada snowpack was especially evident on in the upper Truckee River between Tahoe City and the Lake Tahoe Dam and Truckee, California. This is shown by comparing the flows out of Lake Tahoe with those measured downstream at Truckee, California, and those measured at Reno, Nevada. With all 17 gates wide open, releases at the Lake Tahoe Dam were between 2,500 and 2,600 cfs (actually peaking at 2,690 cfs on Sunday, January 5, 1997). However, only 15 miles downstream at Truckee, flows were measured at nearly 12,000 cfs, an increase in the rate of flow of over 9,300 cfs, or nearly 360 percent. Thus water releases out of Lake Tahoe at Tahoe City comprised just over 20 percent of the total river flows recorded at Truckee. Nearly 80 percent of the flows reaching Truckee were not controlled by any river regulating structure.

Twenty-five miles downstream of Truckee, flows at Reno were measured at approximately 18,200 cfs (at the USGS Reno gage located some 400 feet downstream from the Kietzke Lane Bridge), an increase in the rate of flow of just over 6,000 cfs, or about 51 percent. The significant increase in the river's flow between Tahoe City and Truckee, both in terms of rates of flow and percent of increase, is primarily attributable to flows out of principal upper Truckee River tributaries, namely, Squaw Creek (Squaw Valley), Bear Creek (Alpine Meadows), Pole Creek, and Deep Creek. In addition, between 600–700 cfs was being released simultaneously from Donner Lake, and another approximately 2,000 cfs flowed uncontrolled out of Cold Creek (Stream) and Coldstream Valley into Donner Creek, approximately one-half mile downstream from the Donner Memorial Monument. Cold Creek's unusually high rates of flow were due to the fact that the center of the heavy rainfall storm event was concentrated near the headwaters of Cold Creek, which is situated to the south and west of Donner Lake, below Mount Lincoln (8,383 feet MSL) and nearly seven miles from Cold Creek's confluence with Donner Creek.

In the Carson River Basin, the effects of extensive snowpack meltdown were also clearly evident. For example, at the Spratt Creek SNOTEL site (6,200 feet MSL), the snowpack water content declined by 2.4 inches, which, when combined with 8.8 inches of total precipitation over the December 30, 1996, through January 6, 1997, time period resulted in an available runoff of 11.2 inches. Similarly, at the Poison Flat SNOTEL site (7,900 feet MSL), total precipitation of 10.3 inches was boosted by 0.7 inches of melting snowpack, yielding an available runoff of 11.0 inches. In the Walker River Basin, snowpack water content at the Leavitt Meadows SNOTEL site (7,200 feet MSL) fell by 4.1 inches over the December 30, 1996, through January 6, 1997, time period. This snowpack meltdown, combined with total precipitation of 9.7 inches, resulted in an available runoff of 13.8 inches.

[3] Precipitation Effectively in the Form of Rainfall

The third factor contributing to the severity of the 1997 flood event was that the storm actually consisted of an extensive series of closely packed storm systems stretching essentially from western Nevada and the Sierra Nevada Mountains to beyond Hawaii and contained exceptionally warm, moist air. This condition was labeled the "Tropical Connection", "Hawaiian Express/Connection", "Hawaiian Hoser", and "Pineapple Connection" by meteorologists and weather forecasters. This storm system resulted in rain falling at virtually all elevations during the period of peak precipitation, making snowpack accumulation and absorption of the rain more difficult and contributing to relatively high levels of available runoff even from these higher elevation locations.

Unlike the more typical storm "fronts" of this time of year which originate in the Gulf of Alaska and provide distinct and interrupted events of precipitation, the storm system which arrived in the Sierra Nevada Mountains on Monday, December 30, 1996, actually consisted of an extended, uninterrupted pattern of warm, moist air stretching over 3,200 miles from the Sierra Nevada Mountains back to the west beyond the Hawaiian Islands. This system continually inundated the Sierras well beyond the water holding capacity of both its existing snowpack and its soils.

[4] Relatively Insignificant Additions to Snowpack at High Elevations

The fourth factor was the warmth of the rainfall which resulted in the relatively slight or negligible buildup in the snowpack water content during the period of Monday, December 30, 1996, through Monday, January 6, 1997. As a consequence, rainfall, even at these higher elevations, contributed directly and significantly to total available runoff and eventual downstream flooding, especially where the runoff was not impeded by dams or other retention structures. For example, in the Lake Tahoe Basin, the snowpack at the Heavenly Valley SNOTEL site (8,850 feet MSL) gained only 1.0 inch of water content despite 7.2 inches of precipitation, thereby "passing" 6.2 inches of the total rainfall off as available runoff. Similarly, in the Truckee River Basin, the Mount Rose Ski Area SNOTEL site (8,850 feet MSL) increased its snowpack water content by 5.2 inches during a period of precipitation totaling 12.9 inches, thereby passing off some 7.7 inches of that rainfall as available runoff. This effect was especially evident in the resultant severe flooding of Galena Creek, which drains much of this area to the east into Steamboat Creek and from there to the Truckee River.

The Squaw Valley Gold Coast (G.C.) SNOTEL site (8,200 feet MSL) recorded nominal precipitation of 22.3 inches between Monday, December 30, 1996, and Monday, January 6, 1997, the highest level of precipitation reported for any western Nevada NRCS SNOTEL site over this period of time. Over this same period the snowpack at the Squaw Valley site "lost" 2.7 inches of water content, thereby producing an available runoff of 25.0 inches. This was the highest level of combined available runoff (precipitation plus snowpack meltdown) recorded at any SNOTEL site analyzed. The effects of this especially high runoff from Squaw Valley (Squaw Creek), and no doubt, from other contributing creeks whose drainage areas were being similarly inundated, were particularly severe downstream on the town of Truckee, California, and further downstream on Reno and Sparks, Nevada, in the Truckee Meadows. It was noted by the Federal Water Master's office in Reno that during this time, while approximately 2,500 cfs was being released from the Lake Tahoe Dam at Tahoe City, California, nearly 12,000 cfs was being recorded some 15 miles downstream at Truckee, California, the difference being an indication of the significant contribution of these typically small tributary creeks along this reach of the upper Truckee River.

In the Carson River Basin, the Ebbetts Pass SNOTEL site (8,700 feet MSL) showed that the snowpack absorbed only 4.8 inches of the 16.8 inches of precipitation that fell during the period of December 30, 1996, through January 6, 1997, thereby providing 12.0 inches of rainfall as available runoff for the Carson River East Fork. In the Walker River Basin, the NRCS SNOTEL site at Leavitt Lake (9,400 feet MSL) recorded 15.4 inches of total precipitation over this period, 6.5 inches of which was absorbed in the snowpack and 8.9 inches which contributed to available runoff and subsequent flood flows along the West Walker River. Flooding of the West Walker River had disastrous consequences on the Walker River Canyon between Walker, California, and Sonora Junction, some ten miles upstream.

Flood Event Effects on Storage Reservoirs and River Flows and Comparisons to Historic Events

While the flood event was no doubt particularly severe within the waterbasins of western Nevada, it did not necessarily set consistent records at all gaging station locations. Specifically, in the Truckee River Basin, the Federal Water Master's closure of principal upstream storage facilities (i.e., Martis Creek Dam and Reservoir, Prosser Creek Dam and Reservoir, Stampede Dam and Reservoir, and Boca Dam and Reservoir), an action required when flows at the USGS Reno gage reach 6,000 cfs, prevented the flooding in Reno and Sparks from being far more severe than it was. [See the following analysis on the estimation of hypothetical Truckee River unrestrained flood flows.] Because the Carson and Walker River Basins lack the Truckee's storage facilities, flows there were typically far more severe and in fact did generally set new records. All readings provided in the tables and text are provisional and subject to revision (see section "Notes on Stream Flow Readings and Future Revisions" at the end of this analysis).

[1] Lake Tahoe Basin

Lake Tahoe's surface elevation peaked at 6,229.39 feet MSL on the morning of January 5, 1997. This was Lake Tahoe's highest level since July 17, 1917, when it attained a surface level elevation of 6,229.78 feet MSL (the peak overall recorded surface elevation of Lake Tahoe was recorded on July 18, 1907 at 6,231.26 feet MSL). This January 5, 1997 surface elevation was the lake's highest level since the signing of the 1935 Truckee River Agreement, which limited the range of Lake Tahoe's surface elevation to between 6,223.0 feet MSL (its natural rim) and 6,229.1 feet MSL. From the beginning of the rainfall in the Sierra Nevada Mountains on Monday morning, December

30, 1996, to the peaking of the lake on Sunday morning, January 5, 1997, Lake Tahoe rose by 1.11 feet. This implies a lake inflow of nearly 136,000 acre-feet (over 166,000 acre-feet of lake inflows if concurrent lake outflows of 2,500–2,600 cfs are included). This volume represents over 31 percent of the Lake Tahoe Basin's normal annual water production (approximately 530,000 acre-feet) in just six days.

[2] Truckee River Basin

Hydrologic conditions and flows in the Truckee River, while especially severe at Truckee, California, were minimized in terms of their flood effects further downstream due to the Federal Water Master's ability to close all dams along principal tributary streams, particularly Prosser Dam (Prosser Creek), and Boca Dam and Stampede Dam (Little Truckee River). Due to a leaking dam, small releases were made from Martis Creek Dam (Martis Creek Reservoir) during this time period, however, these releases never exceeded a rate of flow of 362 cfs (January 2, 1997), and were even less on January 1st (204 cfs) and January 3rd (106 cfs).

Truckee River flows at the USGS gaging station at Farad, California (located approximately 3.5 miles upstream from the California–Nevada state line), peaked at 15,000 cfs on the morning of January 2, 1997, below the record of 17,500 cfs set in 1950 (making this a less than a 50-year flood event at that location). Flows at Floriston, California, above Farad, however, were sufficient to wash out Sierra Pacific Power Company's Floriston diversion dam on Wednesday, January 1, 1997. This timber and rock-filled dam provided water for the Farad power station, located nearly two miles downstream from Floriston.

Flows at the City of Reno in the Truckee Meadows peaked at 18,200 cfs on the morning of January 2, 1997, below the record of 20,800 cfs set in 1955 (making this event at this location also less than a 50-year flood event). However, the river stage (height) at Reno reached 14.91 feet, 2.0 feet over flood stage (12.0 feet) and higher than 1950's stage of 13.83 feet. Further downstream, the river's effects were noticeably more severe, primarily due to extensive flood waters entering the Truckee River from Steamboat Creek.

Despite the fact that the flow at the USGS Reno gage only reached 18,200 cfs and was below the prior 1955 record, this rate of flow was nonetheless sufficient to create extensive havoc throughout Reno and Sparks, particularly below this gaging station location. Of particular note was the flooding of the Reno Hilton Hotel and Casino RV park and Hilton pond, and across the Truckee River from the Reno Hilton the inundation of Sierra Pacific Power Company's Glendale water treatment plant, the flooding of the Reno–Tahoe International Airport, the extreme erosion of the Truckee River's banks between the Rock Street and East McCarran Avenue bridges, the extensiveness of the flooding in the Sparks industrial area, and the river's record stage at Vista. Extensive flooding was experienced along Steamboat Creek's reach from Pleasant Valley and the creek's confluence with Galena Creek, to Steamboat Creek's entry into the Truckee River. The water's stage in the lower portion of Steamboat Creek became so high as to cover two primary access roads into the residential community of Hidden Valley, located on the eastern side of the

Truckee Meadows. Steamboat Creek's waters also inundated the Rosewood Lakes Golf Course, flooded the Boynton Slough and nearby homes, and effectively prevented the draining of the Reno–Lake Tahoe International Airport.

Steamboat Creek drains an extensive area of approximately 240 square miles extending nearly 18 miles through the south Truckee Meadows, then through Steamboat and Pleasant Valley to the outlet of Little Washoe Lake in Washoe Valley, and then another eight miles to the southern end of Washoe Valley. Washoe Lake, just to the south of Little Washoe Lake, with its principal tributaries of Franktown Creek and Ophir Creek, nearly flowed over a portion of U.S. Highway 395 during this flood event. Other tributaries to Washoe Lake and Little Washoe Lake, namely Davis Creek and Winters Creek, were also flooding during this event, causing damage to Davis Creek Park as well as flowing over U.S. Highway 395, resulting in some erosion damage to the highway's shoulders.

From Washoe Valley, Steamboat Creek then flows into Pleasant Valley to the north where during this storm event it received the flooding waters of Galena Creek, which flowed down from the Mount Rose Ski Area. In Pleasant Valley, Galena Creek was flooding across U.S. Highway 395 and carving out a new channel some 15–20 feet wide and 3–4 feet deep leading into Steamboat Creek. These combined flood waters then entered the south end of the Truckee Meadows at Steamboat. Further along, Steamboat Creek picked up additional flood waters flowing from the eastern slopes of the Carson Range below Mount Rose (10,778 feet MSL) contained in White's, Thomas, and Jones creeks.

The effects of flooding from these tributary creeks within the southern portion of the Truckee Meadows was greatly reduced due to the recent construction of a 60-acre detention pond and several miles of flood channels. These flood mitigation systems were constructed as part of the development of the Double Diamond area and South Meadows Business Park. The combined flood waters then proceeded along the eastern side of the Truckee Meadows and flooded the eastern portion of the valley north of Huffaker Hills (Rattlesnake Mountain) and between Hidden Valley on the east and East McCarran Avenue on the west.

Within the Truckee Meadows, the most extensive effects of flooding occurred in downtown Reno within several blocks of the Truckee River, throughout and extensive portion of the Sparks industrial area located primarily north of the river and east of Rock Boulevard, and at the Reno–Tahoe International Airport. The airport area was flooded due to a cascading series of events. First, floodwaters from the Truckee River spilled over an embankment just behind the Reno Hilton Hotel and Casino, then flowed through the property's recreation vehicle park and into the "Hilton pond". Then, at about 1:30 a.m. on Thursday, January 2, 1997, waters spilled from this pond across Greg and Mill streets towards the southeast and entered the airport complex, flooding numerous businesses and office buildings along the way. The airport's principal north–south runways became inundated due to a "dip" in the middle, which, it was discovered, is some six feet lower than the runways' elevation at either end.

Floodwaters entering the Reno–Tahoe International Airport complex severely undermined the east–west runway forcing its closure to heavy aircraft. Later, airport authorities announced that due to extensive flooding of the Reno–Tahoe Airport, it would require approximately $33 million to rebuild and upgrade Runway 7/25 (70 degrees east/250 degrees west), the only east-west runway at the airport. While used primarily by smaller aircraft, commercial jets are sometimes forced to use this 7,600-foot runway when severe crosswinds prevent landing on the two north-south runways. Primary Taxi Ways A and B, which cross this east-west runway, were also closed from this flood event. In addition, the airport sustained another several million dollars in flood damage to its terminals, baggage handling equipment, and telephone systems.

The second cause of the flooding of the Reno-Tahoe Airport was the ineffectiveness of deep drainage ditches constructed specifically to prevent airport flooding. These ditches drain into the Boynton Slough and from there empty into Steamboat Creek and ultimately the Truckee River. Due to the flooding in Steamboat Creek and the Boynton Slough, these ditches could not drain the airport until the Truckee River and Steamboat Creek receded sufficiently by Friday, January 3, 1997. By this time the Reno-Tahoe International Airport had been completely closed down for 36 hours.

At Vista, just below the entry of Steamboat Creek into the Truckee River, the river's stage was reported to have reached 24.04 feet, well above the 1963 record stage for this location of 16.76 feet. Despite the levee intended to prevent waters entering the eastern-most portion of the Sparks industrial area, flood waters found ways to enter this area and stood at least five feet deep. As this area lay below the level of the Truckee River, the flood waters could not drain naturally and had to be pumped over the levee and back into the river.

Approximately 55 miles further downstream, the USGS gage at Nixon, which approximates flows into Pyramid Lake, indicated a provisional rate of flow of approximately 22,200 cfs on January 3, 1997 (stage of 16.08 feet, average daily flow 20,700 cfs), well above the previous record flow of 16,300 cfs set in 1986 (stage of 13.01 feet). However, the USGS has since reported that this gage had been damaged during this flood event and most probably considerably overstated the actual rate of flow based on the gage readings upstream at Wadsworth, which recorded a more realistic peak rate of flow of 19,200 cfs.

Based on monthly measurements, Pyramid Lake's surface elevation rose by nearly 2.7 feet from 3,800.0 feet MSL to 3,802.7 feet MSL between Wednesday, December 4, 1996, and Friday, January 10, 1997. The increase in Pyramid Lake's surface elevation corresponds to a volume increase of approximately 302,800 acre-feet during just one month. Using USGS provisional data for the Nixon gaging station, the recorded discharge at this station was estimated to have totaled 117,945 acre-feet for all of December 1996 (average period of record discharge for December is equal to approximately 25,250 acre-feet) and 489,508 acre-feet for all of January 1997 (average period of record discharge for January is equal to approximately 30,880 acre-feet). [The period of record for this gage is from 1958 through the present, and therefore does not cover flows and discharges during the 1950 and 1955 flood events.]

The January 1997 discharge into Pyramid Lake was more than twice as high (132.1 percent) as the previous maximum January discharge of 210,900 acre-feet and 52.4 percent above the previous peak monthly discharge of 321,200 acre-feet in June 1983. The Truckee River's discharge for the December 4, 1996 through January 10, 1997 time period was estimated at approximately 340,080 acre-feet, also the highest monthly discharge prior to this time. The difference between the recorded

Truckee River inflow to Pyramid Lake of some 340,080 acre-feet during this time, and the recorded increase in Pyramid Lake's volume of 302,800 acre-feet (as derived from the 2.7 feet increase in lake surface elevation over this same period of time) was approximately 36,000 acre-feet and can mostly be explained by lake surface evaporation, which averages some 380,670 acre-feet per year (for a surface elevation of 3,802.7 feet MSL).

According to information supplied by the U.S. Bureau of Reclamation (USBR), Lahontan Basin Area Office, Carson City, Nevada, pertaining to upper Truckee River Basin reservoir storage, peak storage in Prosser Reservoir (32,400 acre-feet) on Prosser Creek was reached at noon on Friday, January 3, 1997. This reservoir storage level was 3.32 feet above the spillway crest and resulted in a maximum flow into the Truckee River of 291 cfs. Flows over the Prosser Creek Dam spillway crest continued from 5:00 p.m. on Thursday, January 2, 1997, until 5:00 a.m. on Sunday, January 5, 1997. Releases of 1,000 cfs from Prosser began on Friday, January 3, 1997, at 10:00 a.m., and were increased to 1,500 cfs at 2:00 p.m on that date. However, by this time the flood had already peaked in Reno, Nevada.

Peak storage in Stampede Reservoir (nominal capacity of 226,000 acre-feet) on the Little Truckee River above Boca Reservoir was reached at 4:00 a.m. on Sunday, January 5, 1997 at 240,400 acre-feet. This storage level was 3.97 feet above the spillway crest, resulting in a maximum release into the Little Truckee River (and into Boca Reservoir downstream) of 368 cfs. Releases of 1,500 cfs from Stampede Dam began on Thursday, January 2, 1997, at 2:00 a.m., and were increased to 2,500 cfs from 3:00 p.m. on January 2, until 8:00 a.m. on Friday, January 3, 1997, which then filled Boca Reservoir's remaining unfilled conservation space.

Peak storage in Boca Reservoir (located just downstream from Stampede Reservoir) on the Little Truckee River occurred at 7:00 a.m. on Sunday, January 5, 1997, at 39,200 acre-feet. Releases from this reservoir into the Truckee River some 500 feet downstream of 500 cfs began on Friday, January 3, at 3:00 p.m., and were increased in 500 cfs increments as the flow at the Farad gaging station, located on the mainstem of the Truckee River, declined. Consequently, these upstream reservoirs, primarily on the Little Truckee River (the Truckee River's major tributary) and Prosser Creek, effectively served their function of flood control. Stampede, Prosser, and Martis Creek reservoirs had not been constructed at the time of the 1950 and 1955 flood events, which produced peak Truckee River flows in Reno of 19,900 cfs and 20,800 cfs, respectively.

By contrast, during the 1997 flood event, sufficient reservoir capacity existed in each of these reservoirs prior to the rain so as to effectively detain reservoir inflows and prevent releases until after the flood waters had peaked downstream in Reno and Sparks. Had this not been the case, the effects of the flood's peak would certainly have been far more devastating and without question exceeded prior record peak flows. [See the next sections for an estimation of these effects based on flooding within both the Carson River Basin and the Walker River Basin.]

[3] Carson River Basin

Within the Carson River Basin and along the Carson River system, stream flows tended to be more consistently and more dramatically above previous flood records. Flows on the Carson River East Fork at Markleeville, California, peaked at 21,000 cfs (stage of 11.78 feet) during the afternoon of Thursday, January 2, 1997, considerably above the previous record peak flow at this location of 15,100 cfs (stage of 10.21 feet) set in 1963. Also on the Carson River's East Fork, at Gardnerville, Nevada, the peak flow was reported at 20,000 cfs (stage 12.8 feet), well above the previous peak of 16,700 cfs (stage 11.88 feet) recorded in 1955. Along the Carson River's West Fork, the peak flow at Woodfords, California, was recorded at 8,000 cfs, significantly above the previous record peak flow of 4,890 cfs attained in 1963.

All these flows in both the Carson River East Fork and West Fork above Carson Valley were well in excess of a 100-year flood event for these reaches of the river. These record flow events on the Carson River system may provide some indication of the relative flows that most probably would have existed along the Truckee River without sufficient upstream storage on that river system. The peak flow of the Carson River mainstem at Carson City, by contrast, did not set a record, reaching a peak rate of flow of 27,500 cfs at the Carson City gage on the morning of Friday, January 3, 1997, below the record flow of 30,000 cfs recorded in 1955.

Of significance in assessing the apparent below-record measurement recorded at the USGS Carson City gage were the extreme record flows further downstream recorded at the USGS Fort Churchill gage (or, more accurately, recorded at that gaging station site). Although the Fort Churchill gage, which measures flows into Lahontan Reservoir, was one of six USGS gaging stations completely destroyed during the flood event (29 others were damaged), the USGS continued to take manual recordings at the site. Peak flow readings at this site were estimated at approximately 25,000 cfs on the evening of Friday, January 3, 1997, well in excess of the previous peak of 16,600 cfs recorded in 1986. [Due to the loss of the gage, this peak rate of flow was actually estimated by the National Weather Service (NWS). However, according to the USBR office in Carson City, the NWS estimate may be high by several thousand cfs. Even so, it appears evident that a new record peak flow was definitely achieved at this gaging station location.]

The apparent inconsistencies in measures among USGS gages above Carson Valley, all of which recorded new peak flood flows, and the Fort Churchill gage (more than 50 percent above the previous 100-year flood event record) were due primarily to two factors. First, while flows into Carson Valley from both the East and West Forks set new records, their combined effect in Eagle Valley was attenuated by the "spreading" of waters within Carson Valley. Flooding within Carson Valley extended from south of Gardnerville on the East Fork to below the Cradlebaugh Bridge and the north end of the valley. Below Carson City record rates of flow were again reached primarily due to heavy outflows from Eagle Valley (Carson City).

The streams coming off the eastern slopes of the Carson Range and flowing into Eagle Valley (Carson City), typically contribute very little to Carson River flows. However, during this flood event, these streams experienced a significant outpouring, gouging out new channels, overwhelming storm drains, running down residential streets on the western side of the valley, flooding streets in downtown Carson City, and eventually dumping into the Carson River below the USGS Carson City gage location. Furthermore, prior to this flood event, Carson City had received over two feet of heavy snowfall, all of which melted during the heavy rainfall of January 1 and 2, 1997, further contributing to new record river flows below Carson City and Eagle Valley.

The previous peak January discharge of the Carson River at the USGS Fort Churchill gaging station was 91,600 acre-feet recorded in 1914. Based on estimates by the USBR, the discharge for the month of January 1997 was expected to reach a new record of 147,000 acre-feet. The peak discharge for any month at this location was set in December 1950 at 156,200 acre-feet. Lahontan Reservoir reached its peak stage on January 7, 1997, at an elevation of 4,163.85 feet MSL and a reservoir volume of 322,100 acre-feet. The capacity of this reservoir, with flashboards installed, is about 317,000 acre-feet, hence spills did occur. The four-day volume inflow into Lahontan Reservoir from Friday, January 3, 1997 to Sunday, January 6, 1997, was estimated at approximately 100,000 acre-feet.

Below Lahontan Reservoir, Carson River flows were kept to only 2,000 cfs, well below the peak flow of 2,970 cfs recorded in 1983. This was accomplished due to restricted releases, the use of the dam's flashboards, and the presence of sufficient storage within Lahontan Reservoir to prevent flooding downstream in Fallon and Churchill County. In summary, along most of the reaches of the Carson River, and particularly on its East and West Forks above Carson Valley, this flood event exceeded the criteria of a 100-year flood event. Higher flows at the USGS Carson City gage were largely prevented by the spreading of flood waters in Carson Valley.

[4] Walker River Basin

In the Walker River Basin the January flood event generally exceeded the 100-year flood criteria along all reaches and locations from Yerington, located in Mason Valley, upstream. The USGS gaging station at Wabuska (located below Yerington in the northern portion of Mason Valley), and the gaging station just above Weber Reservoir, located on the Walker River Paiute Indian Reservation, both recorded flows below previous records.

The East Walker River near Bridgeport, California, recorded a new record peak flow of 1,810 cfs by late morning on Saturday, January 4, 1997, above the previous record peak flow of 1,390 cfs recorded in 1963. On the West Walker River below its confluence with the Little Walker River near Coleville, California, flows peaked at 11,700 cfs, well above the previous peak flow of 6,220 cfs set in 1950. In fact, above this USGS gaging station location and through the Walker River Canyon between the community of Walker and Sonora Junction, over eight miles of U.S. Highway 395 were virtually entirely washed out, essentially isolating the communities of Coleville and Walker, located in Mono County, California, as well as Topaz Lake from automobile traffic from the south.

The narrow and highly scenic ten-mile stretch of the Walker Canyon below Sonora Junction had previously shared this portion of the West Walker River with U.S. Highway 395. In a period of less than 24 hours, the river took back this canyon for its exclusive use. At the lower mouth of the Walker Canyon, the community of Walker received extensive damage to homes and property when the West Walker River spilled its banks and rushed unrestrained through the streets of this quiet residential community.

Flows measured on the West Walker River near Hoye Bridge, located between Antelope and Smith Valleys, recorded a peak flow of 5,530 cfs on Friday, January 3, 1997, more than twice as great as the previous record flow of 2,700 cfs recorded in 1955. West Walker River flows measured at Hudson, located between Smith and Mason Valleys in Wilson Canyon, peaked at 5,800 cfs on January 3, 1997, also more than twice the previous record flow of 2,600 cfs set in 1995. A two-mile section of Nevada State Route 208 through Wilson Canyon was washed out during this flood event, cutting off traffic flow from the upper portion of the Walker River Basin to Yerington and Mason Valley located downstream. Extensive flooding in the Yerington area (Mason Valley) probably constituted the most important factor in attenuating the flow of the Walker River by the time it reached the USGS Wabuska gage at the northern end of Mason Valley. The USGS Wabuska gage recorded a peak flow of 2,580 cfs on January 6, 1997, below the previous peak flow of 3,280 cfs recorded in 1906.

River flows in the upper portion of the Walker River Basin also provided convincing evidence of the potential discharge capacity of this storm event, both with respect to the meltdown of existing snowpack and new rainfall. These conditions further support estimates of the potential devastation that would have occurred within the Truckee River Basin had not sufficient storage reservoir capacity existed there.

Precipitation Analysis

The analysis table and graphs of precipitation levels during this flood event are contained in Appendix F and highlight the important events and time periods which contributed to the January 1997 flood event. These National Weather Service (NWS) precipitation sites were chosen to cover lower elevation precipitation recorded at those locations generally not covered by the NRCS SNOTEL data. Graphs of precipitation amounts at various sites show the prior heavy snowfall event of Friday, December 20, 1996, through Monday, December 23, 1996, and another period of brief and generally more moderate precipitation, also in the form of snowfall, around Friday and Saturday, December 27 and 28, 1996.

The graphical analysis also clearly shows the warm rain event which began at the higher elevations beginning around Monday, December 30, 1996, and continued into Friday, January 3, 1997. It was the sudden change in the nature of the form of precipitation (from snowfall to unusually warm rainfall), and the prior deposition of heavy snowpack throughout the Sierra Nevada Mountains and within lower elevation valleys, that appreciably worsened the overall flooding beginning on January 1, 1997.

Notes on Stream Flow Readings and the Potential of Future Data Revisions

Due to the severity of this particular flood event, it may be some time before final figures are obtained on river rates of flow (cubic feet per second readings) and discharge amounts (runoff in acre-feet) for these affected river systems. Some USGS streamflow gaging stations were damaged, washed away entirely, or river levels (stages) exceeded the gage's measuring capability based on existing rating tables (measured stage-flow relationships). Of the approximately 100 USGS gaging stations located throughout these three western Nevada river basins, 35 gaging stations were damaged during this flood event and of those damaged, six were destroyed altogether.

The more extensively a stream or river system flows out of its normal channel during a flood event, the more difficult it is to estimate its actual rate of flow, even if its stage, or water height above a reference level, is known with precision. Under such conditions where the flow of a stream exceeds prior defined stage-flow relationships, flows can only be roughly approximated and possibly compared to prior period "spreading" or expansion across the floodplain. However, changes in channelization, deposition, and human development along the water course can significantly affect subsequent flows, the effects of flooding, and the boundaries of the floodplain, and thereby distort prior-period comparative analysis.

Severe flooding typically gouges out new river channels and reconfigures existing stream beds and banks affecting future streamflow measurements. A streamflow "gage" only measures water height (its stage) above a given reference level (the datum). This water level information is then translated into a rate of flow and/or discharge amount based upon known (and assumed fixed) physical and hydrologic characteristics of the river at that location, which are defined in a rating table of actual stage-flow measures. If significant changes to the river's characteristics occur, then new measurements will have to be taken and a new hydrograph (a graphical relationship between a river's stage and its flow) established.

The reevaluation of the stage-flow relationship at certain gaging sites may necessitate extensive revisions to provisional river flow data and may also affect releases of gaging station data for some time to come. Consequently, the more severe the flood event the more difficult the task of accurately assessing its hydrologic characteristics. And by any gauge and/or gage, "The Flood of 1997" was a severe event indeed.

The Flood of 1997

Supplemental Analysis

An Approximation of "Natural" (Hypothetical) Truckee River Peak Flows at Reno, Nevada and Comparisons to the Record Flood of 1955

The Flood of 1997

Supplemental Flood Analysis: An Approximation of "Natural" (Hypothetical) Truckee River Peak Flows at Reno, Nevada, and Comparisons to the Record Flood of 1955

Questions exist, and will persist, as to the degree of severity of the "Flood of 1997" and its comparison to prior flood events within the Truckee River Basin. According to provisional estimates by the U.S. Geological Survey (USGS) of Truckee River flows through Reno, Nevada, the 1997 event was, at best, a "50-year flood event." However, based on the severity of the storm event which produced the flood event, and particularly considering the combined effects of extremely heavy rainfall and concurrent snowpack "meltdown," it seems incongruous that such a deluge of water produced no record river flows. This is especially true in light of the impacts of runoff along the unregulated reaches of the Truckee River, and particularly in comparison to the impacts experienced in the Carson and Walker River basins. The singular difference in the flood effects between these western Nevada waterbasins is attributable to the far more extensive storage capacity and flood protection afforded within the Truckee River Basin.

In the case of the 1997 flood event, it is conceptually important to separate the "storm event" from the "flood event." It is apparent that the overall storm event of 1997, in all probability, exceeded all prior recorded storm events, particularly when considering the contribution made to total available runoff by the meltdown of prior-period storm events, i.e., the two snowfall events of December 20–23, 1996, and December 27–28, 1996. However, in assessing the resulting flood event, it was the Truckee River Basin's extensive streamflow detention and retention capabilities which marked the differenced between the storm event and the flood event.

As an extreme example of this separation of the storm event from the flood event, if sufficient hypothetical storage capacity exists within a river system (i.e., dams and reservoirs), then theoretically no flood event will occur below the structures irrespective of the intensity and severity of the storm event. While flooding may take place on those river and tributary reaches upstream from the storage facility, in terms of effects below the retention structure, it is possible that no substantive flood effects will be felt at all.

This, dynamic creates a dilemma in assessing the flood event of 1997 and particularly in comparing it to prior flood events. It was the presence of new river flow regulating facilities, constructed subsequent to the record flood of 1955, that greatly attenuated the effects of the storm event on the flood event. This, of course, is the purpose of such facilities; however, it makes comparable analysis to prior flood events far more difficult and, if comparisons are to be made, it requires a hypothetical assessment of the potential river flows without such flood restraining structures.

This analysis is not intended to address any controversy over the "true" designation of the 1997 flood; the USGS record of river flows through Reno has already definitively established that. Nor is the intent of this analysis to define or redefine the concept of a "50-year flood," a "100-year flood," or a "500-year flood." This analysis is intended to predict what would have happened if the storage and retention structures along principal Truckee River tributary streams were not in place at the time of the 1997 storm even, or if sufficient storage capacity did not exist within these reservoirs to attenuate the storm's effects. At the same time, this analysis attempts to better assess the degree to which the upstream regulating reservoirs insulated downstream structures and property from far more extensive destruction and damage. To effect this comparative analysis, we will adjust actual Truckee River flows recorded at the USGS Reno gaging station during the 1997 flood event by the addition of hypothetical flows which were in fact regulated and detained by these upstream reservoirs.

The flood event of 1955 has been chosen as the prior comparative flood event as this flood represented the highest level of river flows ever recorded on the Truckee River at the USGS Reno gaging station, which is located 400 feet downstream from the Kietzke Lane Bridge. In the 1955 flood event, peak flows were recorded at 20,800 cubic feet per second (cfs). During the recent flood event of 1997, peak flows at the Reno gaging station were recorded at 18,200 cfs (or 17,866 cfs according to Federal Water Master reports), making this flood event less severe than the 1955 flood at that location; in fact, the 1997 peak flows were even less than the 1950 flood event, which recorded a peak flow at this gage of 19,900 cfs.

To more accurately compare these two events, separated by over 40 years, it is necessary to return the Truckee River to a more or less "natural," or at least a more comparable setting for both events. This necessitates a recalculation of 1997 Truckee River peak flows based on changes in storage levels within those facilities constructed subsequent to 1955. In effect, we allow the stored waters to pass through the reservoirs as if the storage and retention capability had not existed. This concept encompasses more than just the physical presence of the dams constructed on the Truckee River's tributaries since 1955; it also speaks to having sufficient storage available in these reservoirs at the right time to prevent downstream flooding.

Changes in Truckee River System Storage

[NOTE: As a matter of convention, in this supplemental analysis letters (i.e., A, B, C) will be used to label tables to distinguish them from Natural Resources Conservation Service (NRCS) SNOTEL (snowpack telemetry) snowpack and National Weather Service (NWS) precipitation tables.]

Table A—Principal Truckee River System Storage Lakes and Reservoirs presents a listing of the principal storage lakes and reservoirs within the Truckee River system above the Truckee Meadows, their construction dates, storage capacities, drainage areas, water uses of stored water and agency codes, and other relevant information. The table's entries are ordered by the data of construction of the particular dam and reservoir from the Lake Tahoe Dam built in 1913 (which replaced an old rock-filled timber crib dam built by the Donner Lumber and Boom Company in 1870) through the Martis Creek Dam and Reservoir constructed in 1971.

Table A—Principal Truckee River System Storage Lakes and Reservoirs

Truckee River System Lake/Reservoir	Date Built	Storage Capacity[1] (acre-feet)	Drainage Area (sq. miles)	Water Uses[2]	Remarks (Location)
Lake Tahoe	1913	744,600	506	Floriston Rates (required river flows); Dam Owned by USBR, Operated by TCID	Lake surface area approximately 194 square miles; no designation for flood storage; water stored in upper 6.1 feet from 6,223.0 feet MSL (natural rim) to 6,229.1 feet MSL; waters used to meet Floriston rates (required rates of flow).
Donner Lake	1929	9,500	14	Water Owned Jointly by SPPCo and TCID	Located on Donner Creek; water stored in top 11.8 feet from 5,924.0 feet MSL to 5,935.8 feet MSL; no flood storage.
Independence Lake	1937	17,500	8	Water Owned by SPPCo	Located on Independence Creek, flowing into Little Truckee River; SPPCo acquired dam and reservoir (3,000 acre-feet) in 1937 and increased capacity to 17,500 acre-feet in 1939; no flood storage.
Boca Reservoir	1939	40,800	172	Floriston Rates; COE Flood Control Criteria	Located on Little Truckee River; drainage area includes that of Stampede Reservoir.
Prosser Creek Reservoir	1962	29,800	50	Tahoe-Prosser Exchange Agreement; COE Flood Control Criteria	Located on Prosser Creek; Waters used for instream flow releases through Tahoe-Prosser Exchange Agreement and COE flood control storage.
Stampede Reservoir	1970	226,000	136	Pyramid Lake Fishery; COE Flood Control Criteria	Located on Little Truckee River above Boca Reservoir; drainage area includes that of Independence Creek.
Martis Creek Reservoir	1971	20,400	40	COE Flood Control Criteria	Waters used for flood control only, which is limited due to a leaking dam.

Table Notes:

1 Storage capacity measured to upper legal limit, or top of dam or spillway crest.

2 Water Uses agency codes: USBR = U.S. Bureau of Reclamation; TCID = Truckee–Carson Irrigation District; SPPCo = Sierra Pacific Power Company (Reno, Nevada); COE = U.S. Army Corps of Engineers.

Source: U.S. Bureau of Reclamation, Lahontan Basin Area Office, Carson City, Nevada, and Horton, Gary A., *Truckee River Chronology—A Chronological History of Lake Tahoe and the Truckee River and Related Water Issues*, Nevada Division of Water Planning, Department of Conservation and Natural Resources, Carson City, Nevada.

As can be seen from **Table A–Principal Truckee River System Storage Lakes and Reservoirs**, Prosser Creek Dam and Reservoir, Stampede Dam and Reservoir, and Martis Creek Dam and Reservoir were all constructed subsequent to the flood event of 1955 and have provided additional storage capacity and flood protection on principal Truckee River tributaries of approximately 276,200 acre-feet. In addition, during the 1955 flood, both Independence Reservoir on Independence Creek, a tributary of the Little Truckee River, and Boca Reservoir on the Little Truckee River filled very quickly and therefore provided only a limited retention function during the worst part of that prior 1955 flood event.

Table B–Change in Truckee and Carson River Basin Storage shows the reservoir volume increases in these principal storage facilities, including the Truckee River Basin's terminus, Pyramid Lake, during the entire storm event period from Friday, December 20, 1996, through Saturday or Sunday, January 4 or 5, 1997, whichever latter date corresponded to the peak volume for each specific reservoir. While peak reservoir levels were generally attained by January 4–5, 1997, most of the inflows to these reservoirs were actually recorded over the three-day period of January 1–3, 1997. The total storage or volume change within the Truckee River Basin's lakes and reservoirs over this period was approximately 577,000 acre-feet.

Omitting the volume change in Pyramid Lake as having no effect on storage above the Truckee Meadows, and also disregarding the volume changes in Lake Tahoe, where natural channel restrictions below the Lake Tahoe Dam would have precluded outflows much above 2,600–2,700 cfs, we may see from Table B that total flood storage (and thus the flood protection) provided by these reservoirs on tributaries of the Truckee River was approximately 96,700 acre-feet (577,025 acre-feet in total basin increased lake and reservoir storage minus Pyramid Lake's volume increase of 302,800 acre-feet and less Lake Tahoe's volume change of 177,500 acre-feet). This figure represents the maximum potential, hypothetical discharge, under conditions of no storage capability (i.e., either no dam or no storage capacity), which would have been released into the Truckee River from major tributaries during this particular storm event.

Table B—Change in Truckee and Carson River Basin Storage[1]

For the Period of December 20, 1996 Through January 4–5, 1997[2]

Surface Water Elevations in Feet MSL[3]; Volumes in Acre-Feet (AF)

Lake/Reservoir [Reservoir Storage Capacity—acre-feet]	December 20, 1996 Volume (AF) [Elevation MSL]	January 4–5, 1997 Volume (AF) [Elevation MSL]	Volume Change (AF) [Change]
Lake Tahoe [744,600 acre-feet][4]	**601,900** [6,227.94 feet]	**779,400** [6,229.39 feet]	**177,500** [1.45 feet]
Donner Lake [9,500 acre-feet][5]	**4,387** [5,929.63 feet]	**10,751** [5,937.25 feet]	**6,364** [7.62 feet]
Prosser Reservoir [29,840 acre-feet]	**9,733** [5,703.41 feet]	**31,336** [5,743.15 feet]	**21,603** [39.74 feet]
Independence Reservoir [17,500 acre-feet]	**14,424** [6,944.82 feet]	**17,378** [6,949.11 feet]	**2,954** [4.29 feet]
Stampede Reservoir [226,500 acre-feet]	**204,143** [5,942.02 feet]	**240,387** [5,952.66 feet]	**36,244** [10.64 feet]
Boca Reservoir [40,870 acre-feet]	**16,667** [5,574.90 feet]	**39,234** [5,603.31 feet]	**22,567** [28.41 feet]
Martis Creek Reservoir [20,400 acre-feet]	**801** [5,780.42 feet]	**7,794** [5,815.40 feet]	**6,993** [34.44 feet]
Pyramid Lake [Elevation MSL] [Date of Measurement]	**21,720,000** [3,800.00 feet] [December 4, 1996]	**22,022,800** [3,802.69 feet] [January 10, 1997]	**302,800** [2.69 feet]
Total Change in Flood Storage for Above Lakes/Reservoirs (AF)[6]			**577,025**
Lahontan Reservoir[7] [294,000 acre-feet][8] [Date of Measurement]	**195,759** [4,151.63 feet] [December 20, 1996]	**308,900** [4,162.96 feet] [January 29, 1997]	**71,348** [11.33 feet]

Table Notes:

[1] Figures are provisional and are subject to revision.

[2] Readings are taken as of 8:00 a.m., and as of the 4th or 5th of January, whichever date showed the lake or reservoir surface highest elevation. Even so, most reservoir inflow occurred January 1–3, 1997.

[3] MSL—surface elevation above mean sea level.

[4] Measures only usable storage capacity above Lake Tahoe's natural rim of 6,223.0 feet MSL and its maximum allowable elevation of 6,229.1 feet MSL (per 1944 Orr Ditch Decree and incorporated 1935 Truckee River Agreement); equivalent to approximately 10,172 acre-feet per inch of surface elevation change above 6,223.0 feet MSL.

[5] Measures only usable storage in top 11.8 feet from 5,924.0 feet MSL to 5,935.8 feet MSL.

[6] These storage reservoirs all lie within the Truckee River Basin.

[7] Lahontan Reservoir is located within the Carson River Basin just above Lahontan Valley.

[8] Lahontan Reservoir storage capacity is estimated at nearly 317,000 acre-feet with flashboards installed on the dam's spillway crest.

Source Data: U.S. District Court Water Master's Daily Worksheet, Reno, Nevada.

Hypothetical Truckee River Flows—A First Estimate

As a simplistic first approximation of the hypothetical, unrestrained flows in the Truckee River during the January 1997 flood event, the discharge of the maximum stored flood waters (based on our calculated 96,700 acre-feet of flood storage in upstream reservoirs excluding Lake Tahoe) can be simulated over a period of, say, three to five days. The five-day time period corresponds to the heavy rainfall event which began on Monday, December 30, 1996, and lasted through Friday, January 3, 1997 (for verification of this, see the NWS precipitation table and graphs in Appendix F for the sites of Tahoe City, Truckee, and Boca). The three-day duration, however, is probably more realistic for this analysis as this time period corresponded to the period over which these reservoirs underwent their most significant volume changes and recorded their maximum inflows. This shorter period of time, therefore, more precisely establishes the time frame for our hypothetical reservoir discharges (see Table C, Part II, for actual changes in these reservoirs' volumes).

From the estimate of the total change in reservoir storage and the estimated duration of discharge, one can obtain a rough approximation of the additional Truckee River flow necessary to discharge this volume of additional reservoir flood storage brought on by the late 1996 and early 1997 storm event. Admittedly, this is only a crude estimation and in no way accounts for the fact that maximum reservoir inflows may well have occurred on different days for different reservoirs. Nor does the estimate allow for the delay between the time when these peak inflows were attained in the Sierra Nevada Mountain lakes and reservoirs and when their flow effects would have been felt within the Truckee Meadows and specifically at the USGS Reno gaging station, although realistically that is not a significant issue for this analysis.

Using this simplified methodology, one can estimate that the unrestrained discharge of the additional storage volume of some 96,700 acre-feet over a period of three days would have resulted in an additional flow in the Truckee River of approximately 16,260 cfs (based on a rate of flow of one cubic foot per second for one day is equivalent to a discharge volume of approximately 1.9835 acre-feet.) The estimated additional, hypothetical unrestrained flows are in fact average daily flows that would have existed in the Truckee River system during the entire 3-day period from Wednesday, January 1, 1997, through Friday, January 3, 1997. This rate of flow would have been in addition to the actual (provisional) recorded rate of flow at the USGS Reno gaging station, thereby producing our first estimate of a hypothetical Truckee River peak rate of flow without upstream storage of approximately 34,460 cfs on January 2, 1997 (equivalent to a peak flow of approximately 18,200 cfs actually recorded at the USGS Reno gaging station plus 16,260 cfs of hypothetical flows necessary to discharge stored flood waters in upstream storage reservoirs). Other than the 2,500–2,600 cfs which was actually being released from Lake Tahoe and recorded in Reno, no other storm-related discharges from that lake are included in these hypothetical flows.

Hypothetical Truckee River Flows—Daily Flow Method

In a second, and probably more realistic hypothetical flood-flow estimation process, the reservoir volumes recorded on the U.S. District Court (Federal) Water Master's Daily Worksheets are used to calculate the daily changes in upstream reservoir volumes. These daily inflows and reservoir volume changes are then converted to outflows in cubic feet per second for the same day in which they occurred. In this way the actual Truckee River recorded flows can be adjusted by a daily estimate of hypothetical reservoir outflows to simulate the lack of upstream storage capacity.

Of importance in this analysis is the underlying assumption that all hypothetical outflows from all upstream reservoirs have the same timing, i.e., they arrive in Reno on the same day as actual recorded flood flows. This seems a reasonable assumption as the same storm event that created the actual flows would have also caused the hypothetical additional flows. Furthermore, during this flood event, transit times from upstream reservoirs to downtown Reno, as recorded by the Federal Water Master's office, were only approximately 2 hours.

Actual reservoir volumes, changes in volume, hypothetical discharges, and the rates of flow passing through the reservoirs are presented in **Table C—Truckee River Hypothetical Flood Flows**. In **Table C—Part I** are the Truckee River's upstream lake and reservoir storage volumes recorded on a daily basis over the period of Friday, December 20, 1996, through Thursday, January 9, 1997. **Table C—Part II** presents the day-to-day changes in reservoir volume for the entire storm event period. Using the changes in daily reservoir volumes, and assuming unrestrained river flow and flooding conditions (i.e., no upstream flood-restraining structures, or the existence of upstream reservoirs but no reservoir storage capacity), each reservoir's daily hypothetical discharge volume, measured in acre-feet, is converted to a daily average rate of flow in cubic feet per second. The combination of the daily flows from each reservoir approximates the additional unrestrained flows passing the USGS Reno gaging station (**Table C—Part III**).

Finally, in **Table C—Part IV**, the actual recorded Truckee River flows (provisional USGS estimates) at the USGS Reno gage for the days of Wednesday, January 1, 1997, through Sunday, January 5, 1997 only (representing the most crucial period of peak actual and hypothetical flows) are added to the hypothetical flows from the upstream lakes and reservoirs under four (4) separate scenarios.

> **Scenario 1** constitutes a "worst case" Truckee River discharge scenario incorporating changes in all Truckee River system upstream reservoir volumes and the unrestrained discharges from these reservoirs, including Lake Tahoe. This scenario is probably the least realistic, particularly with respect to discharges from Lake Tahoe. The Lake Tahoe outlet, even without the regulating structure of the Lake Tahoe Dam at Tahoe City, California, is naturally restrained by the carrying capacity of the Truckee River channel just below the dam. Consequently, flows out of Lake Tahoe could not increase much beyond 2,600–2,700 cfs irrespective of the levels of inflows into the lake. Therefore, this scenario is not realistic and is merely presented to show a

maximum potential discharge under a hypothetical condition of completely unrestrained inflows and outflows (natural or otherwise), and serves little other practical purpose for this analysis.

Scenario 2 is a far more realistic representation of potential unregulated flows and constitutes a "moderate case" scenario in which any additional discharges from Lake Tahoe are excluded from the flows reaching Reno, Nevada. Of particular note with respect to Scenario 2 is the difference between this scenario's hypothetical flows and those estimated in Scenario 1, demonstrating the inherent controls provided by the Lake Tahoe outlet, occurring either naturally through channel restrictions or through the presence of the regulating nature of the Lake Tahoe Dam. Without such natural or man-made impediments, inflows into Lake Tahoe would have increased river flows by over 26,000 cfs on Thursday, January 2, 1997, and just over 25,000 cfs on Friday, January 3, 1997. The flood-related effects of these additional flows, amounting to a two-day discharge volume of approximately 101,400 acre-feet, to the Truckee Meadows can only be imagined.

Scenario 3 constitutes a "least case" or minimum river flow scenario and includes the unrestrained discharge and flow effects from only those reservoirs constructed subsequent to the record flood of 1955, namely, Martis Creek Reservoir, Prosser Creek Reservoir, and Stampede Reservoir. This scenario represents a baseline estimate of hypothetical flows and provides an indication of the benefits of additional flood protection added subsequent to the 1955 flood event. In all probability, the most realistic scenario for assessing the hypothetical Truckee River flows for the flood of 1997 lies somewhere between Scenario 3 and Scenario 2, in which some or all of the contribution from Boca Reservoir would be discharged to the unrestrained flows from those reservoirs constructed after the 1955 flood event (i.e., Scenario 3). The inclusion of Boca Reservoir's retention capacity seems valid in comparing the 1997 flood to the 1955 flood as during the prior event Boca Reservoir filled very quickly and thereafter passed through virtually all inflows, thereby effectively negating its further use as a retention reservoir. By contrast, during the 1997 flood event, due to the additional detention provided by Stampede Reservoir, which lies just upstream of Boca Reservoir, Boca Reservoir filled more slowly and releases from Boca were thereby delayed until after the flood had crested in Reno.

Scenario 4 represents the "most likely case" scenario and is equivalent to the unrestrained discharge conditions of Scenario 3 (Martis Creek Reservoir, Prosser Creek Reservoir, and Stampede Reservoir) plus the total inflows of Boca Reservoir also being discharged directly into the Truckee River.

Table C—Part IV shows that under more or less "natural" or comparable (to 1950 and 1955) upstream storage conditions, the unrestrained flows at the USGS Reno gaging station would have increased from the actual peak rate of flow of 17,886 cfs (18,200 cfs) recorded on Thursday, January 2, 1997, to approximately 35,300 cfs ("minimum case" Scenario 3) or 40,800 cfs ("moderate case" Scenario 2) or to nearly 67,000 cfs (unrealistic "worst case" Scenario 1 with full, unrestrained discharges of Lake Tahoe inflows. The "most likely case" scenario (Scenario 4) is estimated to have produced a peak flow in the Truckee River at the Reno gage of approximately 37,600 cfs on Thursday, January 2, 1997. This corresponds to an estimated addition to the actual rate of measured flow of nearly 20,000 cfs.

It should be noted that the estimated hypothetical discharges and resultant rates of flow do not constitute a peak, or instantaneous rate of flow as historical record flows are measured, but are in fact an average daily (i.e., constant 24-hour) rate of flow. Therefore, the volume of water moving through the Truckee Meadows indicated by these hypothetical additional rates of flow would be even greater than if we were calculating an instantaneous peak flow. Using this methodology and the "most likely case" scenario, it may be estimated that a new record rate of flow would have been recorded on the Truckee River at Reno on Thursday, January 2, 1997, at nearly 37,600 cfs (actual flows 17,866 cfs), while by Friday, January 3, 1997, hypothetical flows at the Reno gage would have moderated to 19,800 cfs (actual flows 9,000 cfs).

It may be interesting to note that during these two days, hypothetical *additional* Truckee River flows at the USGS Reno gaging station would have averaged nearly 15,200 cfs over actual recorded flows, equating to a two-day discharge volume of nearly 60,300 acre-feet. To put this into better perspective, this two-day hypothetical additional discharge through Reno and Sparks, Nevada, is approximately equal to the total water withdrawals for municipal and industrial use in the Truckee Meadows for an entire year (60,000–65,000 acre-feet).

All of the hypothetical rates of flow, even under the most restrained scenario (Scenario 3), are considerably higher than the peak of 18,200 cfs (17,866 cfs) recorded on January 2, 1997, and, in fact, nearly twice as great as the record peak Truckee River flow of 1955 when the river reached a rate of flow of 20,800 cfs. These estimates of hypothetical Truckee River flows provide some indication of the potential flows which would have existed in the river system and the degree to which existing environmental and property damage would have been amplified without adequate upstream storage capacity or without the ability to effectively use existing flood storage capacity.

The five graphs following Table C present the results of the estimated hypothetical Truckee River flows from Scenario 1 ("worst case"), Scenario 2 ("moderate case"), Scenario 3 ("least or minimum case"), and Scenario 4 ("most likely case"). Each scenario's flows are then presented side-by-side with actual Truckee River flows recorded at the USGS Reno gaging station. This information is essentially the same as that presented in Part IV of Table C.

Hypothetical Truckee River Flows—Hourly Flow Method

Table D—Truckee River Hypothetical Rates of Flow, presents the results of a similar hypothetical Truckee River flood flow analysis prepared by the Federal Water Master's office in Reno, Nevada, during the 1997 flood event. Table D presents the actual hourly Truckee River flow readings taken over a 14-hour time period from 5:00 a.m. to 6:00 p.m. on Thursday, January 2, 1997, at both the USGS Farad gaging station, located 3.5 miles upstream from the California–Nevada state line, and at the USGS Reno gaging station. Importantly, this time period encompassed the timing of the peak recorded flow at the Reno gage (8:00 a.m.). The estimated unrestrained flows from four upstream reservoirs—Boca, Prosser Creek, Stampede, and Martis Creek—are added to the actual hourly readings of Truckee River rates of flow. This analysis, in which no lag time for flows was used, estimates that the hypothetical, unrestrained Truckee River flows would have peaked at nearly 43,500 cfs at the USGS Farad gaging station at 9:00 a.m. on Thursday, January 2, 1997, and at nearly 47,000 cfs at the USGS Reno gaging station, also at 9:00 a.m. on January 2, 1997. Graphs are presented following Table D which show both the recorded and hypothetical Truckee River flows at the two gaging stations over the 14-hour time period.

It should be noted that this analysis employs hourly peak rates of flow and not daily average flows as were estimated previously. In fact, the average rate of flow estimated from this methodology at the USGS Reno gage over the entire 14-hour period analyzed was approximately 36,100 cfs. This figure is quite comparable to the daily average rate of flow for Thursday, January 2, 1997, of 35,300 cfs estimated under Scenario 3, and 37,600 cfs estimated under Scenario 4 of the previous analysis using daily reservoir volume changes. Notably, the hypothetical Truckee River peak rates of flow derived under Scenario 4 most closely correspond to the Federal Water Master's average flow estimates (36,100 cfs), which also used the unrestrained flood waters discharged from Boca, Prosser Creek, Stampede, and Martis Creek reservoirs. In addition, the estimates derived herein are not much different from the initial naive estimate of a peak average rate of flow of 34,460 cfs, which was calculated using the total upstream changes in reservoir storage volume (excluding Lake Tahoe) and a discharge or flow period of three days.

Irrespective of the estimation process used to calculate hypothetical Truckee River flows during the January 1997 flood event (and they all appear remarkably similar in terms of results), it seems evident that while the USGS Reno gage clearly indicated that no record flood event occurred, this distinction was only avoided by the timely and judicious use of all available flood storage capacity above the Truckee Meadows. It is therefore appropriate to speculate on the potential damage that would have occurred within the Truckee Meadows had Truckee River flows approached any of the hypothetical rates of flow, and then remained at those levels over an extended period of time. It appears evident that a disaster of significantly greater magnitude was only averted in the Truckee Meadows by prudent river operations and prior flood mitigation efforts which provided sufficient upstream storage so as to produce *merely* a "50-year" flood event from what was, in all probability, a "500-year" flood event when it fell from the sky.

Table C--Truckee River Hypothetical Daily Flood Flows

Part 1--Truckee River Basin Lake/Reservoir Daily Volumes

(Truckee River Basin Lake/Reservoir Volumes in Acre-Feet) [Lake/Reservoir Storage Capacities in Acre-Feet]

[Storage] Date	Lake Tahoe [744,600] [1]	Boca Reservoir [40,800]	Prosser Creek Reservoir [29,800]	Stampede Reservoir [226,000]	Donner Lake [9,500] [2]	Independence Reservoir [17,500]	Martis Creek Reservoir [20,400]	Total [1,088,600]
12/20/96	601,900	16,667	9,733	204,143	4,387	14,424	801	852,055
12/21/96	621,600	17,042	9,733	204,143	4,395	14,505	801	872,219
12/22/96	638,800	17,518	9,723	204,825	4,419	14,600	796	890,681
12/23/96	638,800	17,968	9,716	204,760	4,347	14,708	796	891,095
12/24/96	633,900	18,392	9,713	204,500	4,268	14,701	801	886,275
12/25/96	631,400	18,881	9,713	204,500	4,268	14,701	801	884,264
12/26/96	627,800	19,323	9,706	204,241	4,268	14,701	801	880,840
12/27/96	636,400	19,893	9,828	204,630	4,252	14,856	831	890,690
12/28/96	636,400	20,940	9,713	204,078	4,236	14,863	833	891,063
12/29/96	654,800	21,792	9,515	203,430	4,126	14,877	829	909,369
12/30/96	643,700	22,553	9,895	204,143	4,508	14,820	944	900,563
12/31/96	649,900	23,068	11,293	206,063	5,548	14,863	1,320	912,055
01/01/97	670,800	24,306	14,440	211,290	6,712	15,090	2,250	944,888
01/02/97	722,500	29,193	26,520	230,622	10,966	16,788	5,489	1,042,078
01/03/97	772,200	36,932	32,229	237,578	11,817	17,597	7,124	1,115,477
01/04/97	778,200	39,109	31,336	239,924	10,751	17,378	7,587	1,124,285
01/05/97	779,400	39,234	29,698	240,387	10,072	17,019	7,794	1,123,604
01/06/97	777,000	38,272	27,871	239,852	9,150	16,676	7,845	1,116,666
01/07/97	772,200	37,295	25,861	237,826	8,299	16,398	7,690	1,105,569
01/08/97	768,600	36,802	23,695	235,317	7,567	16,177	7,484	1,095,642
01/09/97	766,200	36,423	22,363	231,563	6,926	15,949	7,253	1,086,677

[1] Includes storage capacity only in top 6.1 feet from 6,223.0 feet MSL to 6,229.1 feet MSL.

[2] Includes storage capacity only in top 11.8 feet from 5,924.0 feet MSL to 5,935.8 feet MSL.

Source Data: U.S. District Court Water Master's Daily Worksheets.

Table C--Truckee River Hypothetical Daily Flood Flows

Part II--Truckee River Basin Lake/Reservoir Daily Volume Changes

(Day-to-Day Changes in Lake/Reservoir Volumes in Acre-Feet)

Date	Lake Tahoe	Boca Reservoir	Prosser Creek Reservoir	Stampede Reservoir	Donner Lake	Independence Reservoir	Martis Creek Reservoir	Total
12/20/96	--	--	--	--	--	--	--	
12/21/96	19,700	375	0	0	8	81	0	20,164
12/22/96	17,200	476	(10)	682	24	95	(5)	18,462
12/23/96	0	450	(7)	(65)	(72)	108	0	414
12/24/96	(4,900)	424	(3)	(260)	(79)	(7)	5	(4,820)
12/25/96	(2,500)	489	0	0	0	0	0	(2,011)
12/26/96	(3,600)	442	(7)	(259)	0	0	0	(3,424)
12/27/96	8,600	570	122	389	(16)	155	30	9,850
12/28/96	0	1,047	(115)	(552)	(16)	7	2	373
12/29/96	18,400	852	(198)	(648)	(110)	14	(4)	18,306
12/30/96	(11,100)	761	380	713	382	(57)	115	(8,806)
12/31/96	6,200	515	1,398	1,920	1,040	43	376	11,492
01/01/97	20,900	1,238	3,147	5,227	1,164	227	930	32,833
01/02/97	51,700	4,887	12,080	19,332	4,254	1,698	3,239	97,190
01/03/97	49,700	7,739	5,709	6,956	851	809	1,635	73,399
01/04/97	6,000	2,177	(893)	2,346	(1,066)	(219)	463	8,808
01/05/97	1,200	125	(1,638)	463	(679)	(359)	207	(681)
01/06/97	(2,400)	(962)	(1,827)	(535)	(922)	(343)	51	(6,938)
01/07/97	(4,800)	(977)	(2,010)	(2,026)	(851)	(278)	(155)	(11,097)
01/08/97	(3,600)	(493)	(2,166)	(2,509)	(732)	(221)	(206)	(9,927)
01/09/97	(2,400)	(379)	(1,332)	(3,754)	(641)	(228)	(231)	(8,965)

Source Data: U.S. District Court Water Master's Daily Worksheets.

Table C--Truckee River Hypothetical Daily Flood Flows

Part III--Lake/Reservoir Daily Volume Changes Converted to Rates of Flow

Unlagged Estimated Flows Measured at Reno, Nevada (Truckee Meadows)

(Hypothetical Flows at the USGS Reno Gaging Station in Cubic Feet per Second)

Date	Lake Tahoe	Boca Reservoir	Prosser Creek Reservoir	Stampede Reservoir	Donner Lake	Independence Reservoir	Martis Creek Reservoir	Total
12/20/96	--	--	--	--	--	--	--	--
12/21/96	9,932	189	0	0	4	41	0	10,166
12/22/96	8,672	240	(5)	344	12	48	(3)	9,308
12/23/96	0	227	(4)	(33)	(36)	54	0	209
12/24/96	(2,470)	214	(2)	(131)	(40)	(4)	3	(2,430)
12/25/96	(1,260)	247	0	0	0	0	0	(1,014)
12/26/96	(1,815)	223	(4)	(131)	0	0	0	(1,726)
12/27/96	4,336	287	62	196	(8)	78	15	4,966
12/28/96	0	528	(58)	(278)	(8)	4	1	188
12/29/96	9,277	430	(100)	(327)	(55)	7	(2)	9,229
12/30/96	(5,596)	384	192	359	193	(29)	58	(4,440)
12/31/96	3,126	260	705	968	524	22	190	5,794
01/01/97	10,537	624	1,587	2,635	587	114	469	16,553
01/02/97	26,065	2,464	6,090	9,746	2,145	856	1,633	48,999
01/03/97	25,057	3,902	2,878	3,507	429	408	824	37,005
01/04/97	3,025	1,098	(450)	1,183	(537)	(110)	233	4,441
01/05/97	605	63	(826)	233	(342)	(181)	104	(343)
01/06/97	(1,210)	(485)	(921)	(270)	(465)	(173)	26	(3,498)
01/07/97	(2,420)	(493)	(1,013)	(1,021)	(429)	(140)	(78)	(5,595)
01/08/97	(1,815)	(249)	(1,092)	(1,265)	(369)	(111)	(104)	(5,005)
01/09/97	(1,210)	(191)	(672)	(1,893)	(323)	(115)	(116)	(4,520)

Source Data: U.S. District Court Water Master's Daily Worksheets.

Table C--Truckee River Hypothetical Daily Flood Flows

Part IV--Scenario Analysis of Hypothetical Rates of Flow without Upstream Storage

Unrestrained Truckee River Flows at USGS Reno Gage for January 1, 1997--January 5, 1997

(Scenarios 1, 2, 3, and 4 Rates of Flow in Cubic Feet per Second)

Date	Actual Provisional Measured Rates of Flow at the USGS Reno Gaging Station	Additional Flows to Include All Upstream Reservoir Discharges[1]	Additional Flows to Exclude Hypothetical Lake Tahoe Discharges[2]	Additional Flows to Include Only Martis, Prosser, and Stampede Discharges[3]	Total Hypothetical Flows With Lake Tahoe Discharges[1]	Total Hypothetical Flows Without Lake Tahoe Discharges[2]	Total Hypothetical Flows With Only Martis, Prosser, and Stampede Discharges[3]	Total Hypothetical Flows Under Scenario 3 with Discharges from Boca Reservor[4]
01/01/97	8,951	16,553	6,016	4,691	25,504	14,967	13,642	14,203
01/02/97	17,866	48,999	22,934	17,470	66,865	40,800	35,336	37,553
01/03/97	9,042	37,005	11,948	7,209	46,047	20,990	16,251	19,763
01/04/97	8,233	4,441	1,416	966	12,674	9,649	9,199	10,187
01/05/97	7,423	n.a.	n.a.	n.a.	7,423	7,423	7,423	7,480

Note: U.S. Geological Survey (USGS) Reno gaging station is located 400 feet below the Kietzke Lane Bridge.

[1] Scenario 1 ("Worst Case"): Hypothetical rates of flow to include all Truckee River upstream lakes and reservoirs.

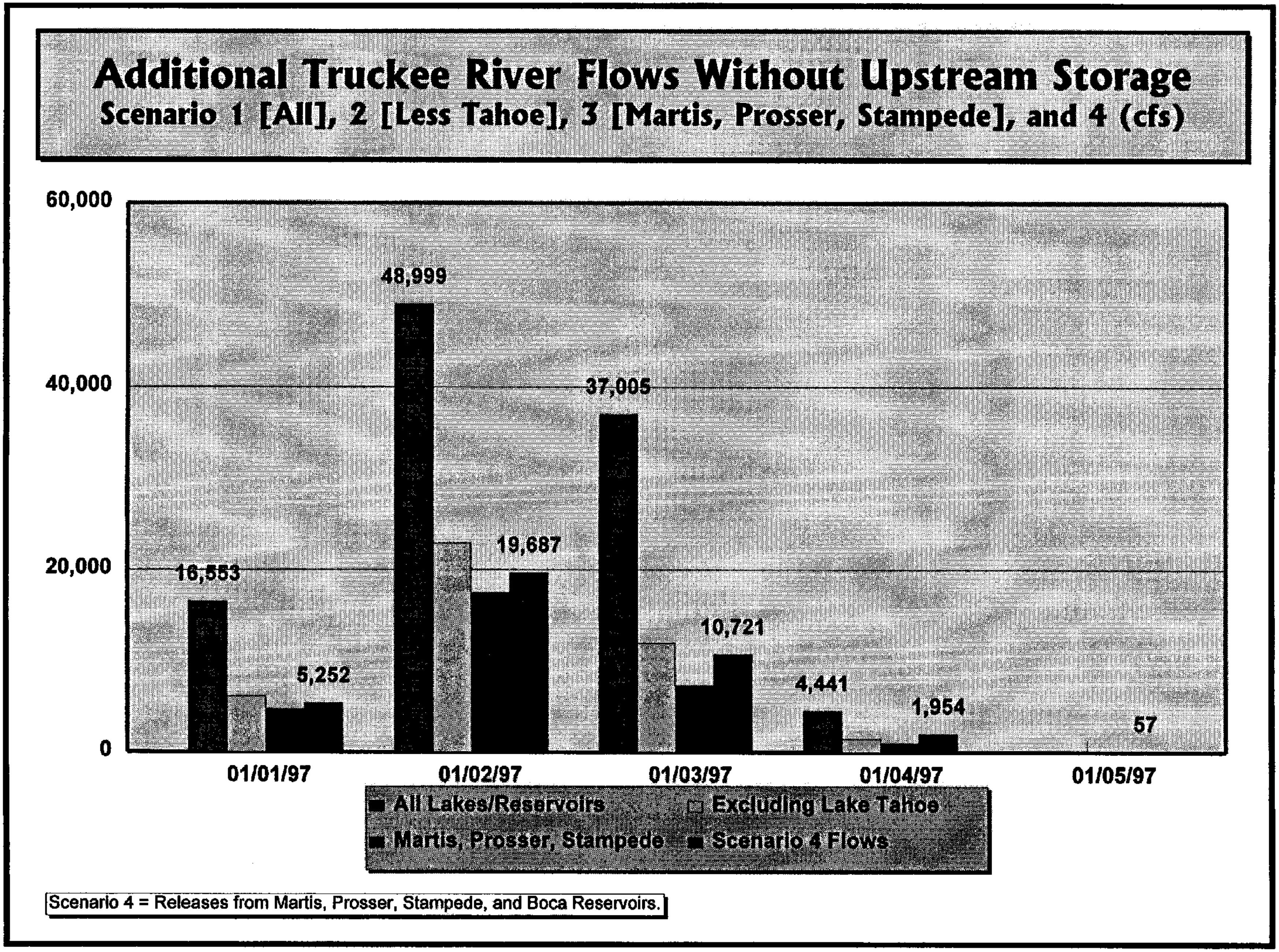
[2] Scenario 2 ("Moderate Case"): Hypothetical rates of flow to include all Truckee River upstream lakes and reservoirs except Lake Tahoe.

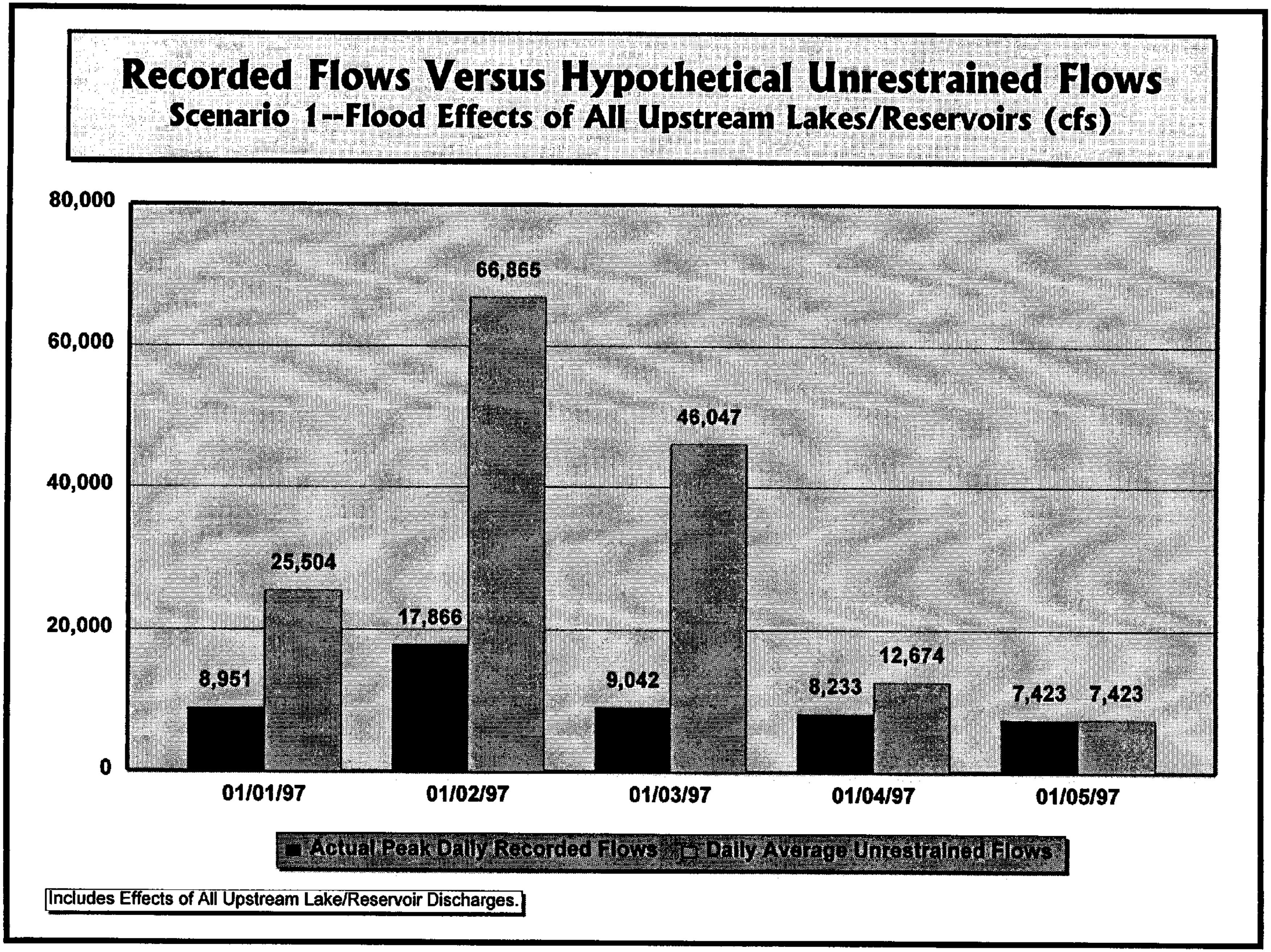
[3] Scenario 3 ("Least Case"): Hypothetical rates of flow to include discharges from only Martis Creek, Prosser Creek, and Stampede Reservoirs.

[4] Scenario 4 ("Most Likely Case"): Hypothetical rates of flow under Scenario 3 (Martis, Prosser, and Stampede) plus full releases from Boca Reservoir.

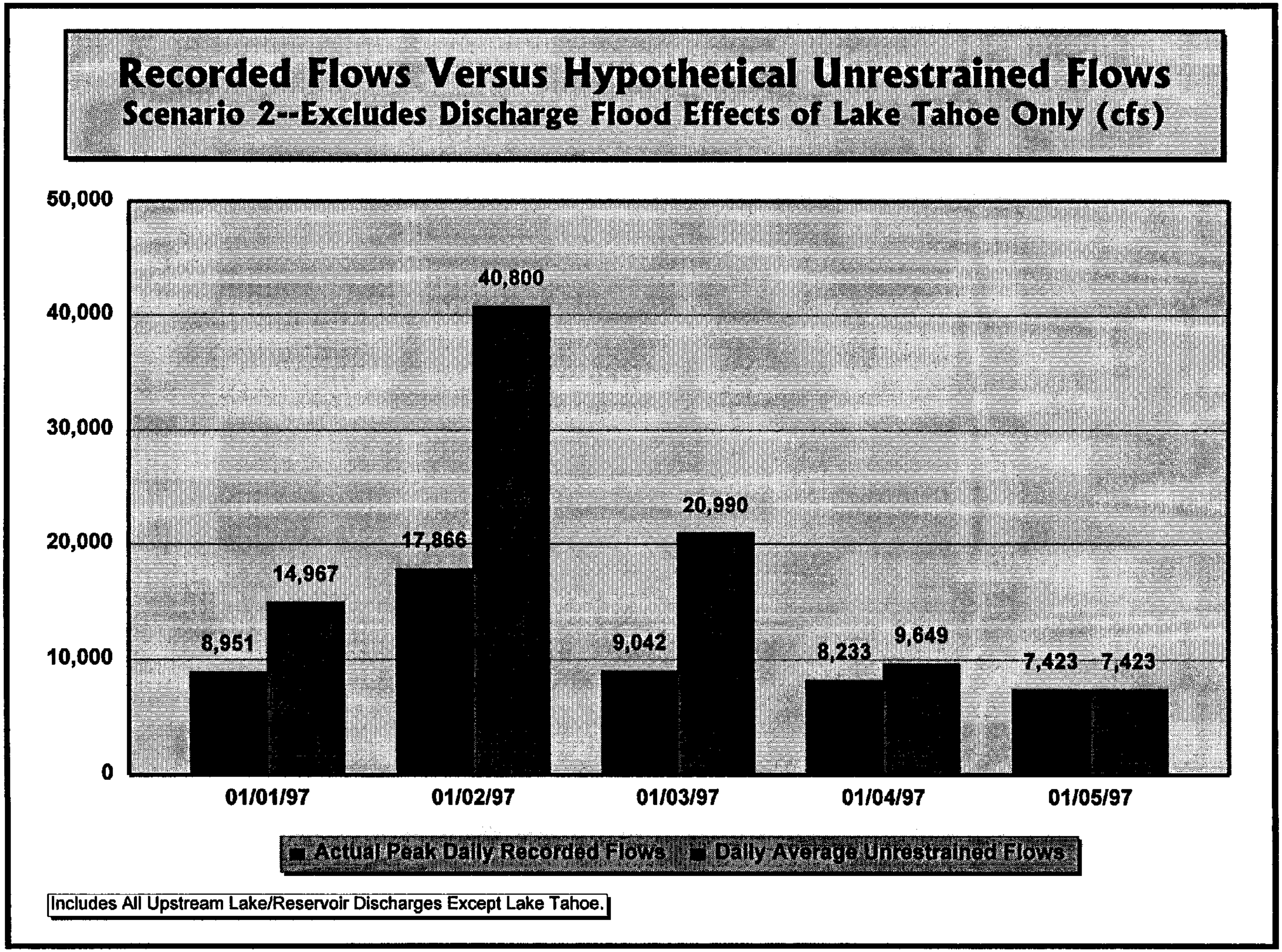
n.a. = Reservoir net volume changes (inflows less outflows) are negative and therefore unrestrained flows not applicable (i.e., reservoirs in recession).

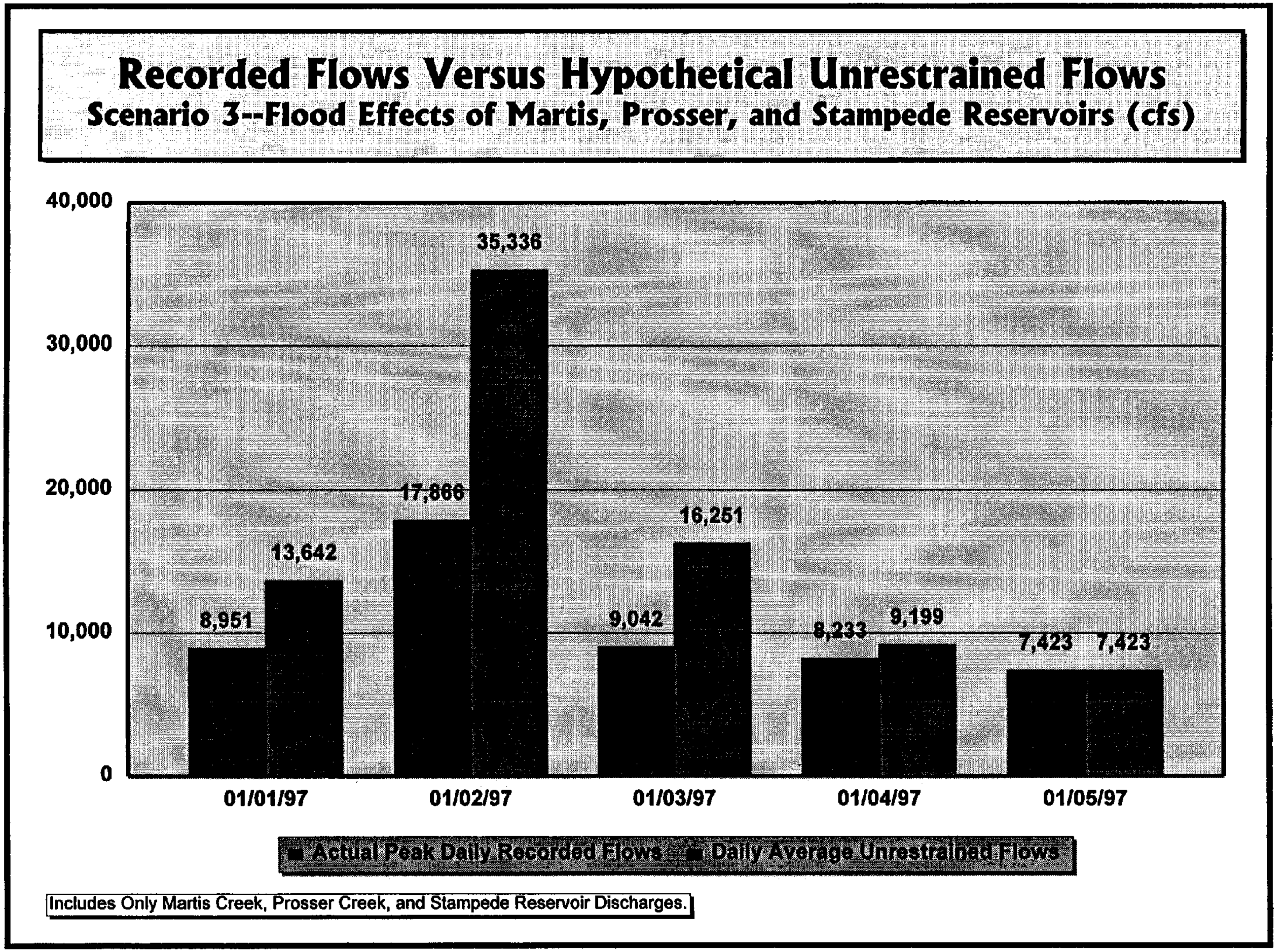
Source Data: U.S. District Court Water Master's Daily Worksheets.

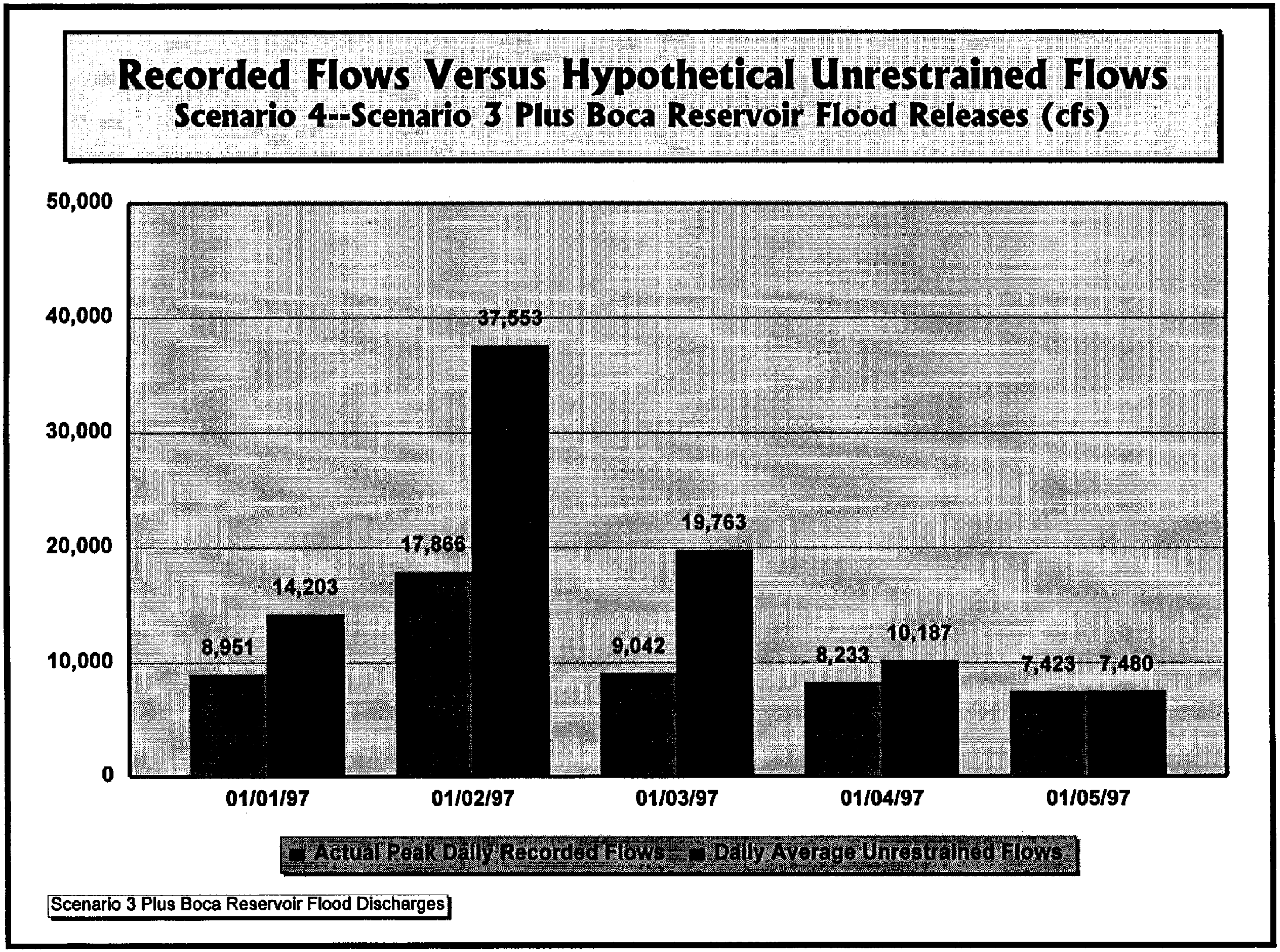

Additional Truckee River Flows Without Upstream Storage
Scenario 1 [All], 2 [Less Tahoe], 3 [Martis, Prosser, Stampede], and 4 (cfs)
60,000
40,000
20,000
0
48,999
37,005
19,687
16,553
10,721
5,252
4,441
1,954
57
01/01/97
01/02/97
01/03/97
01/04/97
01/05/97
All Lakes/Reservoirs
Excluding Lake Tahoe
Martis, Prosser, Stampede
Scenario 4 Flows
Scenario 4 = Releases from Martis, Prosser, Stampede, and Boca Reservoirs.



Recorded Flows Versus Hypothetical Unrestrained Flows
Scenario 1--Flood Effects of All Upstream Lakes/Reservoirs (cfs)
80,000
60,000
40,000
20,000
0
8,951
25,504
17,866
66,865
9,042
46,047
8,233
12,674
7,423
7,423
01/01/97
01/02/97
01/03/97
01/04/97
01/05/97
Actual Peak Daily Recorded Flows
Daily Average Unrestrained Flows
Includes Effects of All Upstream Lake/Reservoir Discharges.


Recorded Flows Versus Hypothetical Unrestrained Flows
Scenario 2--Excludes Discharge Flood Effects of Lake Tahoe Only (cfs)
50,000
40,000
30,000
20,000
10,000
0
8,951
14,967
17,866
40,800
9,042
20,990
8,233
9,649
7,423
7,423
01/01/97
01/02/97
01/03/97
01/04/97
01/05/97
Actual Peak Daily Recorded Flows
Daily Average Unrestrained Flows
Includes All Upstream Lake/Reservoir Discharges Except Lake Tahoe.


Recorded Flows Versus Hypothetical Unrestrained Flows
Scenario 3--Flood Effects of Martis, Prosser, and Stampede Reservoirs (cfs)
40,000
30,000
20,000
10,000
0
8,951
13,642
17,866
35,336
9,042
16,251
8,233
9,199
7,423
7,423
01/01/97
01/02/97
01/03/97
01/04/97
01/05/97
Actual Peak Daily Recorded Flows
Daily Average Unrestrained Flows
Includes Only Martis Creek, Prosser Creek, and Stampede Reservoir Discharges.



Recorded Flows Versus Hypothetical Unrestrained Flows
Scenario 4--Scenario 3 Plus Boca Reservoir Flood Releases (cfs)
50,000
40,000
30,000
20,000
10,000
0
8,951
14,203
17,866
37,553
9,042
19,763
8,233
10,187
7,423
7,480
01/01/97
01/02/97
01/03/97
01/04/97
01/05/97
Actual Peak Daily Recorded Flows
Daily Average Unrestrained Flows
Scenario 3 Plus Boca Reservoir Flood Discharges

Table D--Truckee River Hypothetical Hourly Rates of Flow

Actual and Hypothetical Flows Measured at USGS Farad and Reno Gaging Stations

Estimated Unrestrained Flows Calculated by Federal Water Master's Office

Hourly Flow Measures and Estimates for Thursday, January 2, 1997 (Cubic Feet per Second)

Time [01/02/97]	Actual Provisional Flows at USGS Farad Gaging Station[1]	Actual Provisional Flows at USGS Reno Gaging Station[2]	Estimated Unrestrained Flows from Boca Reservoir	Estimated Unrestrained Flows from Prosser Reservoir	Estimated Unrestrained Flows from Stampede Reservoir	Estimated Unrestrained Flows from Martis Creek Reservoir	Hypothetical[3] Flows at Farad Gaging Station	Hypothetical[3] Flows at Reno Gaging Station
5:00 a.m.	**14,670**	16,860	3,396	6,938	12,086	1,981	39,071	41,261
6:00 a.m.	14,380	17,270	2,904	5,087	9,905	1,576	33,852	36,742
7:00 a.m.	14,340	17,382	3,256	6,655	11,198	2,021	37,470	40,512
8:00 a.m.	14,400	**17,866**	1,388	6,817	12,424	0	35,029	38,495
9:00 a.m.	14,550	17,800	2,314	8,107	16,320	2,158	**43,449**	**46,699**
10:00 a.m.	14,500	17,822	4,295	6,164	11,400	1,729	38,088	41,410
11:00 a.m.	14,280	17,700	2,522	4,950	8,367	1,601	31,720	35,140
Noon	14,040	17,590	2,438	4,949	11,016	1,652	34,095	37,645
1:00 p.m.	13,560	17,630	2,975	5,337	11,520	1,591	34,983	39,053
2:00 p.m.	12,630	17,590	883	3,030	8,119	1,482	26,144	31,104
3:00 p.m.	11,780	17,250	1,507	3,586	7,712	1,325	25,910	31,380
4:00 p.m.	10,990	16,730	1,247	4,325	8,680	1,222	26,464	32,204
5:00 p.m.	10,380	15,940	2,543	3,115	5,697	1,033	22,768	28,328
6:00 p.m.	9,774	15,160	335	2,750	6,562	973	20,394	25,780

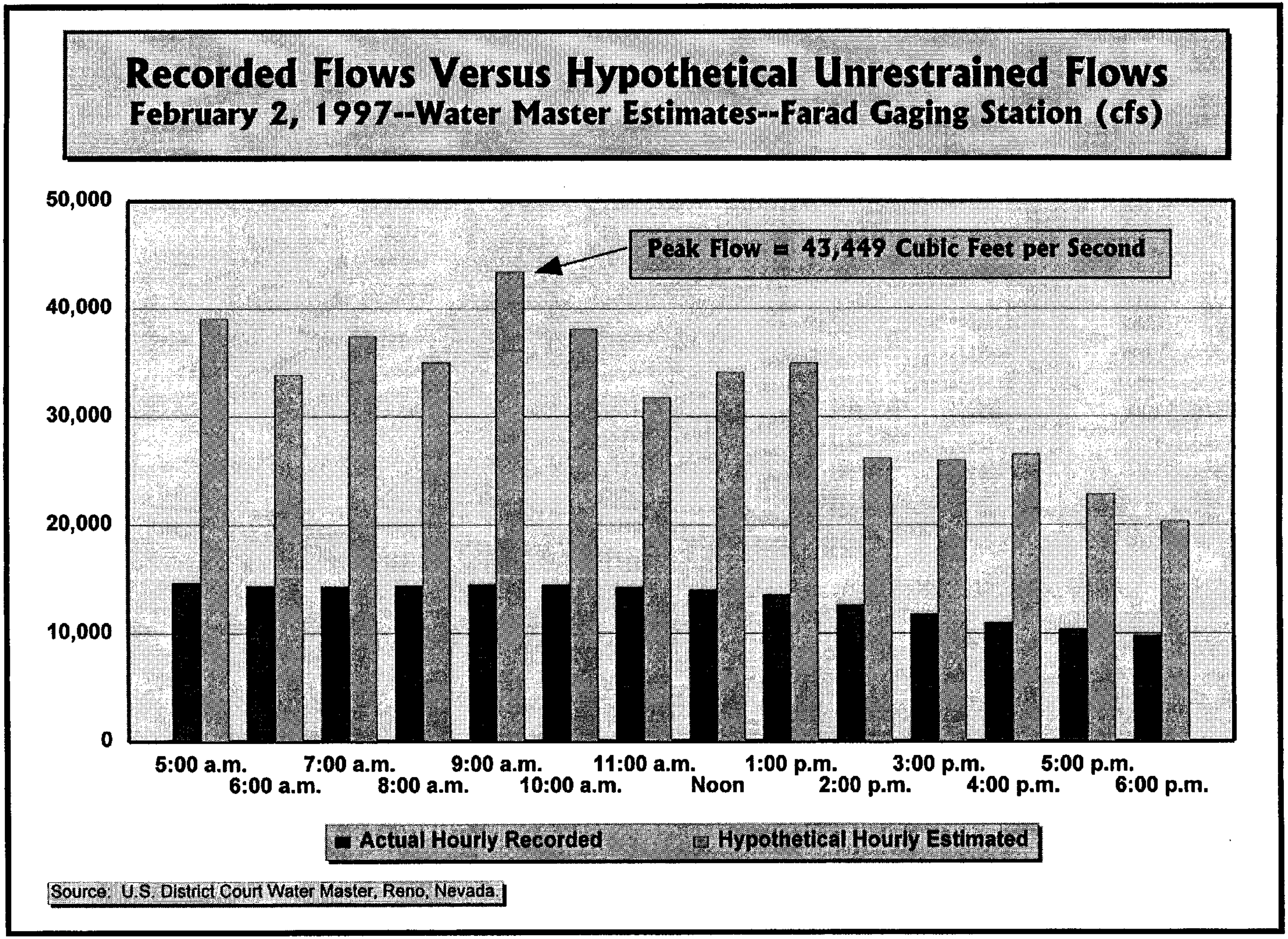
Note: All data is provisional and subject ot revision. Peak flow for 1955 flood event was 20,800 cubic feet per second. Hypothetical flows at the Farad and Reno gaging stations are determined by taking the actual (provisional) flows at these gaging stations and adding the estimated unrestrained flows from Boca, Prosser Creek, Stampede, and Martis Creek reservoirs. Peak actual flows and hypothetical estimated flows appear in bold type.

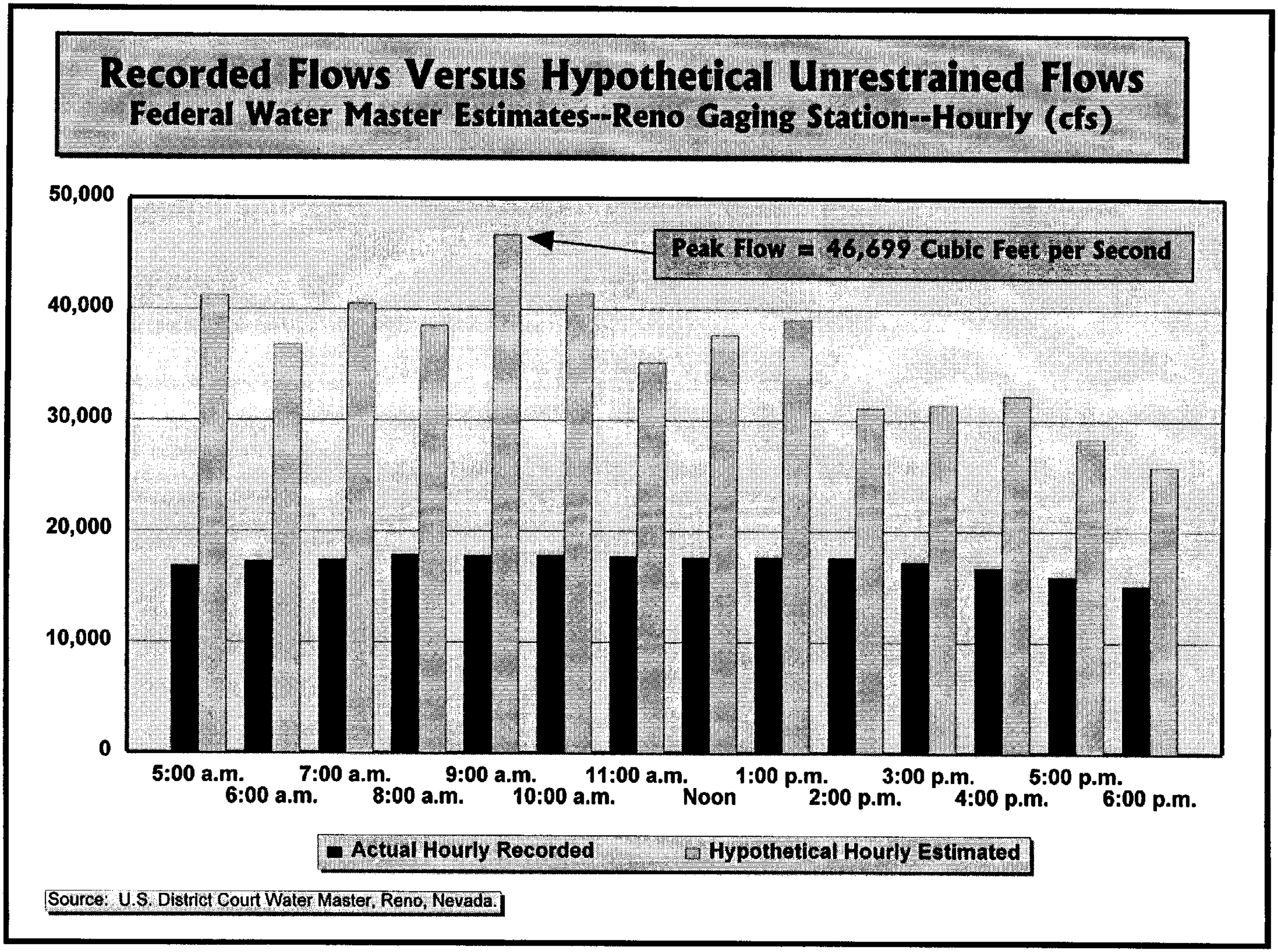
[1] The USGS Farad gaging station is located 3.5 miles upstream from the California-Nevada state line.

[2] The USGS Reno gaging station is located 400 feet downstream from the Kietzke Lane Bridge.

[3] Hypothetical river flows are based on actual (provisional) recorded flows plus estimate reservor discharges reflecting 100 percent flow-through of inflows.

Source: U.S. District Court Water Master's High Water Worksheets, Reno, Nevada.


Recorded Flows Versus Hypothetical Unrestrained Flows
February 2, 1997--Water Master Estimates--Farad Gaging Station (cfs)
Peak Flow = 43,449 Cubic Feet per Second
50,000
40,000
30,000
20,000
10,000
0
5:00 a.m.
6:00 a.m.
7:00 a.m.
8:00 a.m.
9:00 a.m.
10:00 a.m.
11:00 a.m.
Noon
1:00 p.m.
2:00 p.m.
3:00 p.m.
4:00 p.m.
5:00 p.m.
6:00 p.m.
Actual Hourly Recorded
Hypothetical Hourly Estimated
Source: U.S. District Court Water Master, Reno, Nevada.



Recorded Flows Versus Hypothetical Unrestrained Flows
Federal Water Master Estimates--Reno Gaging Station--Hourly (cfs)
Peak Flow = 46,699 Cubic Feet per Second
50,000
40,000
30,000
20,000
10,000
0
5:00 a.m.
6:00 a.m.
7:00 a.m.
8:00 a.m.
9:00 a.m.
10:00 a.m.
11:00 a.m.
Noon
1:00 p.m.
2:00 p.m.
3:00 p.m.
4:00 p.m.
5:00 p.m.
6:00 p.m.
Actual Hourly Recorded
Hypothetical Hourly Estimated
Source: U.S. District Court Water Master, Reno, Nevada.

Appendix A

Northern Nevada Principal Watershed Maps, River Flow Schematics, NRCS SNOTEL Sites, and Nevada Hydrographic Basins

Hydrologic Features of the Truckee and Carson River Basins

Lake Tahoe Area and Basin

Walker River Basin

Lake Tahoe and Upper Truckee River Flow Schematic

Lower Truckee River Flow Schematic

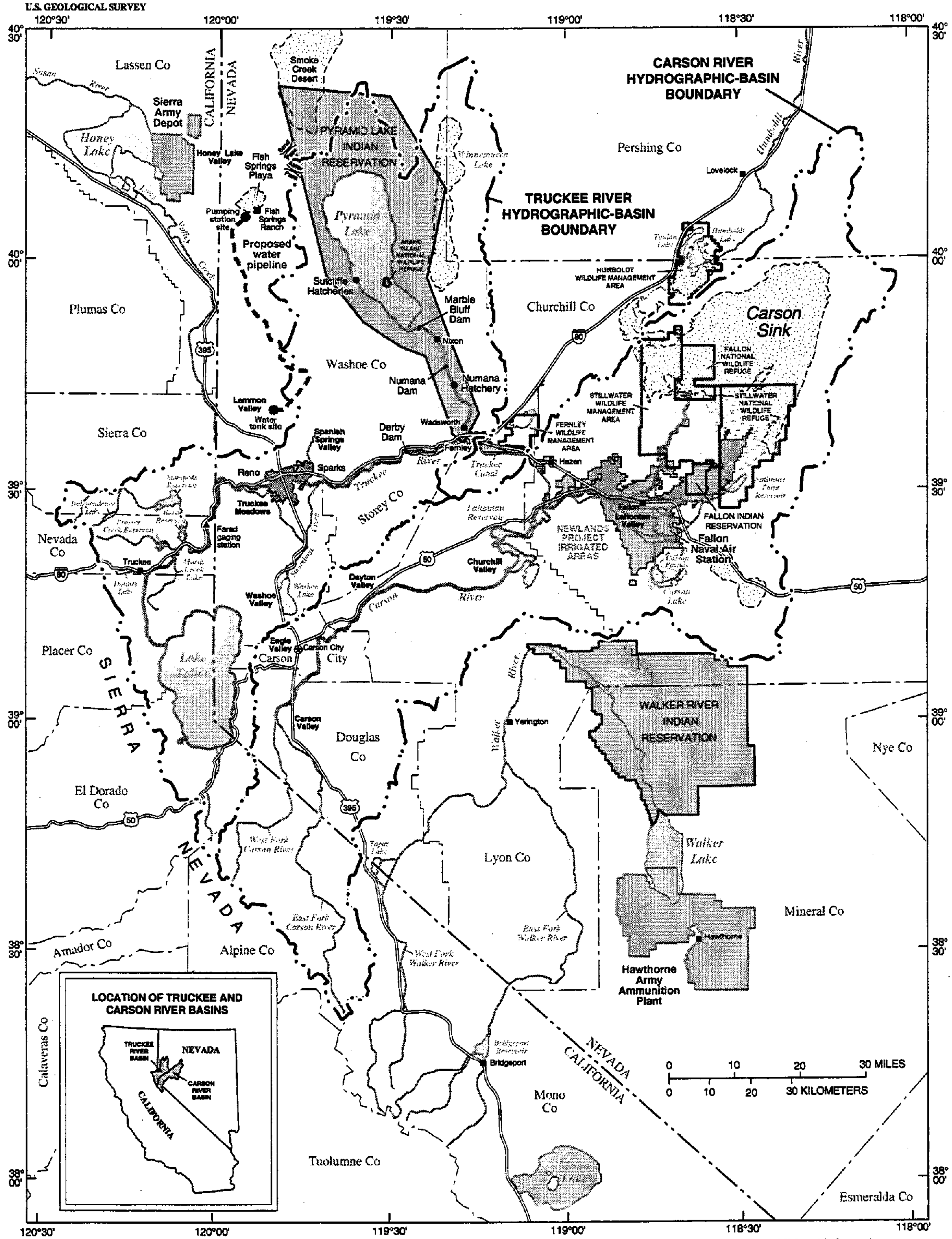
Carson River Flow Schematic

Walker River Flow Schematic

NRCS SNOTEL Site Locations in Western Nevada and California
[NRCS = Natural Resources Conservation Service]
[SNOTEL = Snow telemetry]

<u>Nevada Hydrographic Basins</u>

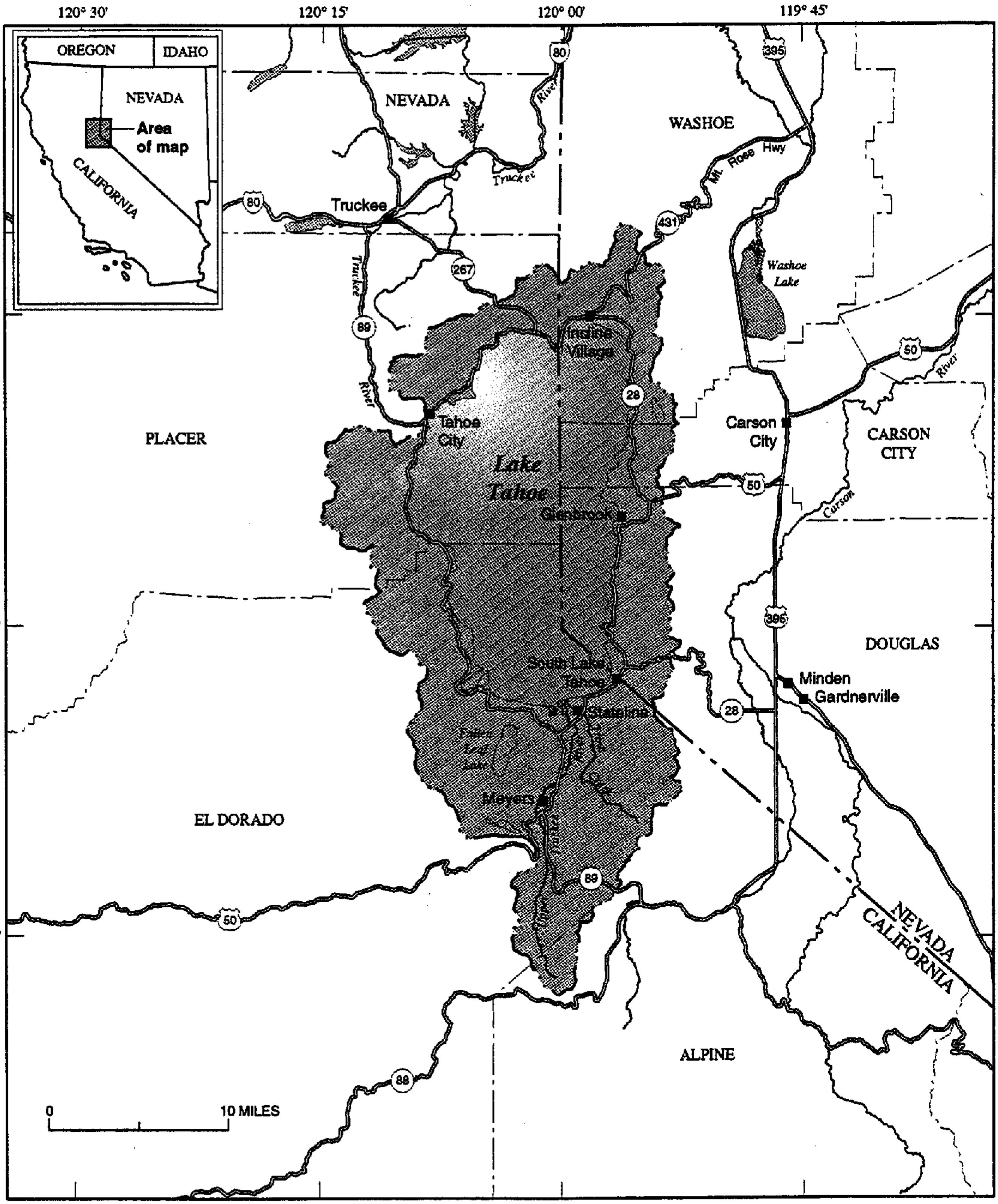
Lake Tahoe and Truckee River Basins
Carson River Basin
Walker River Basin



Base from U.S. Geological Survey digital data 1:100,000, 1977-85
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -119°00'

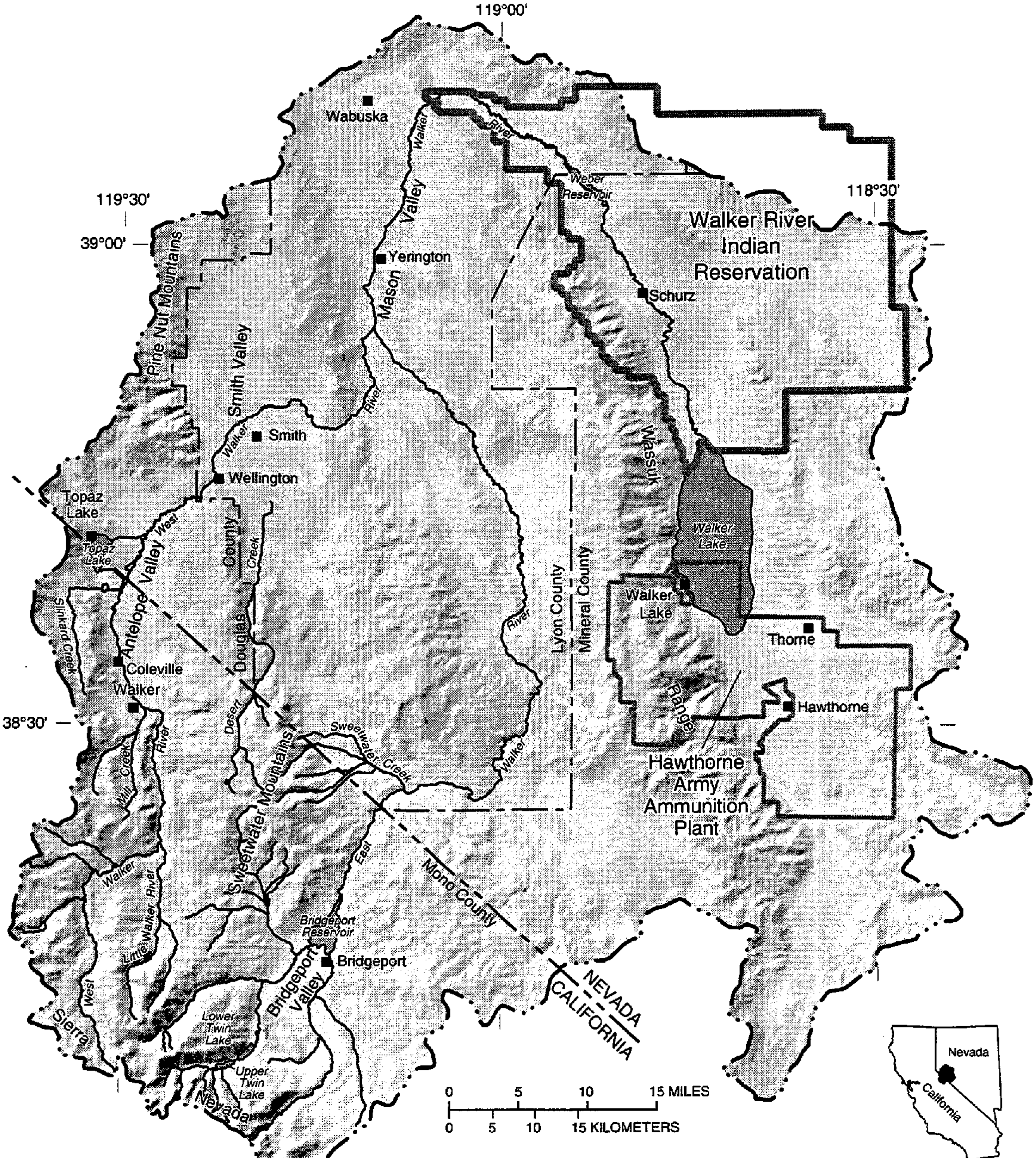
For additional information, contact
District Chief / U.S. Geological Survey
333 W. Nye Lane / Carson City, NV 89706

HYDROLOGIC FEATURES OF THE TRUCKEE AND CARSON RIVER BASINS AND ADJACENT AREAS, WESTERN NEVADA AND EASTERN CALIFORNIA

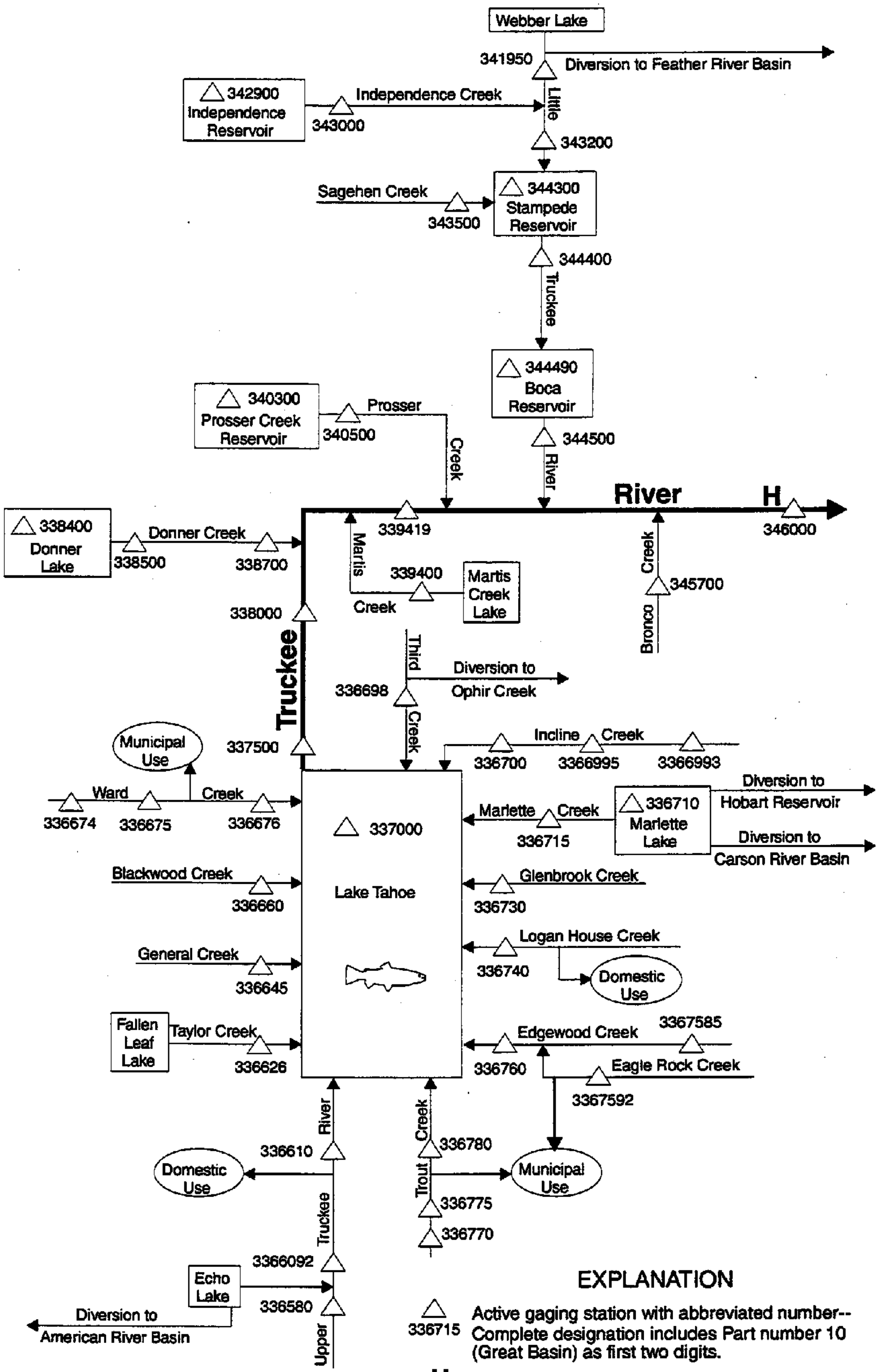


Base from U.S. Geological Survey digital data, 1:100,000, 19xx
Universal Transverse Mercator projection.
Zone 11

U.S. GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
CARSON CITY, NEVADA



Walker River Basin

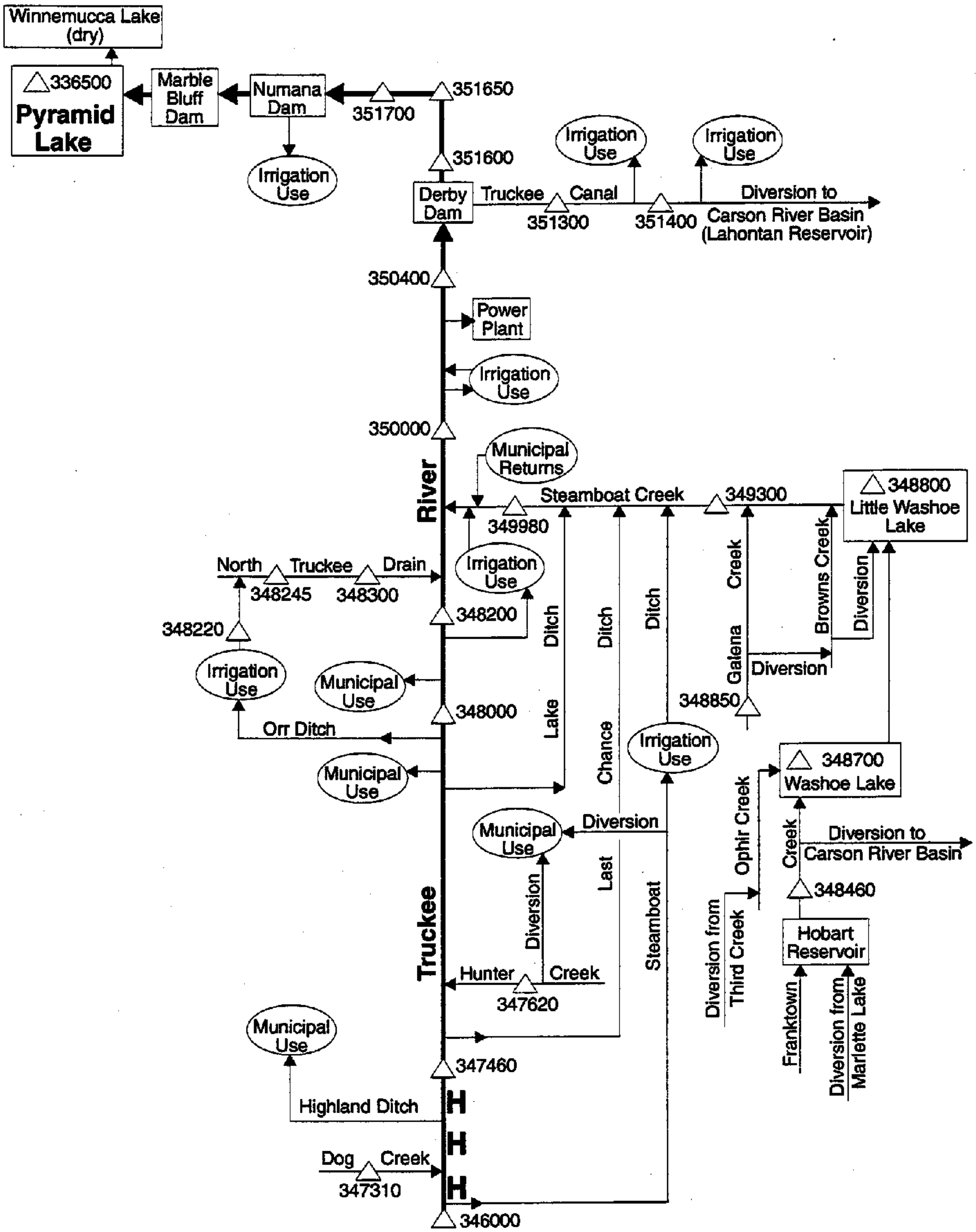


Lake Tahoe and Upper Truckee River Flow Schematic

Lake Tahoe and Truckee River Basins

Listing of USGS Gaging Stations

Schematic diagram provided courtesy of
U.S. Geological Survey, Water Resources
Division, Carson City, Nevada, 1996



EXPLANATION

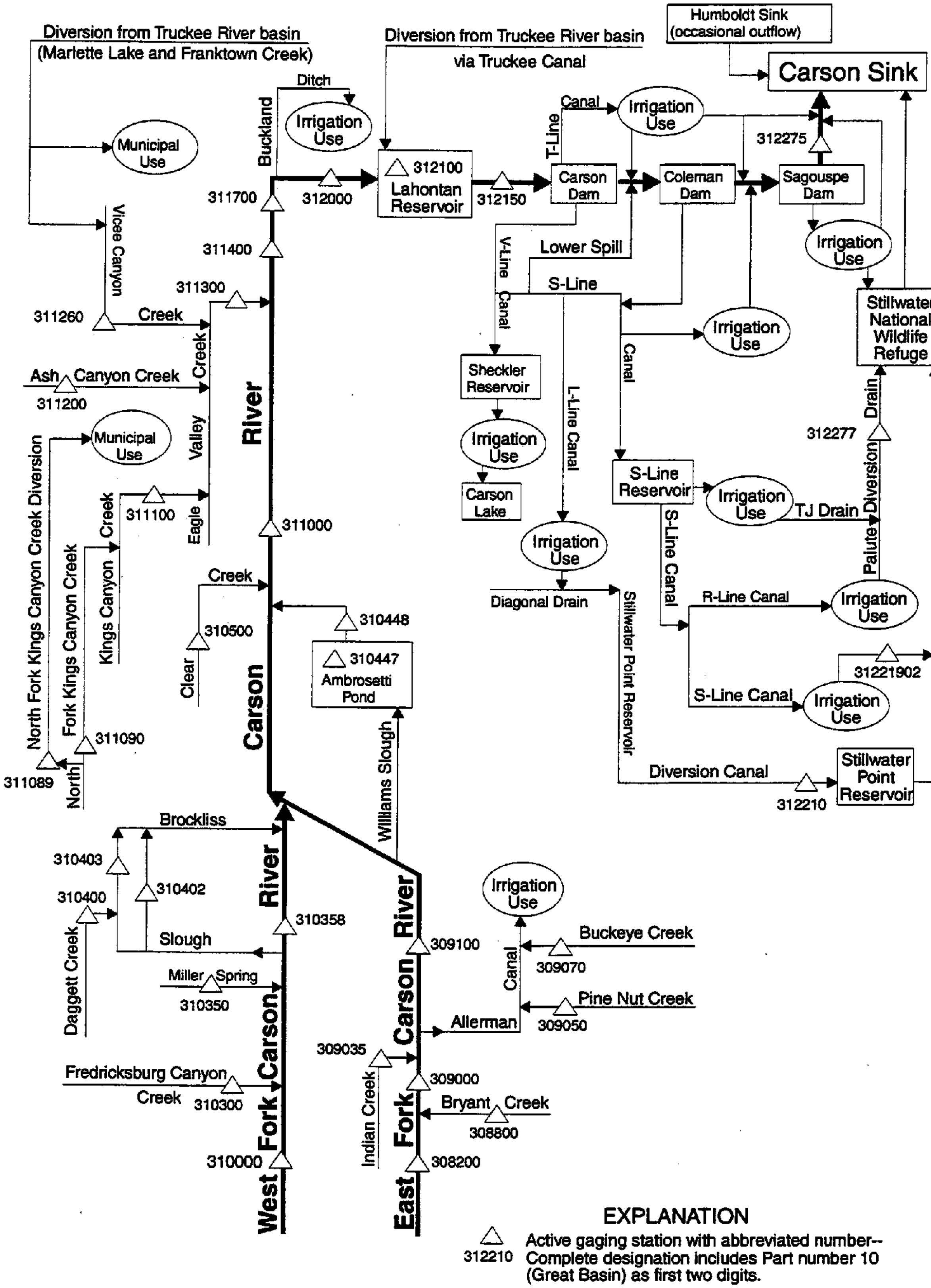
△ 346000 **Active gaging station with abbreviated number--** Complete designation includes Part number 10 (Great Basin) as first two digits.

H Hydroelectric powerplant.

Lower Truckee River Flow Schematic

Truckee River Basin Listing of USGS Gaging Stations

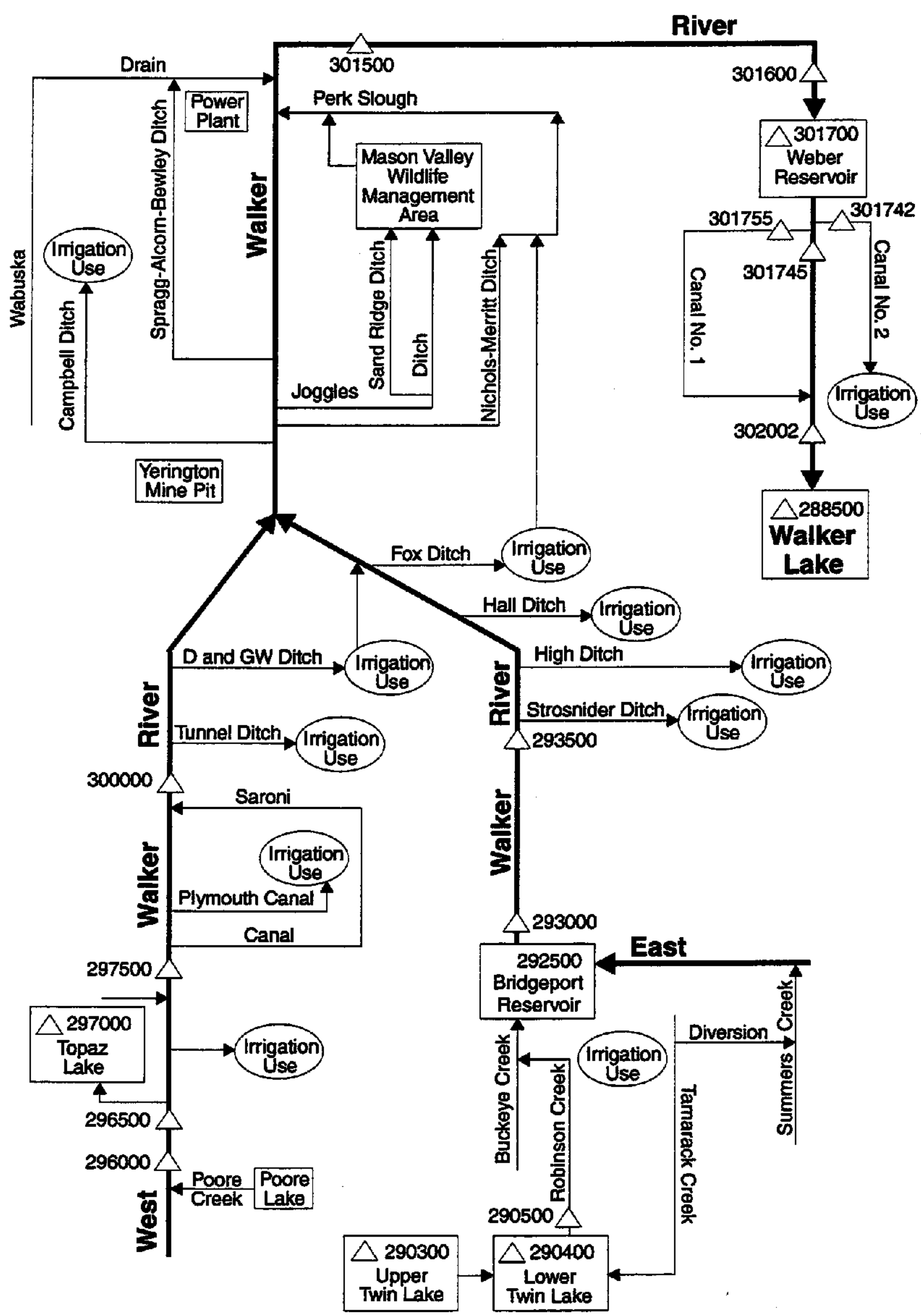
Schematic diagram provided courtesy of U.S. Geological Survey, Water Resources Division, Carson City, Nevada, 1996



Carson River Flow Schematic

Carson River Basin Listing of USGS Gaging Stations

Schematic diagram provided courtesy of
U.S. Geological Survey, Water Resources
Division, Carson City, Nevada, 1996



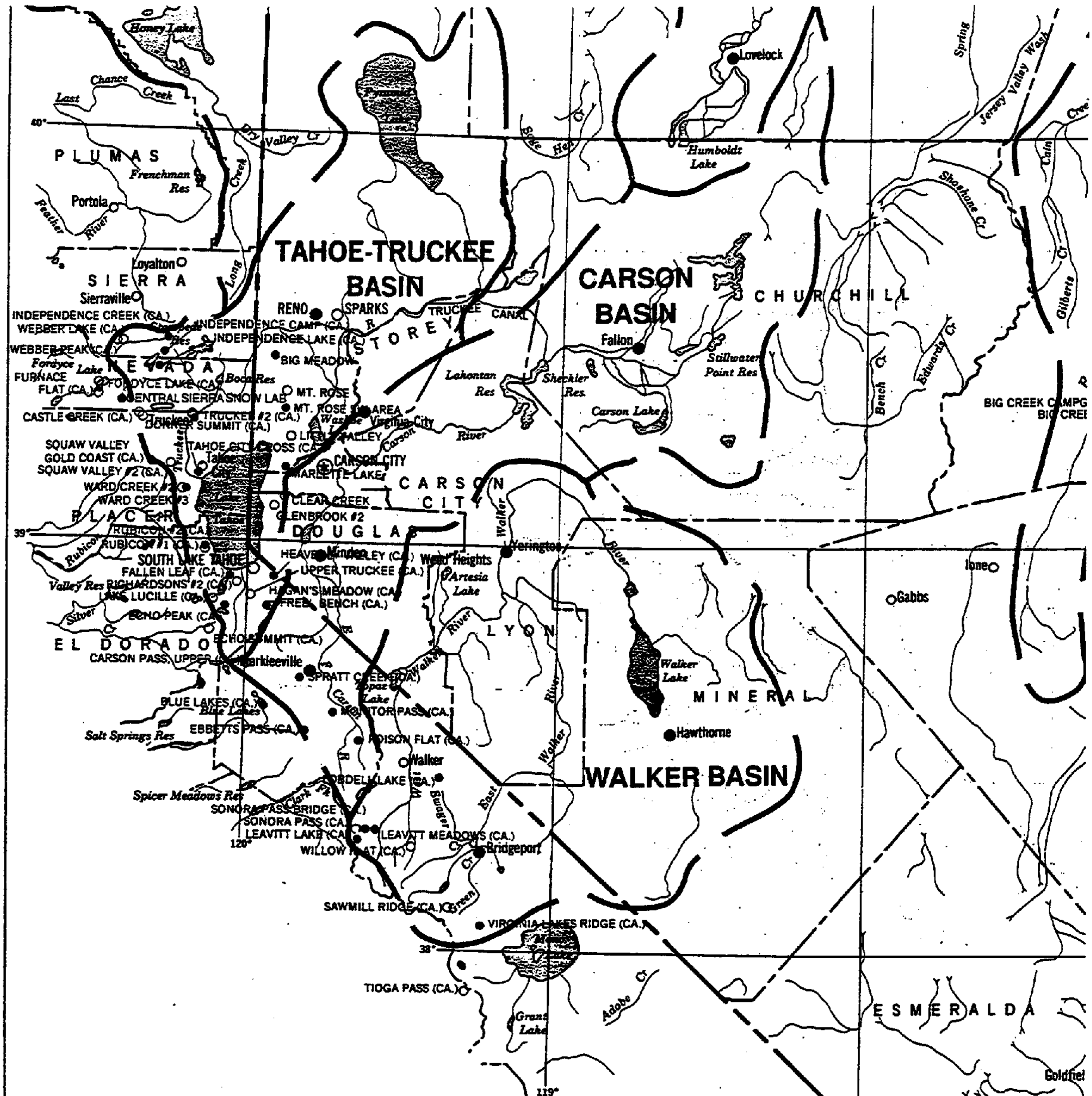
EXPLANATION

288500 **Active gaging station with abbreviated number–** Complete designation includes Part number 10 (Great Basin) as first two digits.

Walker River Flow Schematic

Walker River Basin Listing of USGS Gaging Stations

Schematic diagram provided courtesy of U.S. Geological Survey, Water Resources Division, Carson City, Nevada, 1996



Natural Resources Conservation Service—SNOTEL Site Locations in Western Nevada and California

LEGEND

- BASIN BOUNDARY
- COUNTY BOUNDARY
- o SNOW COURSE/AERIAL MARKER MEASURING SITE
- • SNOTEL DATA SITE

NEVADA HYDROGRAPHIC BASINS

A **Hydrographic Basin**, or **Waterbasin**, is defined as a geographic area drained by a single major stream or an area consisting of a drainage system comprised of streams and often natural or man-made lakes. Waterbasins are also referred to as Drainage Basin, Watershed, or Hydrographic Region. The U.S. Geological Survey (USGS) and the Nevada Division of Water Resources, Department of Conservation and Natural Resources, have divided the State of Nevada into discrete hydrologic units for water planning and management purposes. These have been identified as 232 Hydrographic Areas (256 areas and sub-areas, combined) within 14 major Hydrographic Regions or Basins. These 14 Nevada Hydrographic Regions (Basins) are:

[1] ***Northwest Region***—Covers 3,052 square miles (7,905 square kilometers or 1,953,280 acres) of northern Washoe and Humboldt counties and encompasses 16 hydrographic areas; also extends into the State of California to the west and the State of Oregon to the north;

[2] ***Black Rock Desert Region***—Covers 8,632 square miles (22,357 square kilometers or 5,524,480 acres) of parts of Washoe, Humboldt, and Pershing counties and includes 17 valleys (hydrographic areas), two of which are divided into two hydrographic sub-areas each; also extends into the State of California to the west and the State of Oregon to the north;

[3] ***Snake River Basin***—Covers 5,230 square miles (13,546 square kilometers or 3,347,200 acres) in parts of Elko and Humboldt counties to include eight hydrographic areas; also extends into the states of Oregon and Idaho to the north and the State of Utah to the east;

[4] ***Humboldt River Basin***—Covers over 16,843 square miles (43,623 square kilometers or 10,779,520 acres) in parts of eight counties—Elko, White Pine, Eureka, Humboldt, Lander, Nye, Pershing, and Churchill—and the largest stream (Humboldt River) wholly within Nevada. This basin contains 34 hydrographic areas and one hydrographic sub-area; this basin is one of only two that are wholly contained within the State of Nevada;

[5] ***West Central Region***—Covers 1,656 square miles (4,289 square kilometers or 1,059,840 acres) and includes parts of Pershing, Lyon, and Churchill counties and comprises five hydrographic areas; this basin is one of only two that are wholly contained within the State of Nevada;

[6] ***Truckee River Basin***—Encompasses 2,300 square miles (5,957 square kilometers or 1,472,000 acres) containing parts of Washoe, Pershing, Churchill, Lyon, Douglas, Carson City, and Storey counties comprising 12 hydrographic areas; has its origin to the west in the State of California;

[7] ***Western Region***—Covers 602 square miles (1,559 square kilometers or 385,280 acres) and is wholly contained in Washoe County and contains nine valleys (hydrographic areas) one of which is divided into two sub-areas and another divided into one hydrographic sub-area; also extends to the west into the State of California;

[8] ***Carson River Basin***—Covers 3,519 square miles (9,114 square kilometers or 2,252,160 acres) and includes parts of six counties—Douglas, Carson City, Lyon, Storey, Churchill, and Pershing—containing five hydrographic areas and one hydrographic sub-area along the Carson River and its tributaries; has its origin to the west in the State of California;

[9] ***Walker River Basin***—Covers 3,046 square miles (7,889 square kilometers or 1,949,440 acres) of Mineral, Lyon, and Douglas counties (and a very small portion of Churchill County) including five hydrographic areas, one of which has been divided into three hydrographic sub-areas; has its origin to the west in the State of California;

[10] ***Central Region***—By far the largest hydrographic region in Nevada covering 46,783 square miles (121,167 square kilometers or 29,941,120 acres) in 13 counties—Nye, Elko, White Pine, Lincoln, Clark, Humboldt, Pershing, Churchill, Lander, Eureka, Lyon, Mineral, and Esmeralda. This region includes 78 valleys (hydrographic areas), 10 of which are divided into two hydrographic sub-areas and one into three hydrographic sub-areas; extends to the south and west into the State of California;

[11] ***Great Salt Lake Basin***—Covers 3,807 square miles (9,860 square kilometers or 2,436,480 acres) of the easternmost portions of Elko, White Pine, and Lincoln counties. It consists of eight hydrographic areas, one of which is divided into four hydrographic sub-areas; extends to the east into the State of Utah;

[12] ***Escalante Desert Basin***—This basin covers a large area in Utah but only a very small part of it is in Lincoln County—106 square miles (275 square kilometers or 67,480 acres)—and is made up of only one hydrographic area; extends to the east into the State of Utah;

[13] ***Colorado River Basin***—Covers 12,376 square miles (32,054 square kilometers or 7,920,640 acres) including parts of Clark, Lincoln, Nye, and White Pine counties and is divided into 27 hydrographic areas; extends to the south into the State of California, borders the Colorado River to the east and south, and extends into the states of Arizona and Utah to the east;

[14] ***Death Valley Basin***—Covers 2,593 square miles (6,716 square kilometers or 1,659,520 acres) of Nye and Esmeralda counties including eight hydrographic areas, one of which has been divided into two hydrographic sub-areas; extends into the State of California to the south and west.

[NOTES: Areas listed above are for Nevada portion only. A complete listing of Nevada's Hydrographic Areas and Sub-Areas is presented in the Nevada Division of Water Planning's ***WATER WORDS DICTIONARY***, Appendix A–1 (listed sequentially by Hydrographic Area number and Hydrographic Region/Basin), Appendix A–2 (listed alphabetically by Hydrographic Area and Sub-Area name), and Appendix A–3 (listed alphabetically by principal Nevada county(ies) in which located).]

The Flood of January 1997

Impacted Nevada Hydrographic Regions (Basins), Areas, and Sub-Areas

[1] Area Num.	[2] Area (sq mi)	[3] Area (acres)	[4] Hydrograph Area/Sub-Area	[5] Counties (Ordered by Location)	[6] Nearest City(ies)	[7] Des.
HYDROGRAPHIC REGION [6]--TRUCKEE RIVER BASIN						
80	371	237,440	Winnemucca Lake Valley	Pershing, Washoe	Nixon, Gerlach	No
81	672	430,080	Pyramid Lake Valley	Washoe	Nixon, Sutcliffe	No
82	92	58,880	Dodge Flat	Washoe	Wadsworth	No
83	285	182,400	Tracy Segment	Lyon, Storey, Washoe	Sparks, Fernley	Yes
84	247	158,080	Warm Springs Valley	Washoe	Sparks	Yes
85	76	48,640	Spanish Springs Valley	Washoe	Sparks, Reno	Yes
86	10	6,400	Sun Valley	Washoe	Sun Valley, Sparks	Yes
87	203	129,920	Truckee Meadows	Washoe	Reno, Sparks	Yes
88	39	24,960	Pleasant Valley	Washoe	Reno, Washoe City	Yes
89	82	52,480	Washoe Valley	Washoe	Washoe City	Yes
90	139	88,960	Lake Tahoe Basin	Carson City, Douglas, Washoe	Incline Village, Glenbrook, Stateline	Yes
91	84	53,760	Truckee Canyon Segment	Washoe	Verdi	Yes
Total	**2,300**	**1,472,000**	**Square miles/acres**			
HYDROGRAPHIC REGION [8]--CARSON RIVER BASIN						
101	2,022	1,294,080	Carson Desert	Churchill, Lyon, Pershing	Fallon, Stillwater	Yes
101A	160	102,400	Carson Desert/Parkard Valley	Pershing	Lovelock	Yes
102	480	307,200	Churchill Valley	Douglas, Lyon, Pershing, Storey	Fallon	Yes
103	369	236,160	Dayton Valley	Carson City, Douglas, Lyon, Storey	Dayton, Virginia City	Yes
104	69	44,160	Eagle Valley	Carson City, Douglas	Carson City	Yes
105	419	268,160	Carson Valley	Carson City, Douglas	Minden, Gardnerville	Yes
106	115	73,600	Antelope Valley	Douglas	Topaz, Wellington	Yes
Total	**3,634**	**2,325,760**	**Square miles/acres**			

[1] Area Num.	[2] Area (sq mi)	[3] Area (acres)	[4] Hydrograph Area/Sub-Area	[5] Counties (Ordered by Location)	[6] Nearest City(ies)	[7] Des.
HYDROGRAPHIC REGION [9]--WALKER RIVER BASIN						
107	479	306,560	Smith Valley	Douglas, Lyon	Wellington	Yes
108	516	330,240	Mason Valley	Lyon, Mineral	Yerington, Mason	Yes
109	586	375,040	East Walker Area	Lyon, Mineral	Bridgeport, Yerington	No
110A	502	321,280	Walker Lake Valley/Schurz Sub-Area	Lyon, Mineral	Schurz	No
110B	307	196,480	Walker Lake Valley/Lake Sub-Area	Mineral	Walker Lake, Hawthorne, Schurz	No
110C	541	346,240	Walker Lake Valley/Whiskey Flat-Hawthorne Sub-Area	Mineral	Hawthorne, Babbit	Yes
Total	**2,931**	**1,875,840**	**Square miles/acres**			

County Hydrologic Regions, Areas, and Sub-Areas Table Notes:

Note: Areas are for the Nevada portions only.

A Hydrographic Region or Basin is defined as a geographic area drained by a single major stream or an area consisting of a drainage system comprised of streams and often natural or man-made lakes. Also referred to as Drainage Basin, Watershed, or Waterbasin. The U.S. Geological Survey and the Nevada Division of Water Resources, Department of Conservation and Natural Resources, have divided the state into discrete hydrologic units for water planning and management purposes. These have been identified as 232 Hydrographic Areas (256 areas and sub-areas, combined) within 14 major Hydrographic Regions or Basins.

[1] Nevada Hydrographic Area/Sub-Area number (1-232; Hydrographic Sub-Areas designated A, B, C, etc.).

[2] and [3] Hydrographic Area/Sub-Area surface areas in square miles and acres, respectively. Areas are for Nevada only.

[4] Nevada Area or Sub-Area (valley) name.

[5] Nevada Counties wholly or partially included, listed by principal county first.

[6] Nearest principal city or cities.

[7] Des. = Designated Groundwater Basin (Area or Sub-Area). Designated Groundwater Basins are hydrographic areas or sub-areas where permitted ground water rights approach or exceed the estimated average annual recharge (i.e., the perennial yield of the basin) and water resources are being depleted or require additional administration. Under such conditions, and, in the interest of public welfare, the Nevada State Engineer, Division of Water Resources, Department of Conservation and Natural Resources, will so designate a groundwater basin (hydrographic area or sub-area) and declare preferred water uses.

Source: Office of the State Engineer, Nevada Division of Water Resources, Department of Conservation and Natural Resources.

Appendix B

Lake Tahoe Basin

NRCS SNOTEL Sites

Heavenly Valley
Marlette Lake
Echo Peak
Rubicon #2
Fallen Leaf
Tahoe City Cross

Tables

1A. Precipitation Summary

1B. Comparisons of Changes in Precipitation and Snowpack Water Content

Part I—12/16/96–12/23/96

Part II—12/30/96–01/06/97

Part III—12/16/96–01/06/97

Graphs

Snowpack Water Content and Total Precipitation (Inches)

Ratio of Snowpack Water Content and Total Precipitation (Percent)

Estimated Total Available Runoff by Time Period (Inches)

Composition of Total Available Runoff (Inches)—12/30/96–01/06/97

Percent of Normal—Snowpack Water Content/Total Precipitation (Percent)

1A--Lake Tahoe Basin--Precipitation Summary

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97 [1]

NRCS SNOTEL Sites	SNOTEL Site Elevation (feet MSL) [2]	Change in Precipitation (Inches)	Change in Snowpack Water Content (Inches)	Precipitation/ Snowpack Difference (Inches) [3]
Heavenly Valley:	8,850			
December 16-23, 1996......................		5.3	6.5	**-1.2**
December 30, 1996-January 6, 1997.		7.2	1.0	**6.2**
Marlette Lake:	8,000			
December 16-23, 1996......................		3.1	6.8	**-3.7**
December 30, 1996-January 6, 1997.		8.2	-0.4	**8.6**
Echo Peak:	7,800			
December 16-23, 1996......................		5.4	9.9	**-4.5**
December 30, 1996-January 6, 1997.		15.8	-1.5	**17.3**
Rubicon #2:	7,500			
December 16-23, 1996......................		5.0	6.3	**-1.3**
December 30, 1996-January 6, 1997.		12.4	-2.7	**15.1**
Fallen Leaf:	6,300			
December 16-23, 1996......................		4.9	5.3	**-0.4**
December 30, 1996-January 6, 1997.		11.8	-5.2	**17.0**
Tahoe City Cross:	6,750			
December 16-23, 1996......................		4.1	7.8	**-3.7**
December 30, 1996-January 6, 1997.		10.9	-4.6	**15.5**

[1] December 16, 1996--December 23, 1996 was a heavy snowfall event with significant additions to snowpack water content; December 30, 1996--January 6, 1997 was a heavy, warm rainfall event with significant runoff and snowpack depletion.

[2] MSL = Above mean sea level.

[3] Positive values for column entries under "Precipitation/Snowpack Difference" reflect available runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation. Table Interpretation: Entries under "Change in Precipitation" and "Change in Snowpack Water Content" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time can the change in snowpack water content accumulated between dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content, are not realistic and along with values close to zero (0) should be interpreted only in the sense that the snowpack is absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle event) the effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

1B--LAKE TAHOE BASIN

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97

Sites		Precipitation			Snowpack Water Content			
Part I--12/16/96-12/23/96	Elevation (feet MSL)	12/16/96	12/23/96	Change (inches of water)	12/16/96	12/23/96	Change (inches of water)	Precipitation/ Snowpack Difference [1]
Heavenly Valley...............	8,850	11.5	16.8	5.3	10.5	17.0	6.5	**-1.2**
Percent of Normal		139%	179%		133%	183%		
Marlette Lake..................	8,000	11.3	14.4	3.1	6.4	13.2	6.8	**-3.7**
Percent of Normal		127%	144%		97%	176%		
Echo Peak.......................	7,800	36.2	41.6	5.4	20.5	30.4	9.9	**-4.5**
Percent of Normal		210%	209%		167%	213%		
Rubicon #2.......................	7,500	18.3	23.3	5.0	7.3	13.6	6.3	**-1.3**
Percent of Normal		158%	175%		95%	149%		
Fallen Leaf.......................	6,300	18.9	23.8	4.9	0.3	5.6	5.3	**-0.4**
Percent of Normal		266%	294%		14%	243%		
Tahoe City Cross.............	6,750	17.0	21.1	4.1	2.1	9.9	7.8	**-3.7**
Percent of Normal		157%	172%		42%	165%		
Part II--12/30/96-01/06/97	**Elevation (feet MSL)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**Precipitation/ Snowpack Difference [1]**
Heavenly Valley...............	8,850	19.6	26.8	7.2	20.8	21.8	1.0	**6.2**
Percent of Normal		188%	231%		196%	185%		
Marlette Lake..................	8,000	19.8	28.0	8.2	16.7	16.3	(0.4)	**8.6**
Percent of Normal		177%	224%		199%	173%		
Echo Peak.......................	7,800	49.5	65.3	15.8	36.1	34.6	(1.5)	**17.3**
Percent of Normal		220%	265%		221%	189%		
Rubicon #2.......................	7,500	28.4	40.8	12.4	19.0	16.3	(2.7)	**15.1**
Percent of Normal		191%	247%		183%	142%		
Fallen Leaf.......................	6,300	28.0	39.8	11.8	6.0	0.8	(5.2)	**17.0**
Percent of Normal		311%	390%		240%	28%		
Tahoe City Cross.............	6,750	25.0	35.9	10.9	9.6	5.0	(4.6)	**15.5**
Percent of Normal		181%	235%		139%	63%		

1B--LAKE TAHOE BASIN

For the Entire Period: 12/16/96--01/06/97

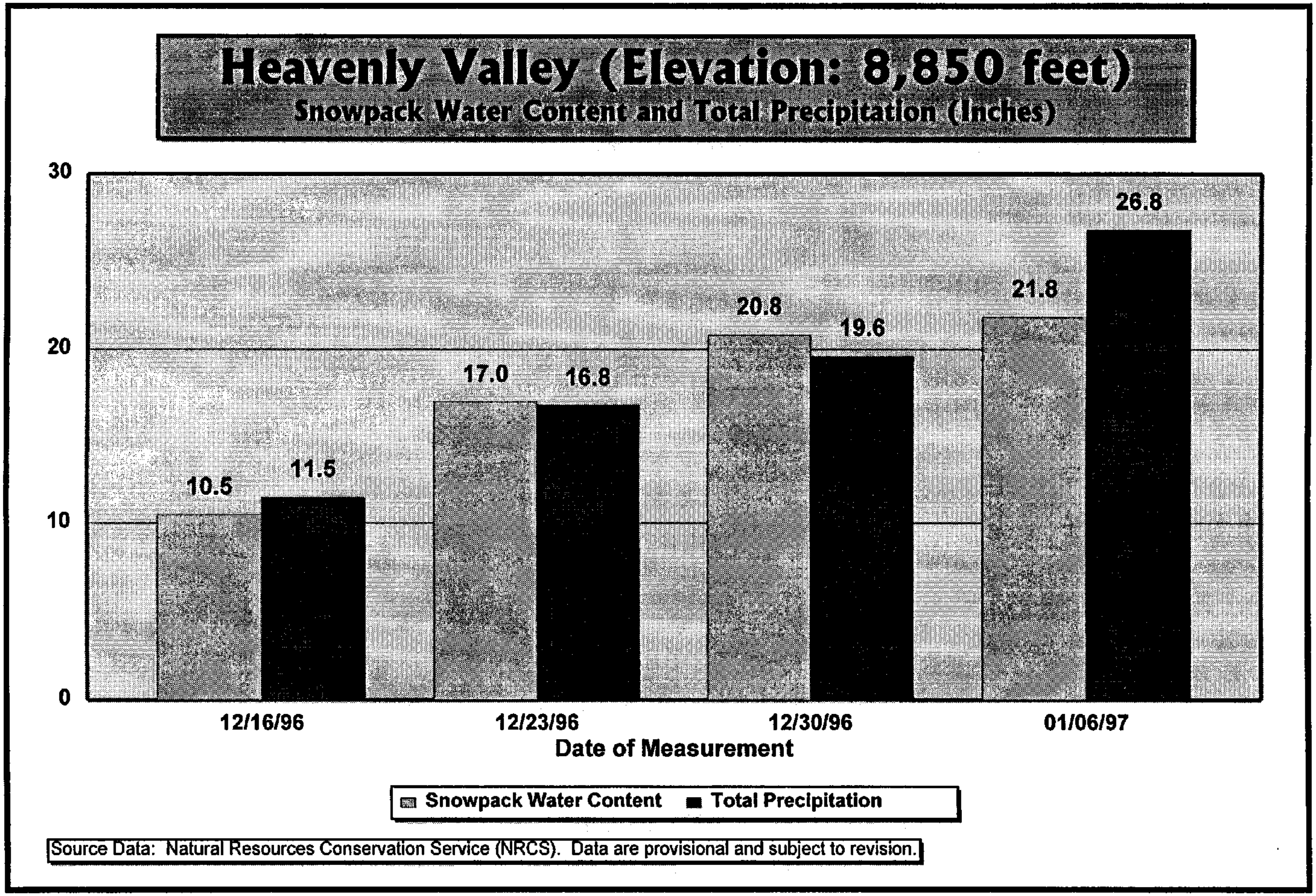
Sites		Precipitation			Snowpack Water Content			
Part III--12/16/96-01/06/97	Elevation (feet MSL)	12/16/96	01/06/97	Change (inches of water)	12/16/96	01/06/97	Change (inches of water)	Precipitation/ Snowpack Difference [1]
Heavenly Valley...............	8,850	11.5	26.8	15.3	10.5	21.8	11.3	**4.0**
Percent of Normal		139%	231%		133%	185%		
Marlette Lake..................	8,000	11.3	28.0	16.7	6.4	16.3	9.9	**6.8**
Percent of Normal		127%	224%		97%	173%		
Echo Peak.......................	7,800	36.2	65.3	29.1	20.5	34.6	14.1	**15.0**
Percent of Normal		210%	265%		167%	189%		
Rubicon #2.......................	7,500	18.3	40.8	22.5	7.3	16.3	9.0	**13.5**
Percent of Normal		158%	247%		95%	142%		
Fallen Leaf.......................	6,300	18.9	39.8	20.9	0.3	0.8	0.5	**20.4**
Percent of Normal		266%	390%		14%	28%		
Tahoe City Cross.............	6,750	17.0	35.9	18.9	2.1	5.0	2.9	**16.0**
Percent of Normal		157%	235%		42%	63%		

[1] Positive values for column entries under "Precipitation/Snowpack Difference" reflect direct runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

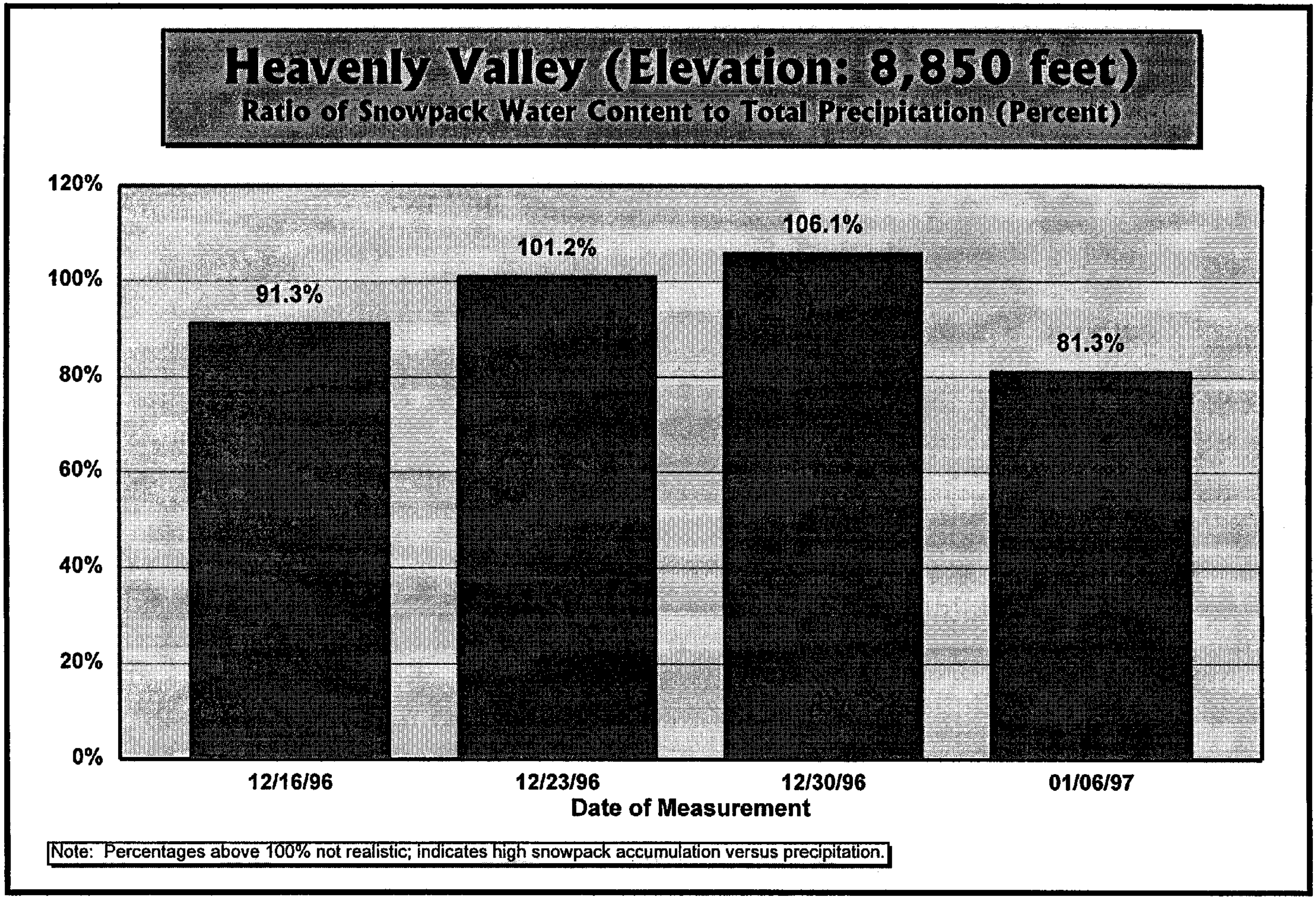
MSL = Above mean sea level.

Table Interpretation: Entries under "Precipitation Change" and "Snowpack Water Content Change" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time should the change in snowpack water content accumulated between two dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content are therefore not realistic and should be interpreted only in the sense that the snowpack appears to be absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle) effective runoff equals up to 80 percent of available runoff.

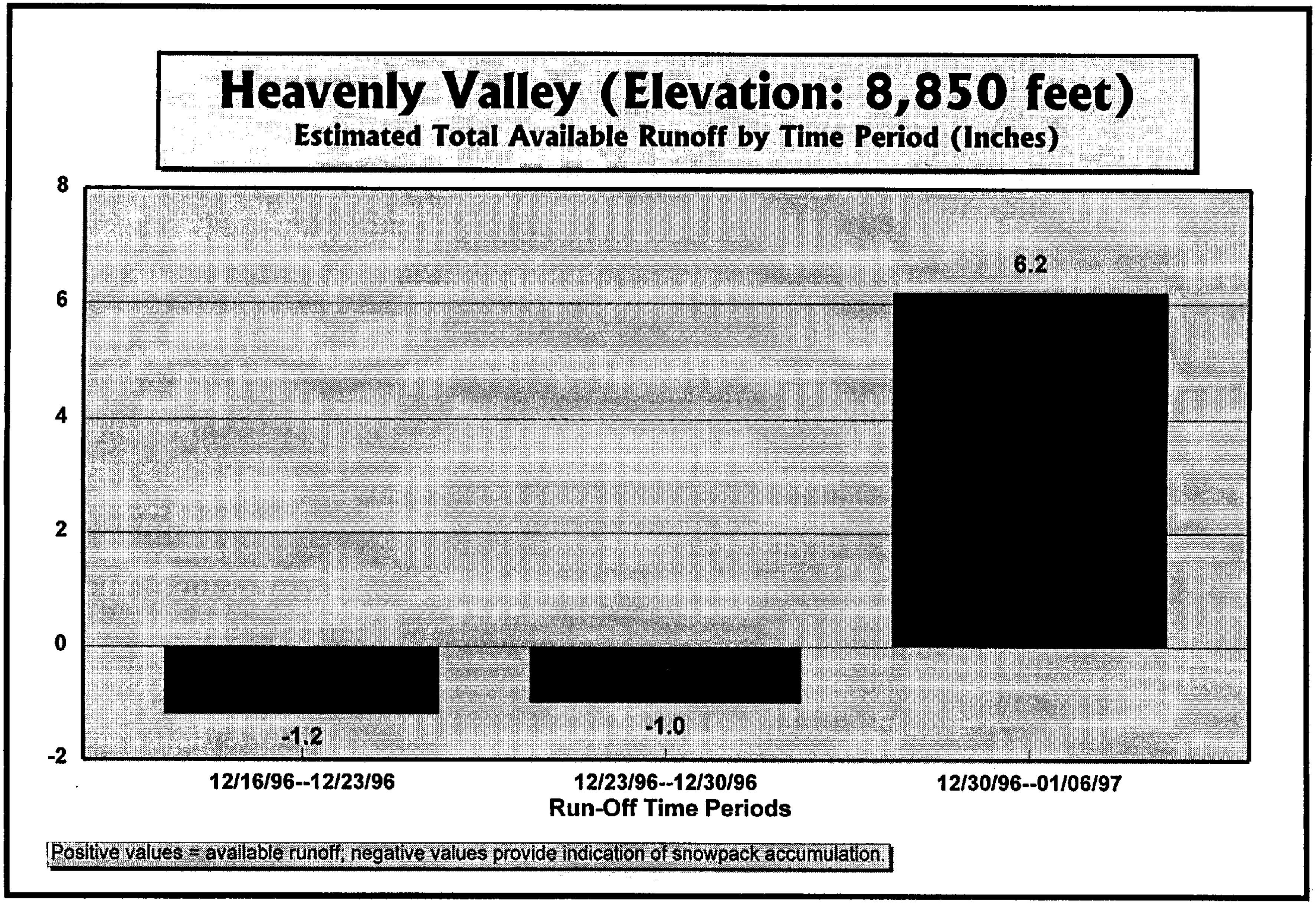
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

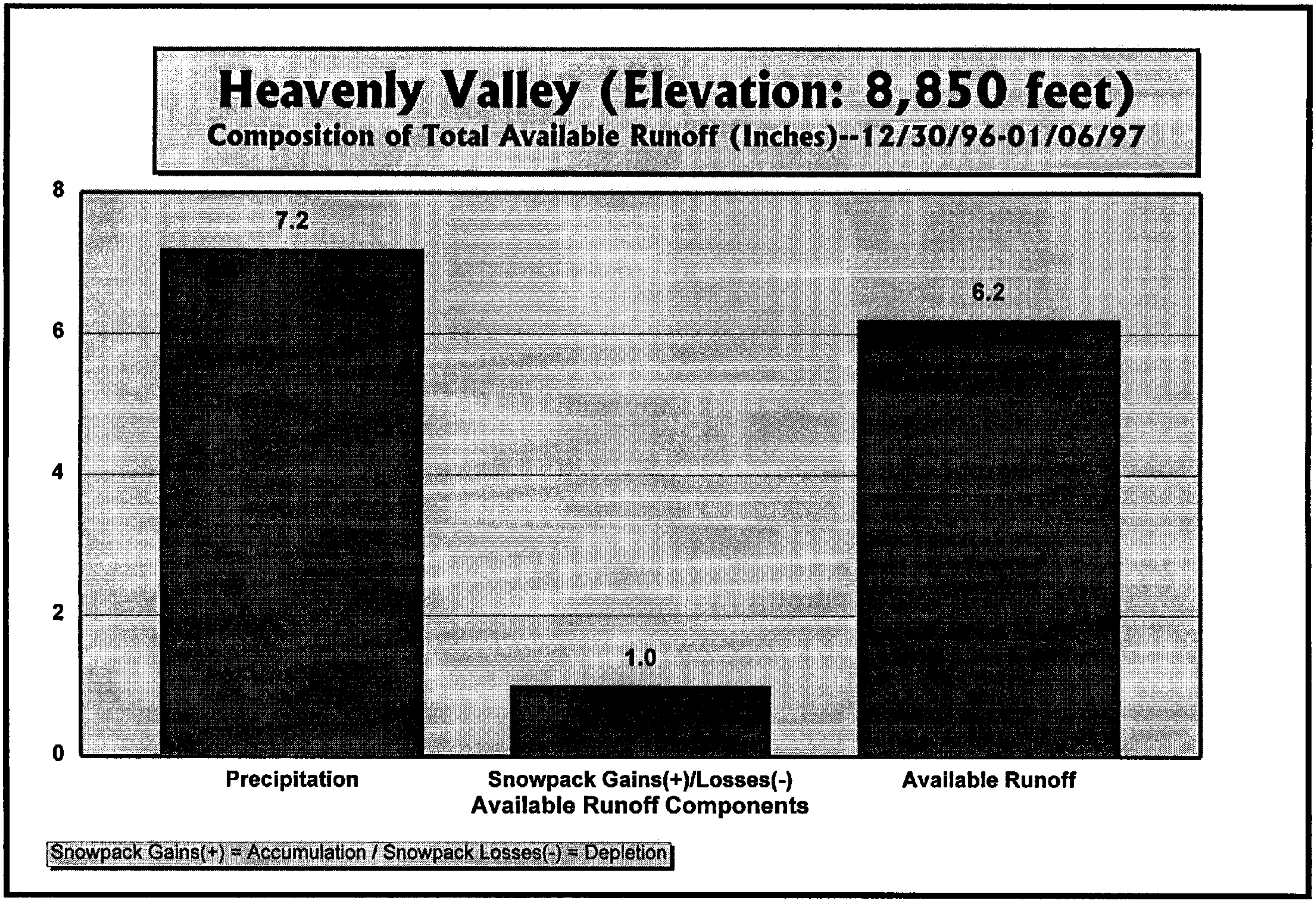


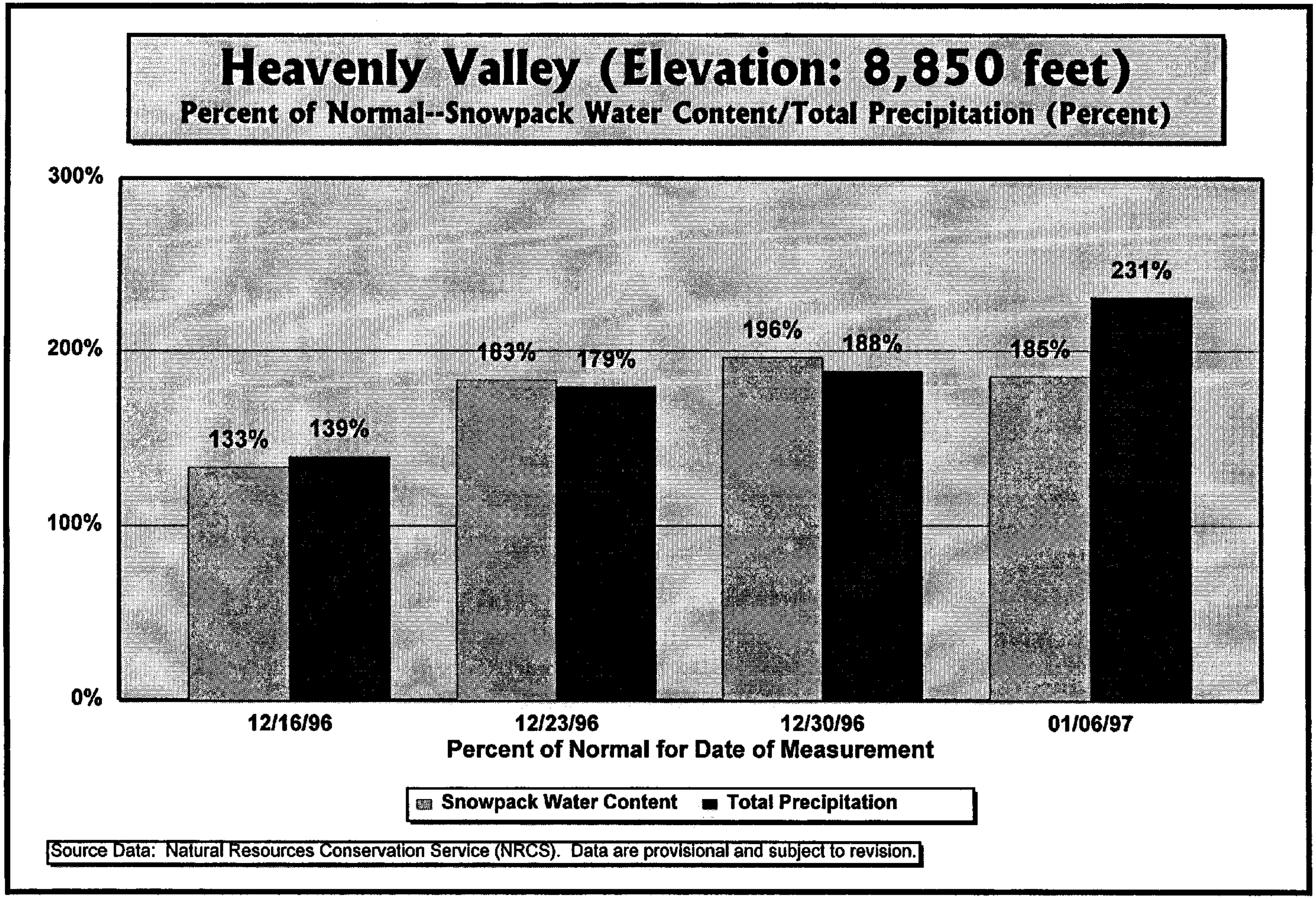
Heavenly Valley (Elevation: 8,850 feet)
Snowpack Water Content and Total Precipitation (Inches)
30
20
10
0
10.5
11.5
17.0
16.8
20.8
19.6
21.8
26.8
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.



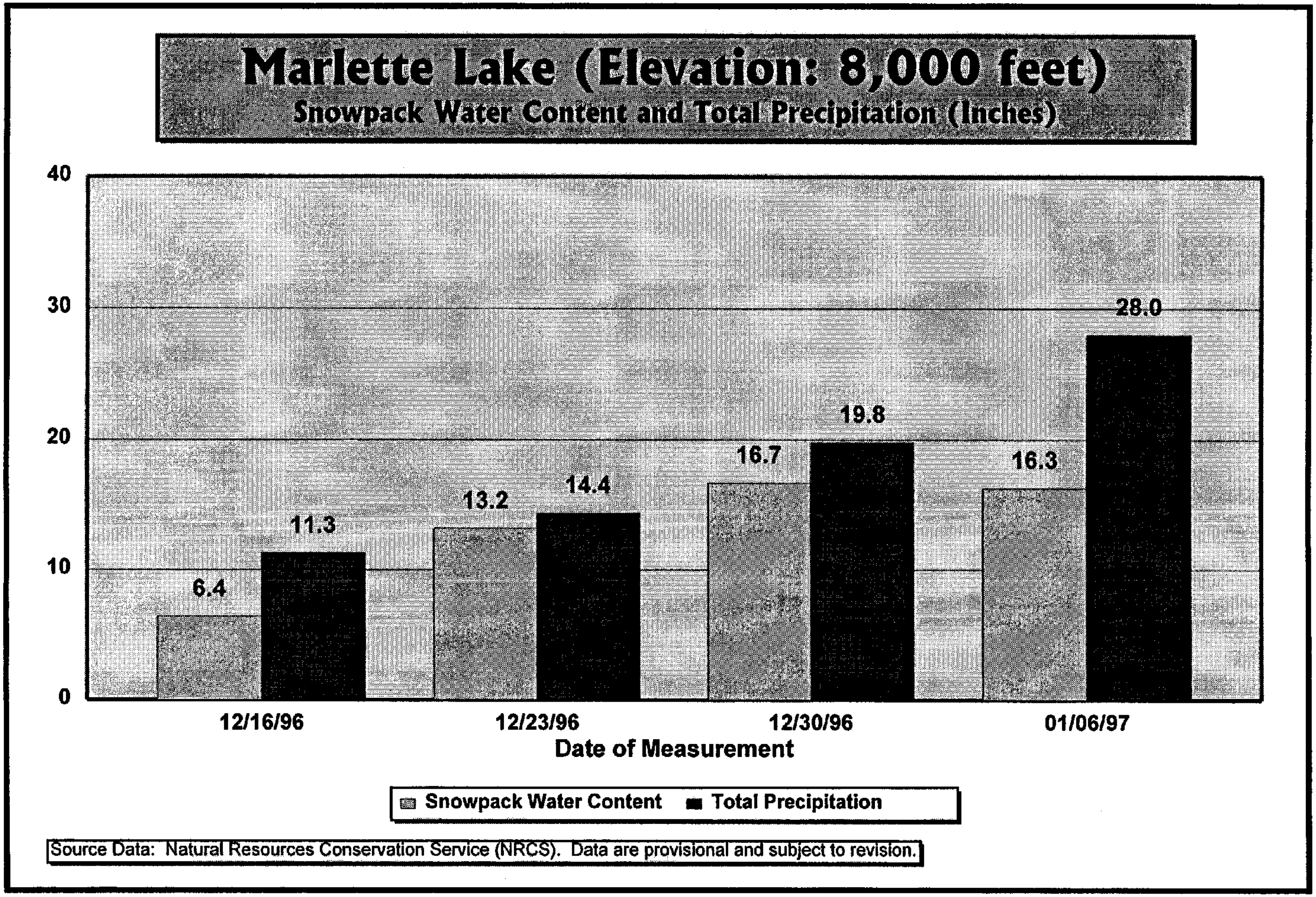
Heavenly Valley (Elevation: 8,850 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
120%
100%
80%
60%
40%
20%
0%
91.3%
101.2%
106.1%
81.3%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.


Heavenly Valley (Elevation: 8,850 feet)
Estimated Total Available Runoff by Time Period (Inches)
8
6
4
2
0
-2
6.2
-1.2
-1.0
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

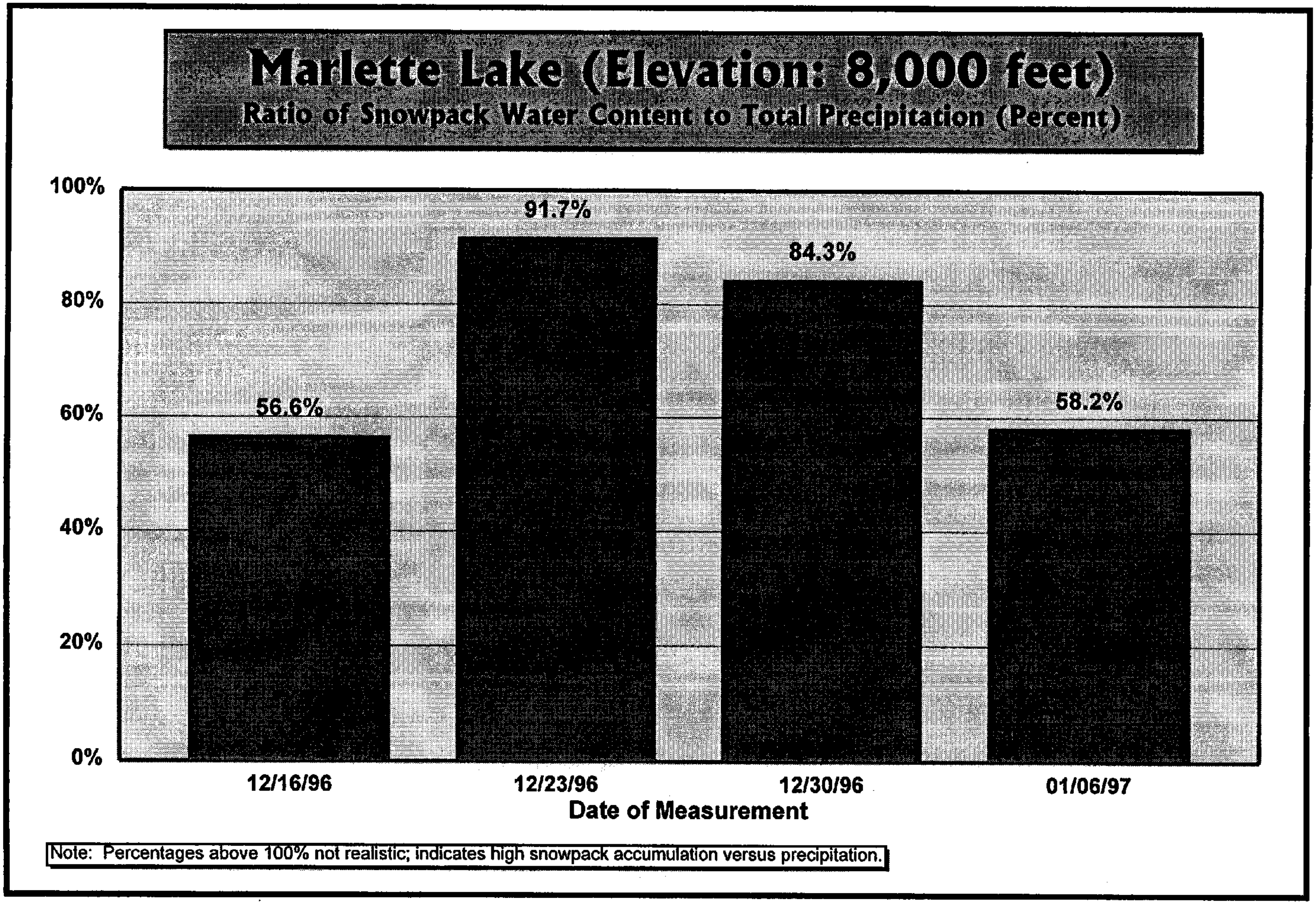

Heavenly Valley (Elevation: 8,850 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
8
6
4
2
0
7.2
1.0
6.2
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion



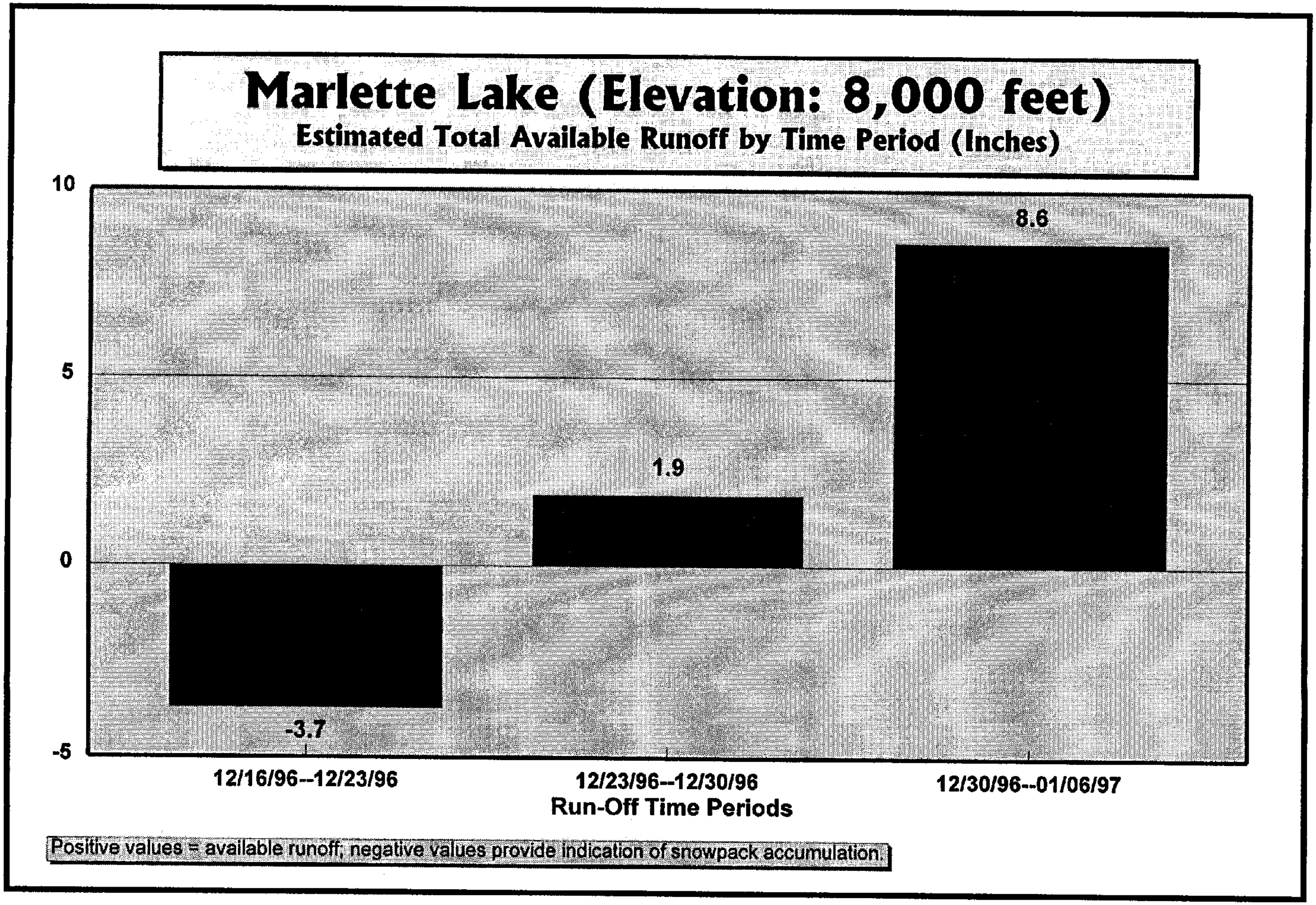
Heavenly Valley (Elevation: 8,850 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
133%
139%
183%
179%
196%
188%
185%
231%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.



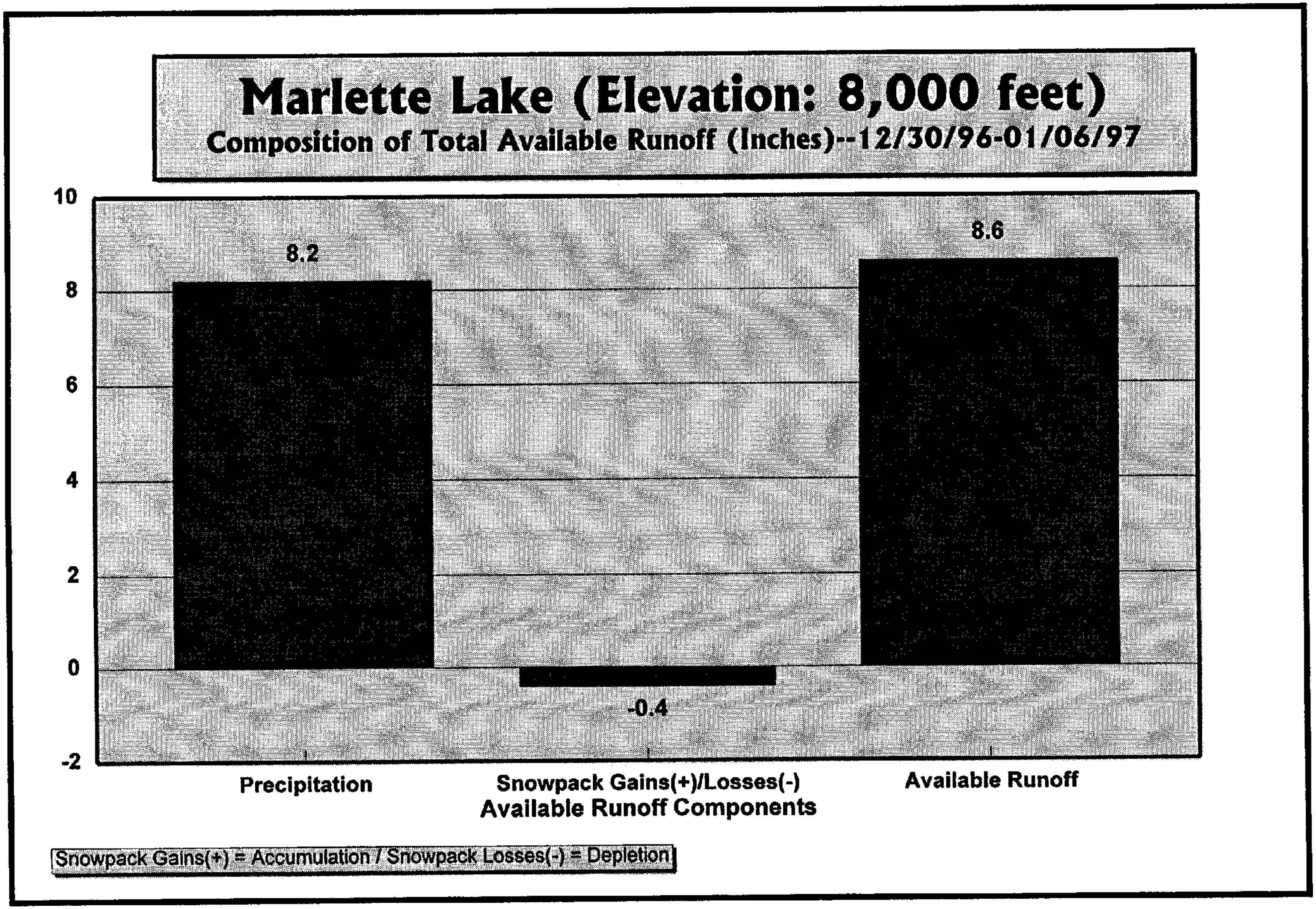
Marlette Lake (Elevation: 8,000 feet)
Snowpack Water Content and Total Precipitation (Inches)
40
30
20
10
0
6.4
11.3
13.2
14.4
16.7
19.8
16.3
28.0
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.



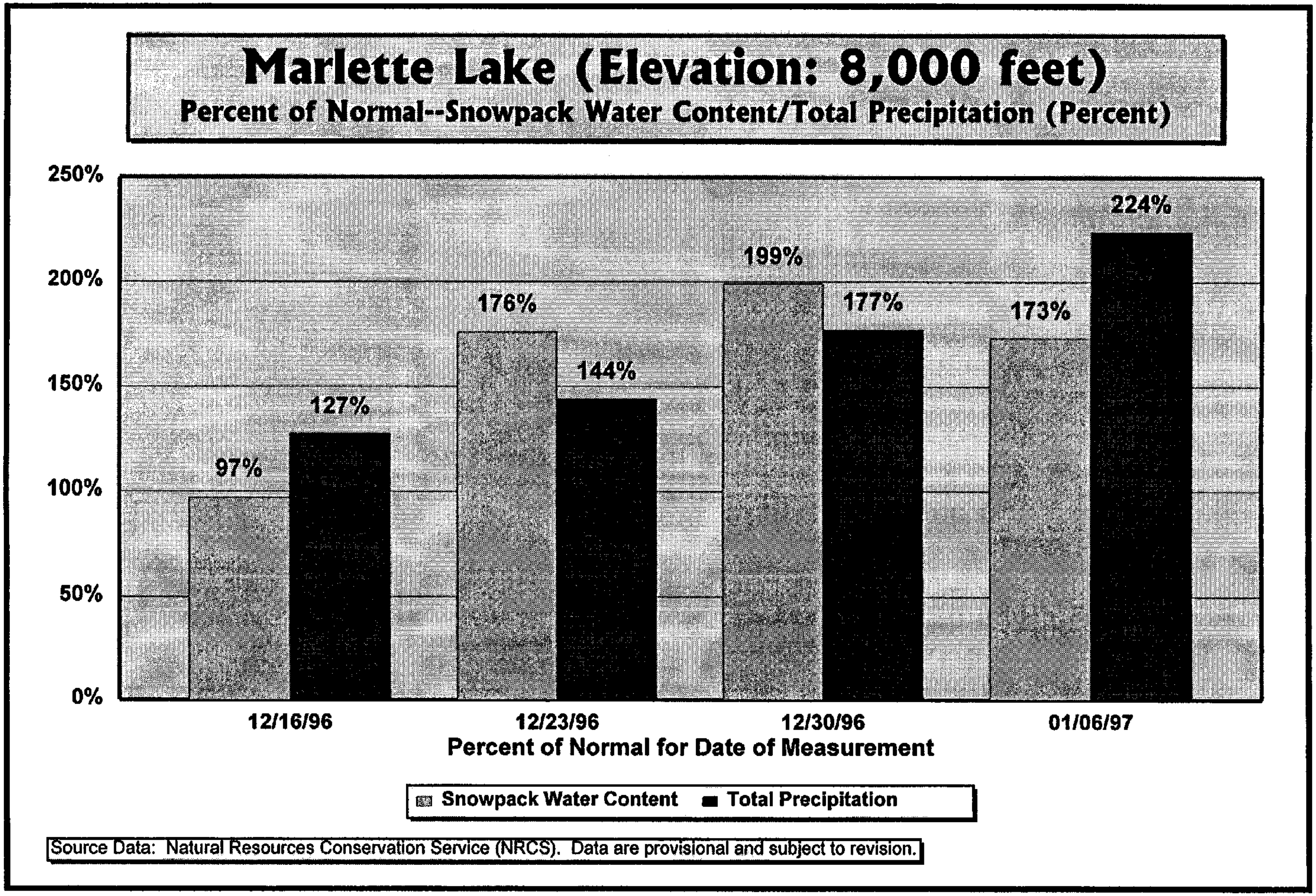
Marlette Lake (Elevation: 8,000 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
100%
80%
60%
40%
20%
0%
56.6%
91.7%
84.3%
58.2%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.



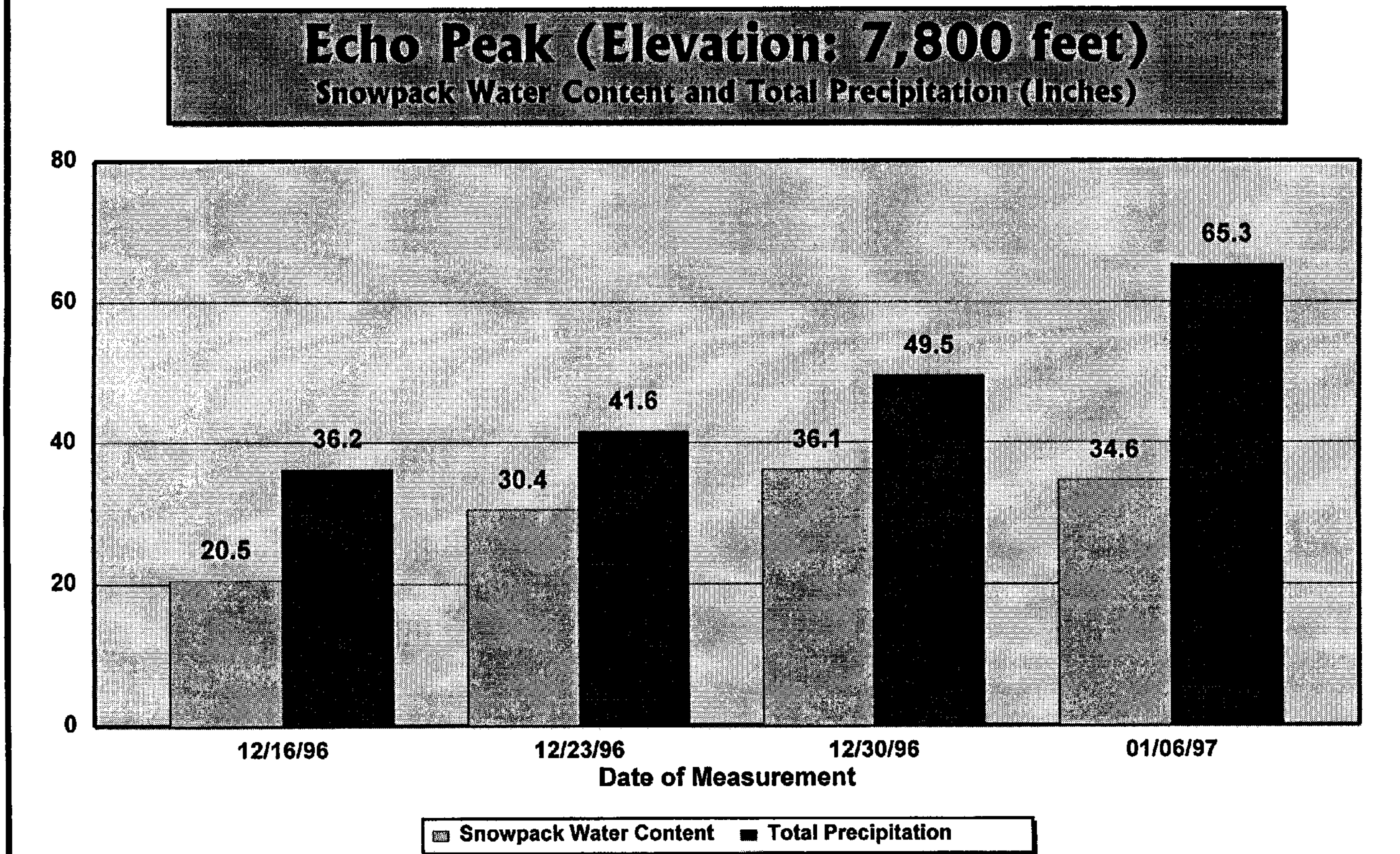
Marlette Lake (Elevation: 8,000 feet)
Estimated Total Available Runoff by Time Period (Inches)
10
5
0
-5
8.6
1.9
-3.7
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.



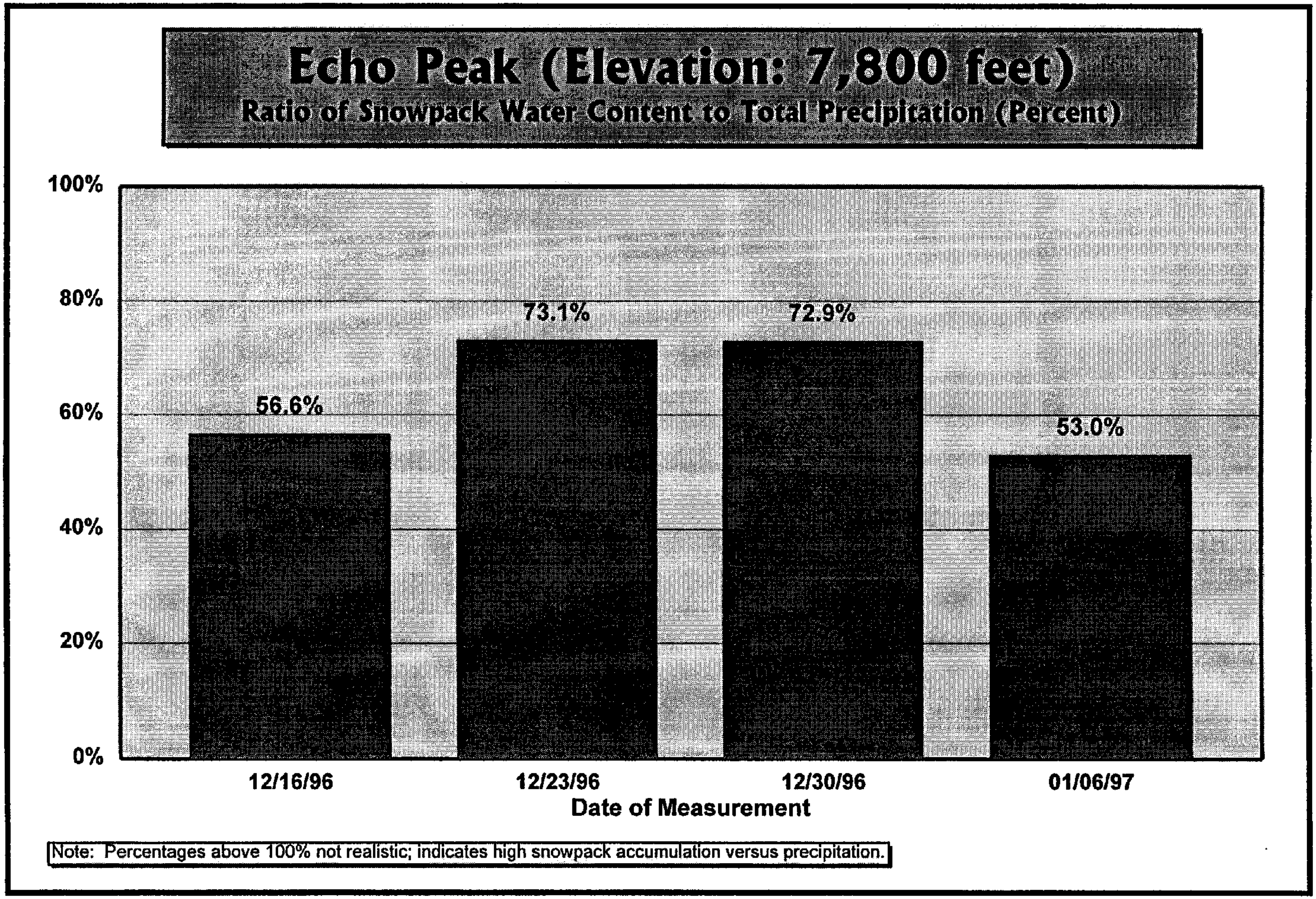
Marlette Lake (Elevation: 8,000 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
10
8
6
4
2
0
-2
8.2
-0.4
8.6
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion



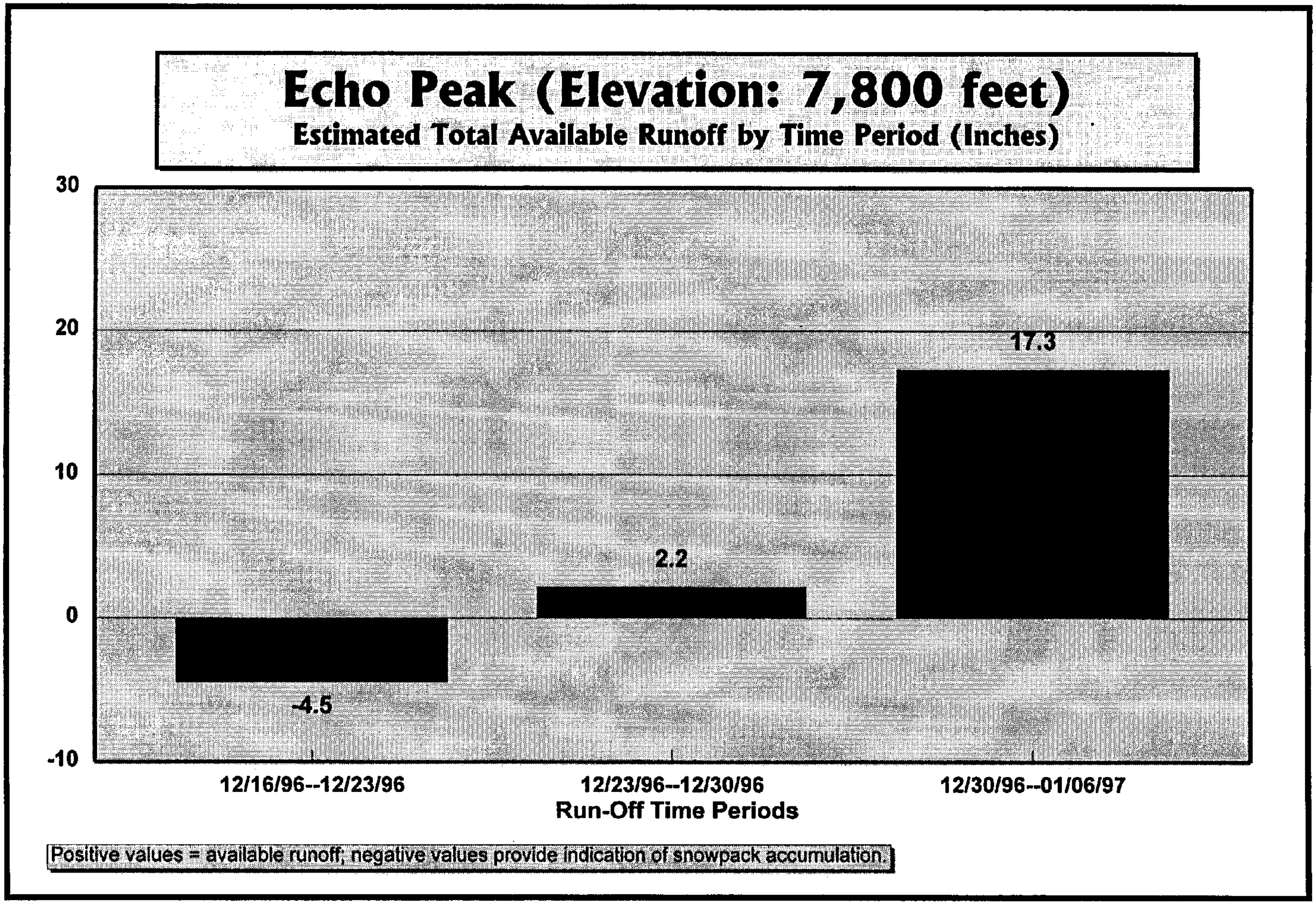
Marlette Lake (Elevation: 8,000 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
250%
200%
150%
100%
50%
0%
97%
127%
176%
144%
199%
177%
173%
224%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

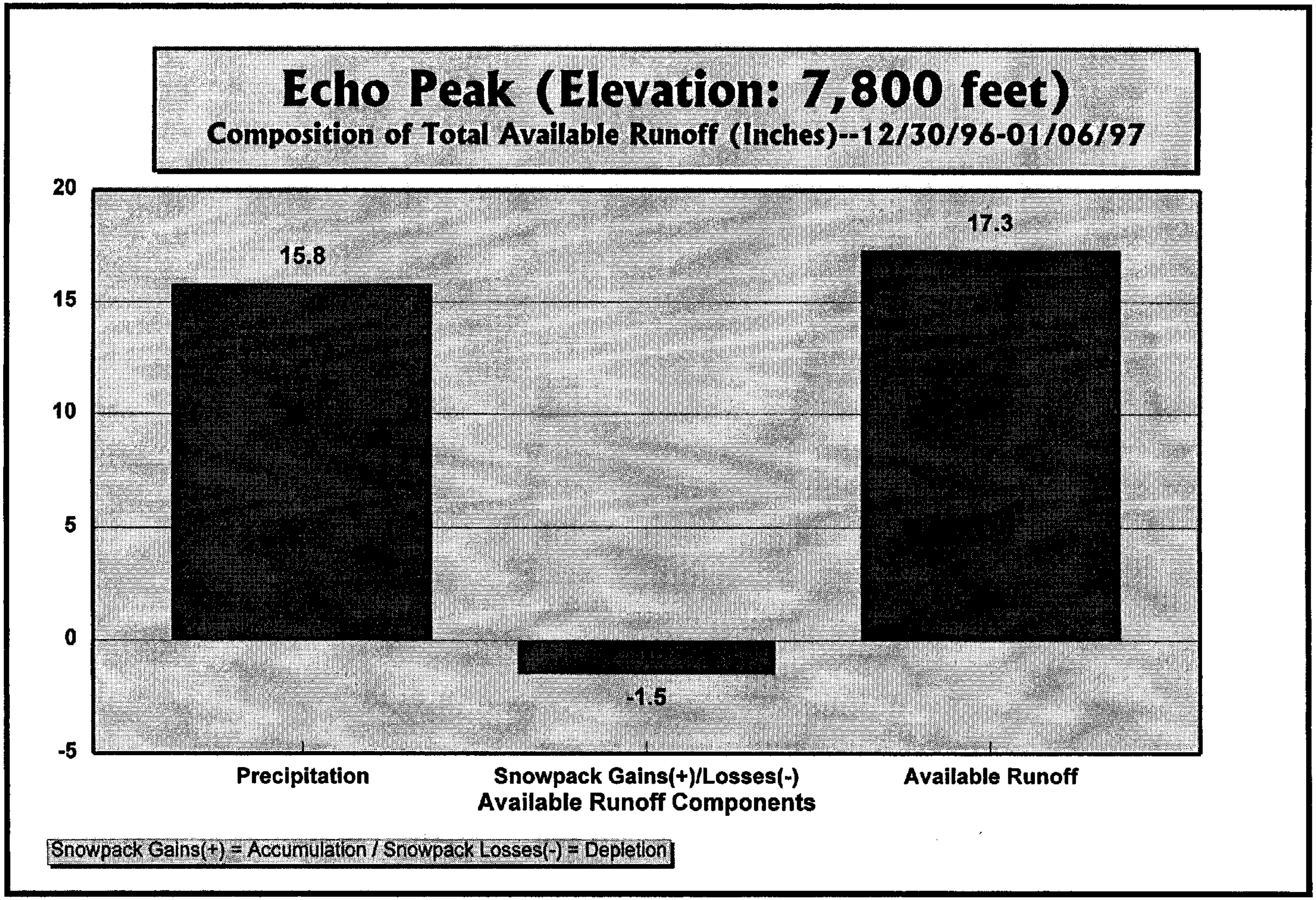


Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

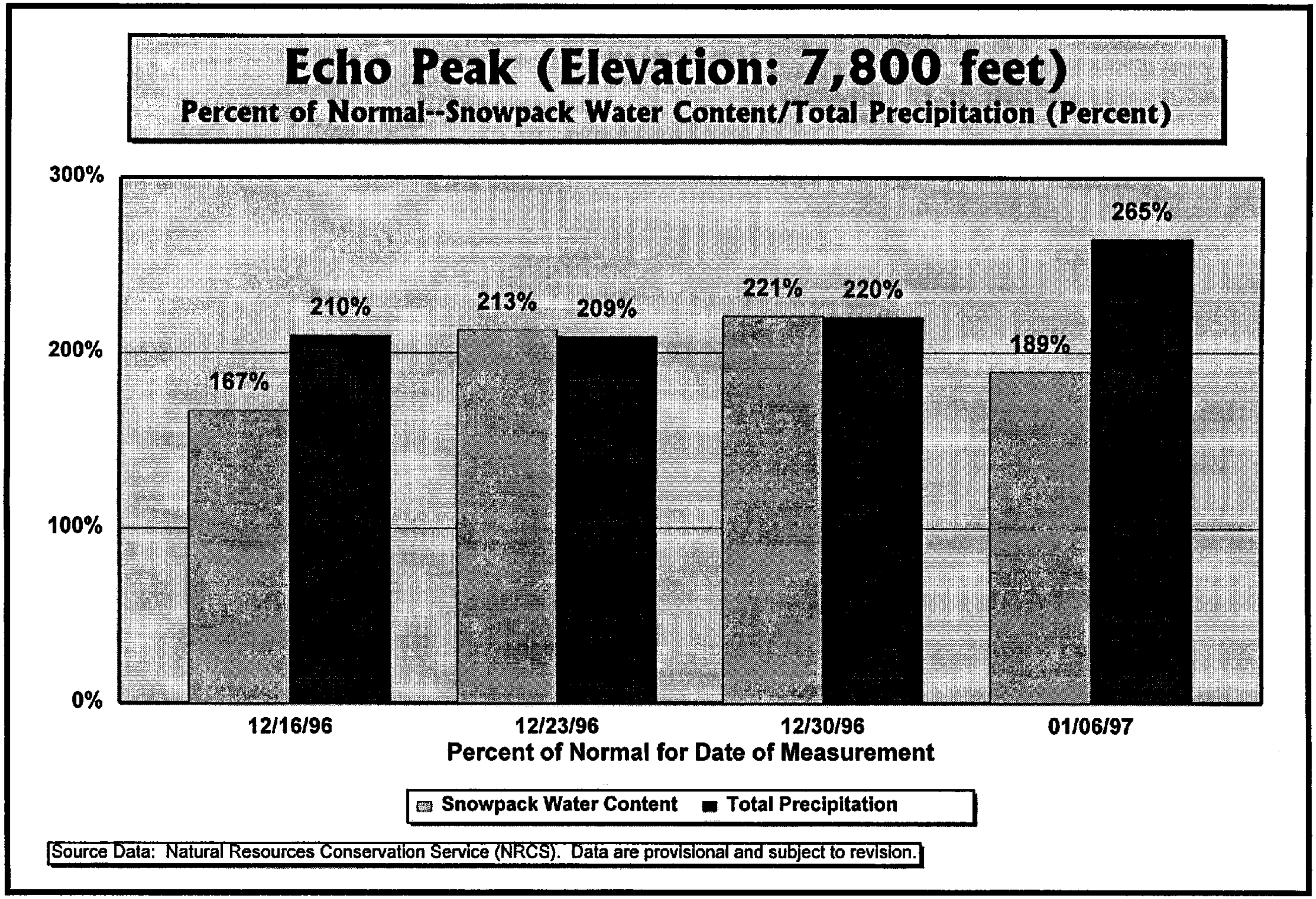


Echo Peak (Elevation: 7,800 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
100%
80%
60%
40%
20%
0%
56.6%
73.1%
72.9%
53.0%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

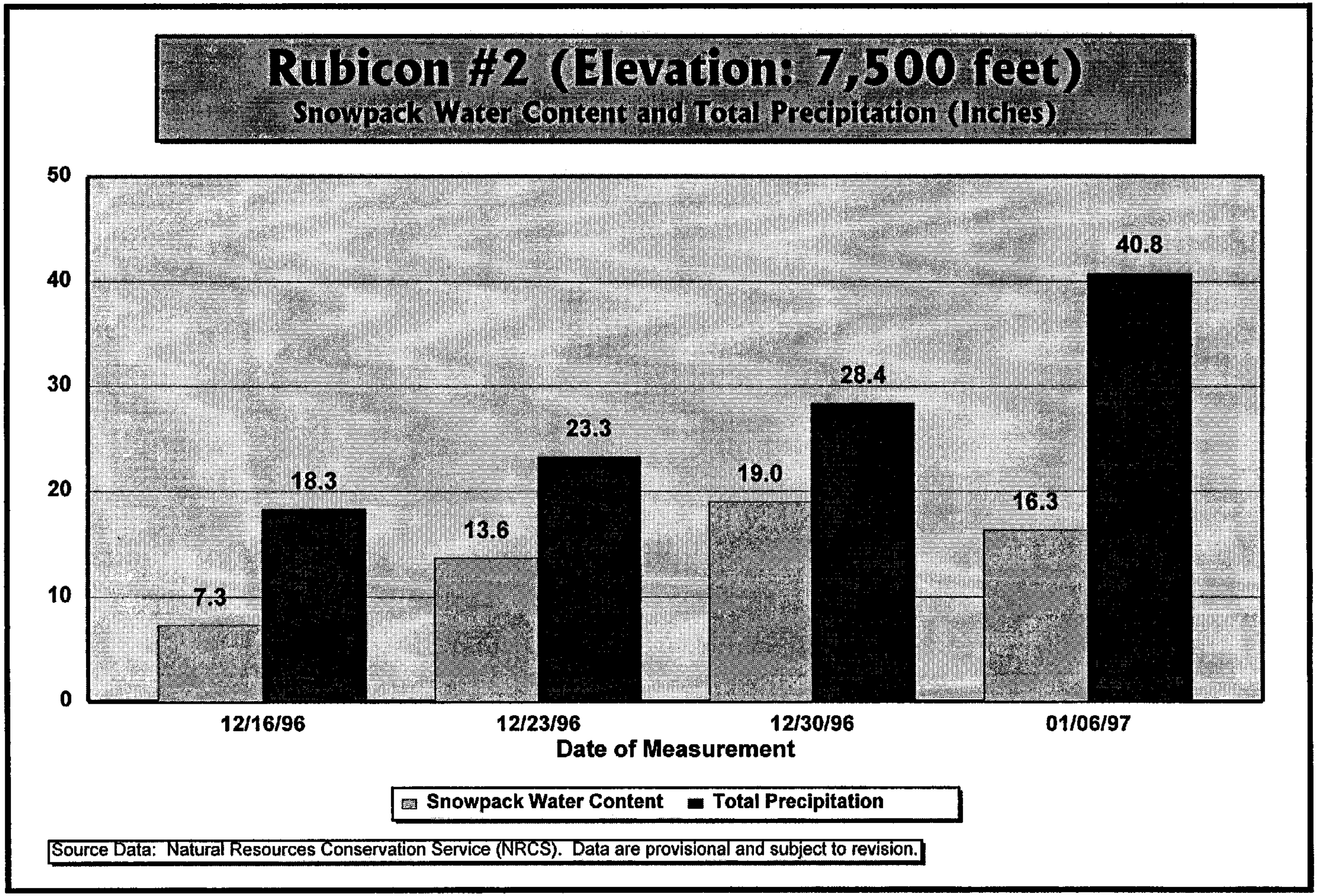

Echo Peak (Elevation: 7,800 feet)
Estimated Total Available Runoff by Time Period (Inches)
30
20
10
0
-10
17.3
2.2
-4.5
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.



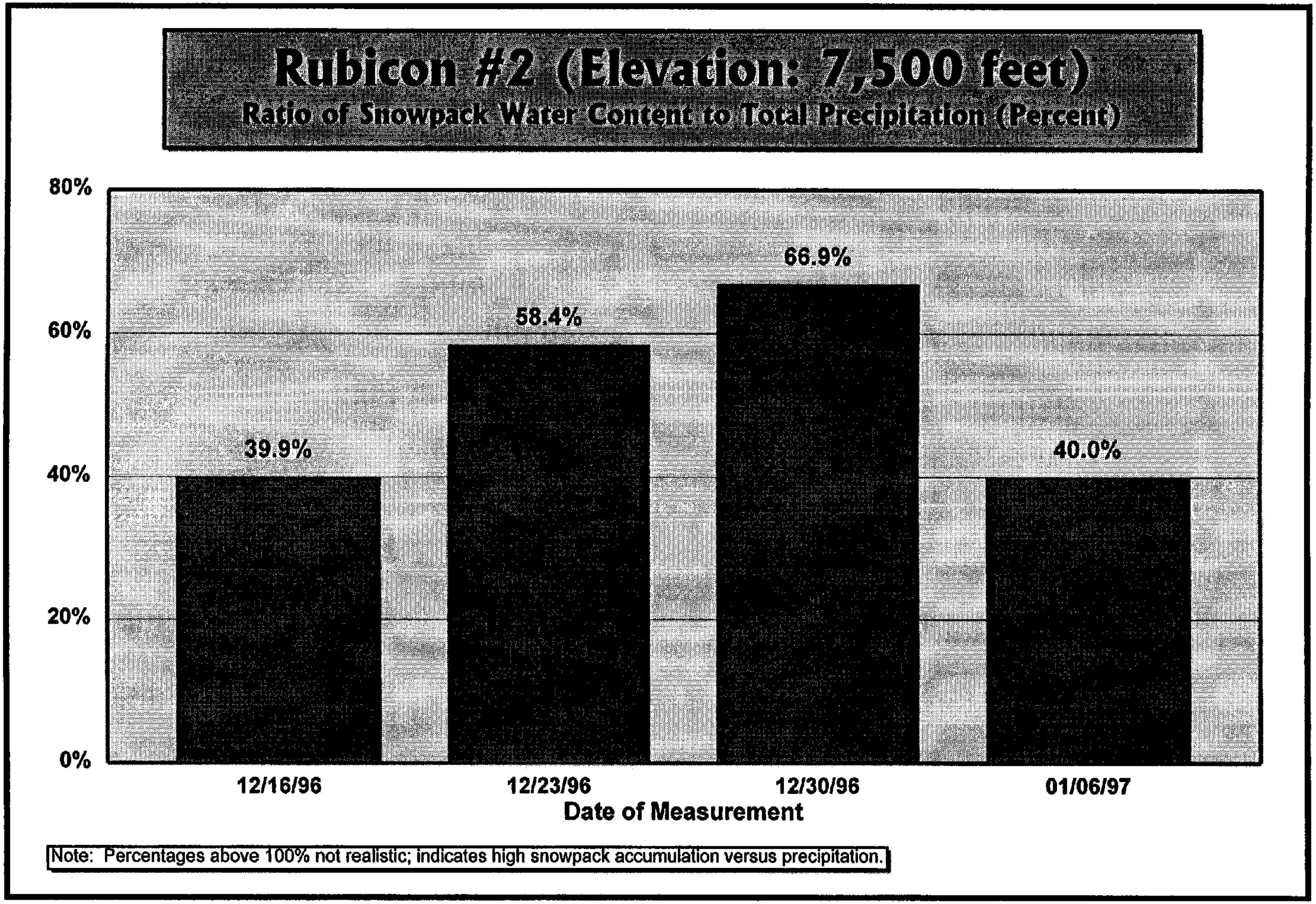
Echo Peak (Elevation: 7,800 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
15
10
5
0
-5
15.8
-1.5
17.3
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

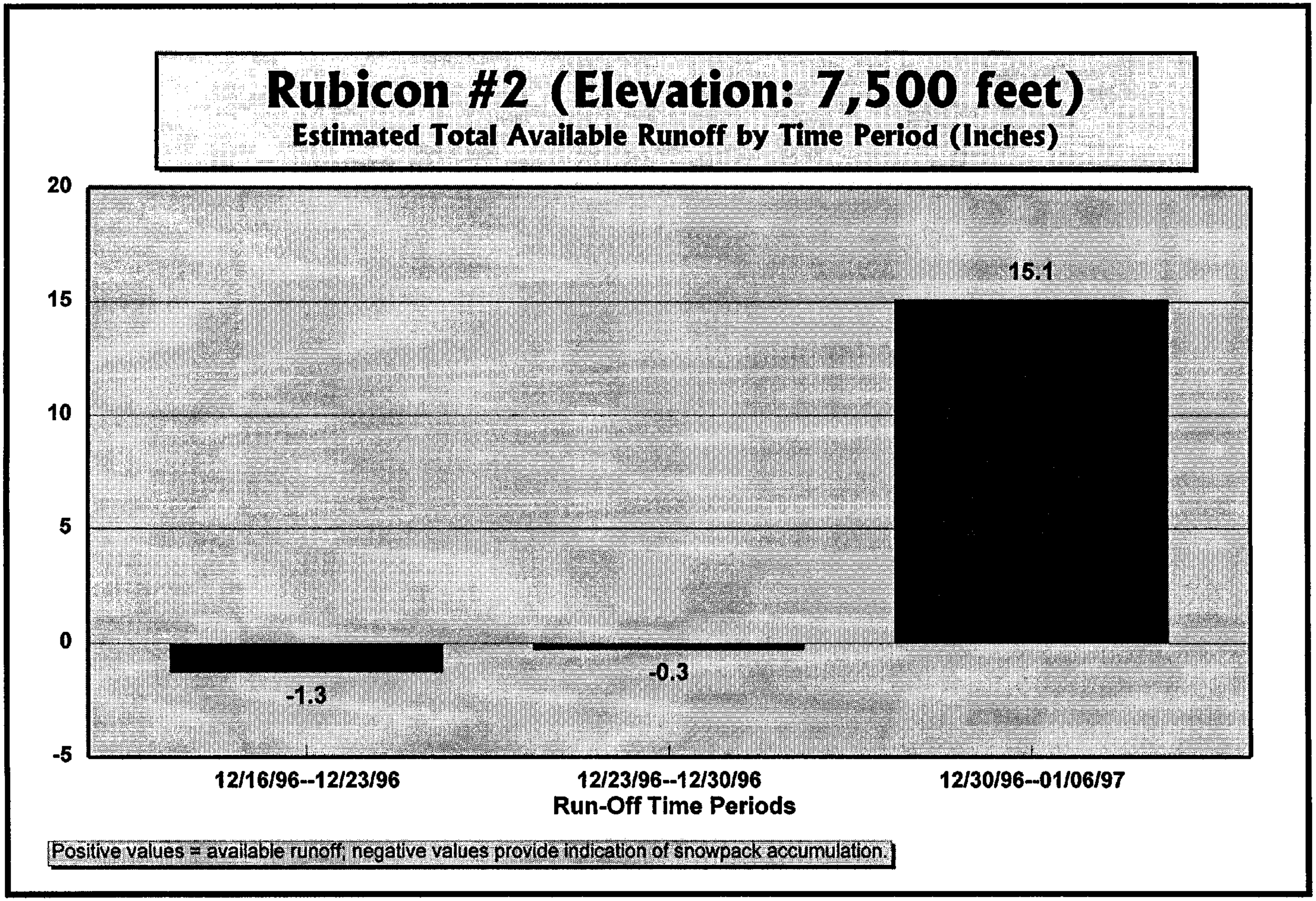


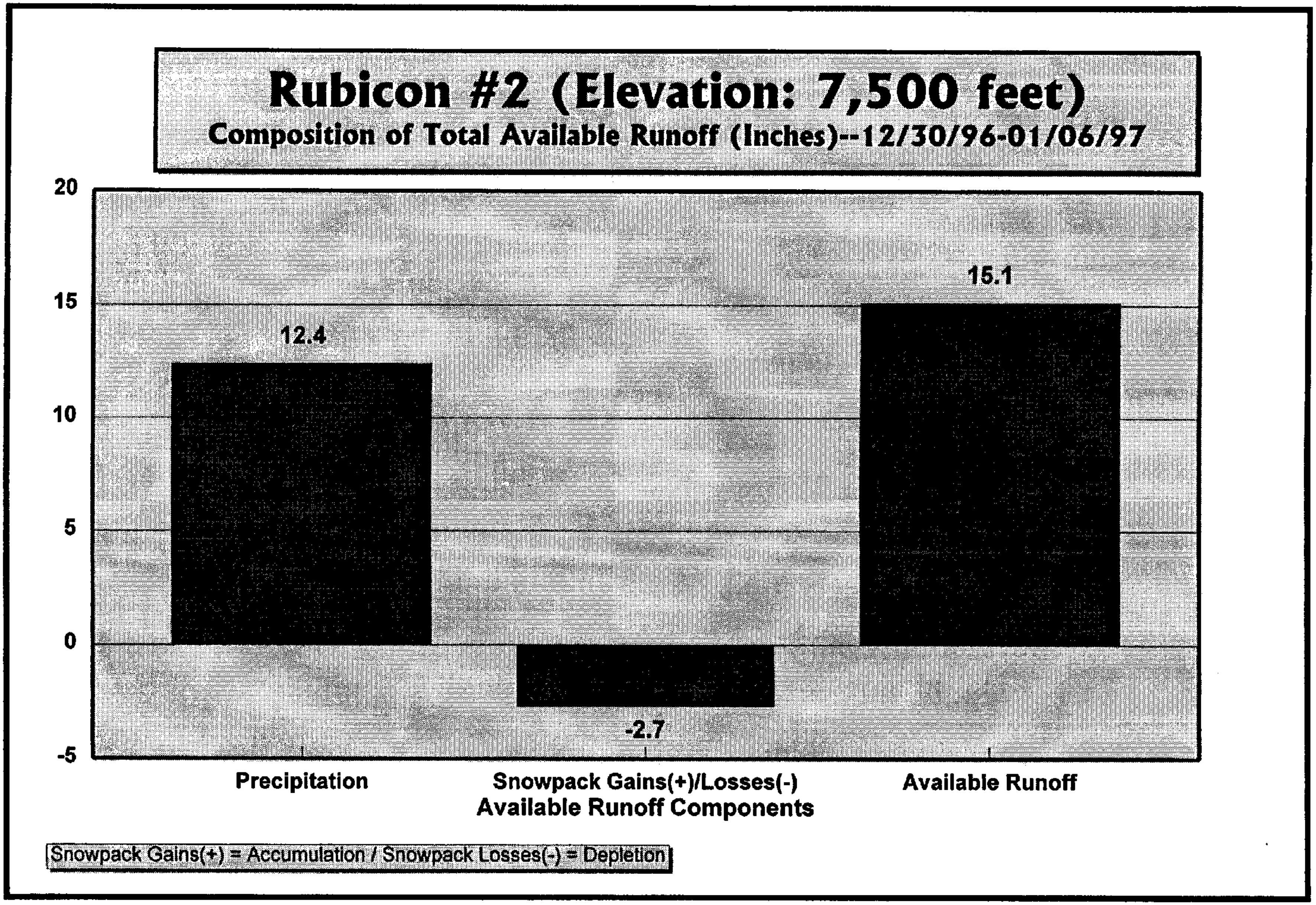
Echo Peak (Elevation: 7,800 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
167%
210%
213%
209%
221%
220%
189%
265%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

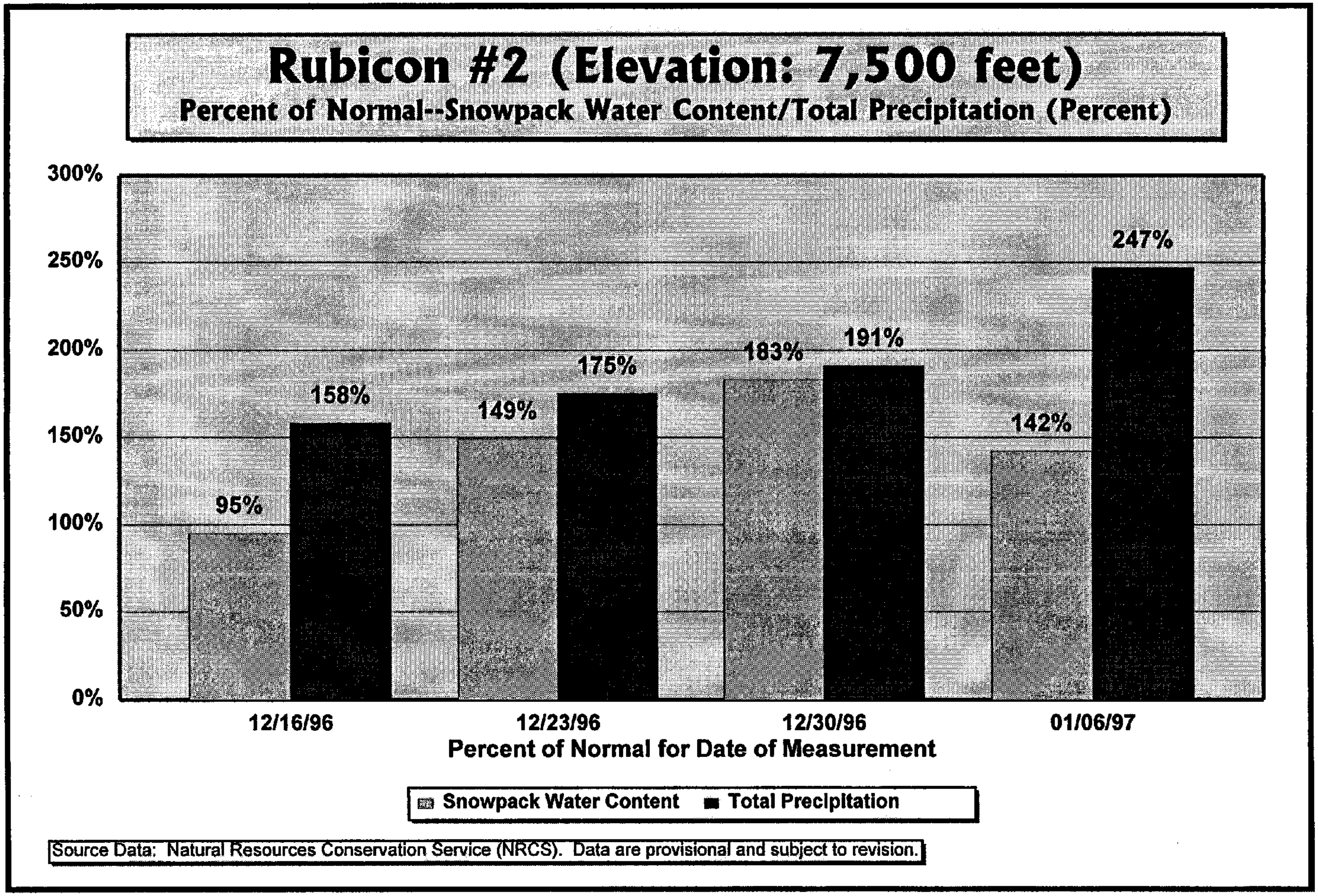


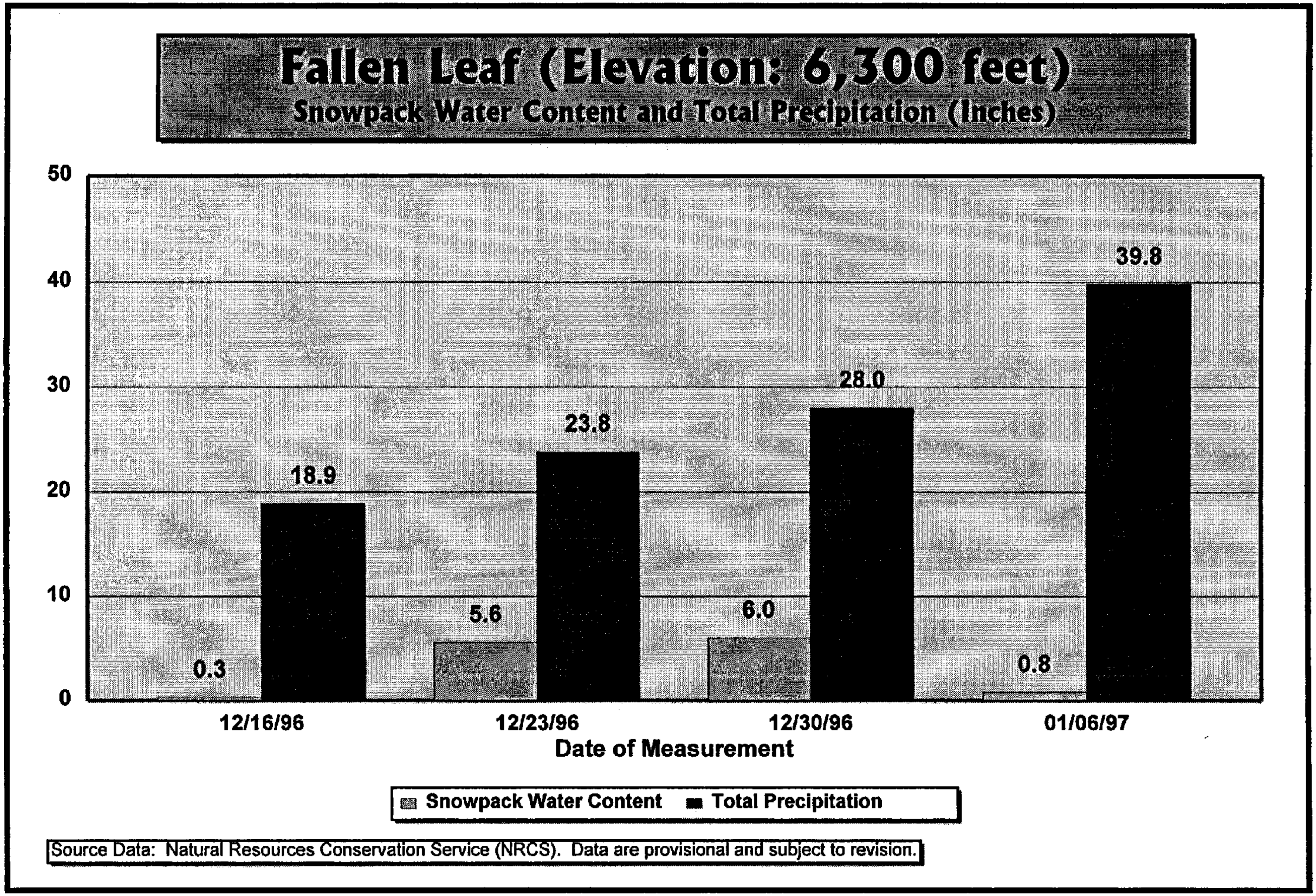
Rubicon #2 (Elevation: 7,500 feet)
Snowpack Water Content and Total Precipitation (Inches)
50
40
30
20
10
0
7.3
18.3
13.6
23.3
19.0
28.4
16.3
40.8
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

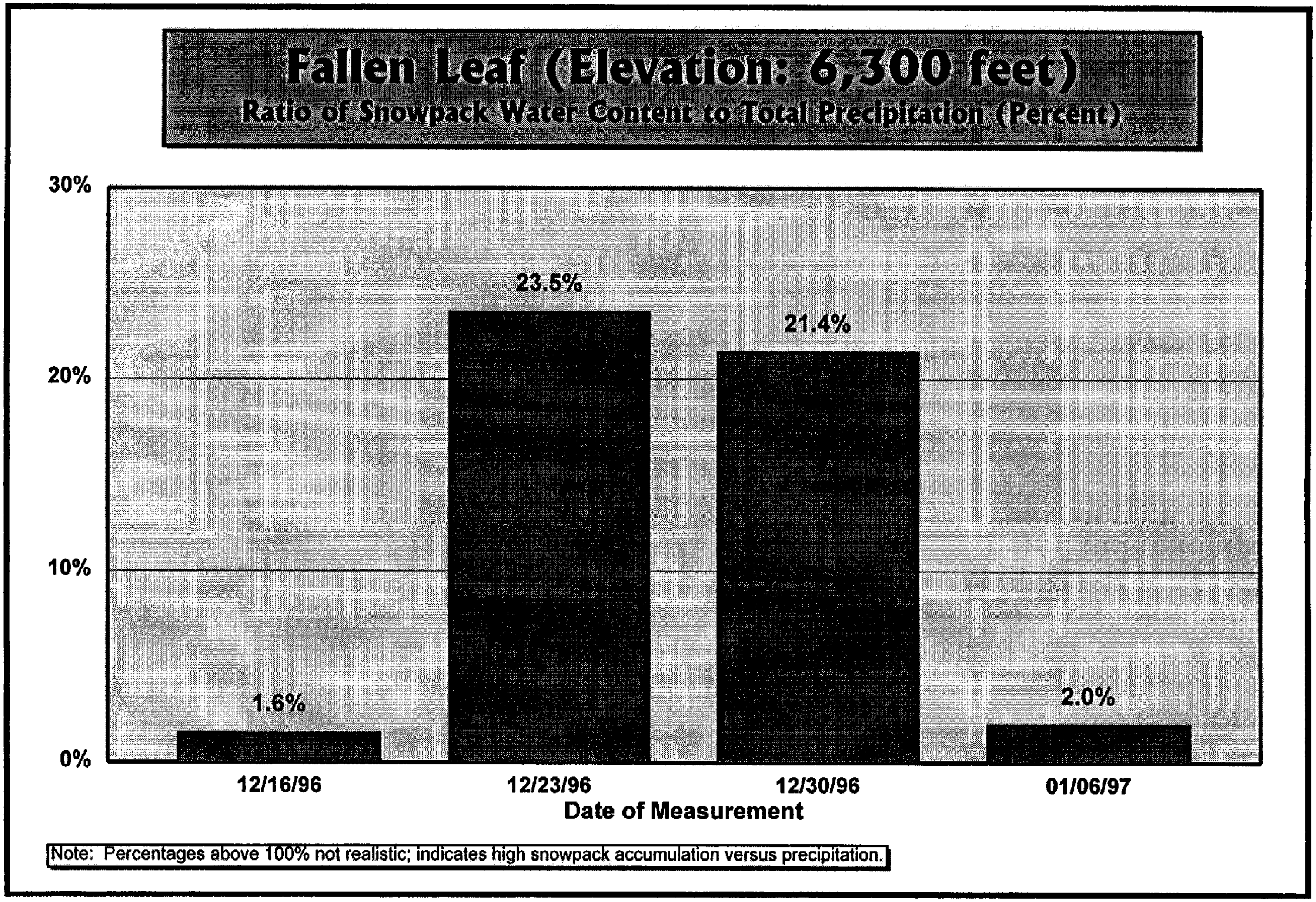

Rubicon #2 (Elevation: 7,500 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
80%
60%
40%
20%
0%
39.9%
58.4%
66.9%
40.0%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.


Rubicon #2 (Elevation: 7,500 feet)
Estimated Total Available Runoff by Time Period (Inches)
20
15
10
5
0
-5
15.1
-1.3
-0.3
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

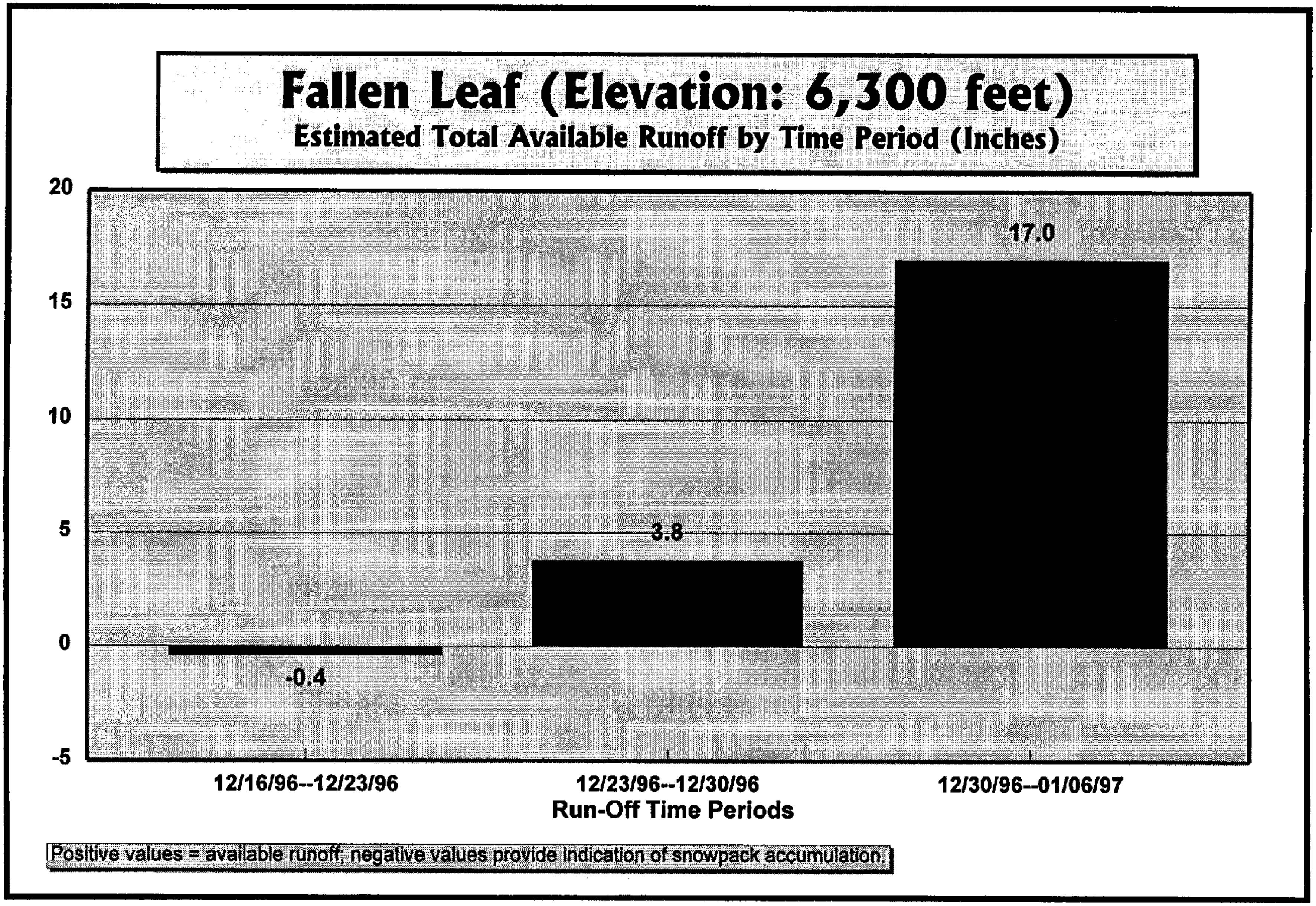

Rubicon #2 (Elevation: 7,500 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
15
10
5
0
-5
12.4
-2.7
15.1
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion


Rubicon #2 (Elevation: 7,500 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
250%
200%
150%
100%
50%
0%
95%
158%
149%
175%
183%
191%
142%
247%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

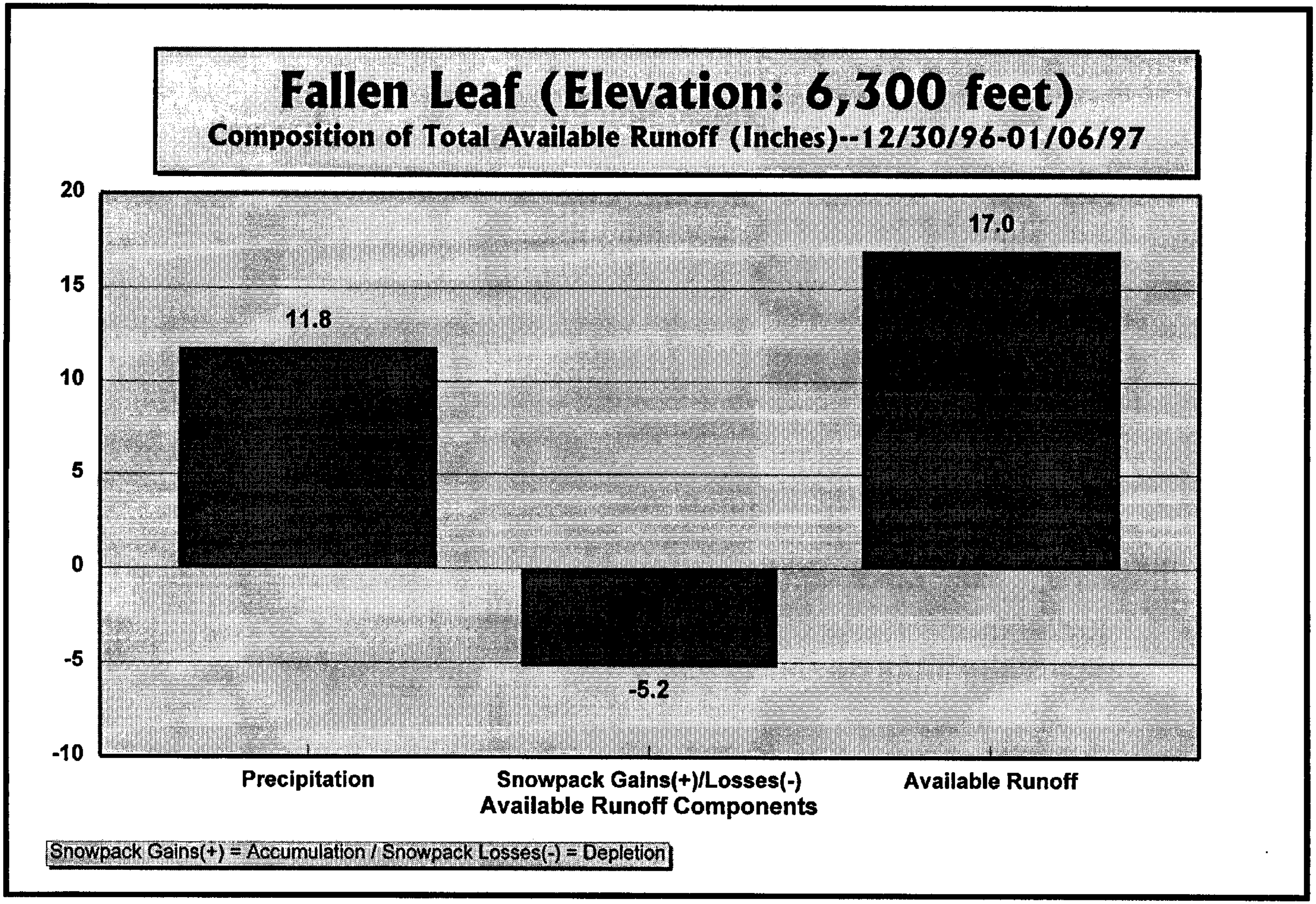

Fallen Leaf (Elevation: 6,300 feet)
Snowpack Water Content and Total Precipitation (Inches)
50
40
30
20
10
0
39.8
28.0
23.8
18.9
5.6
6.0
0.3
0.8
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

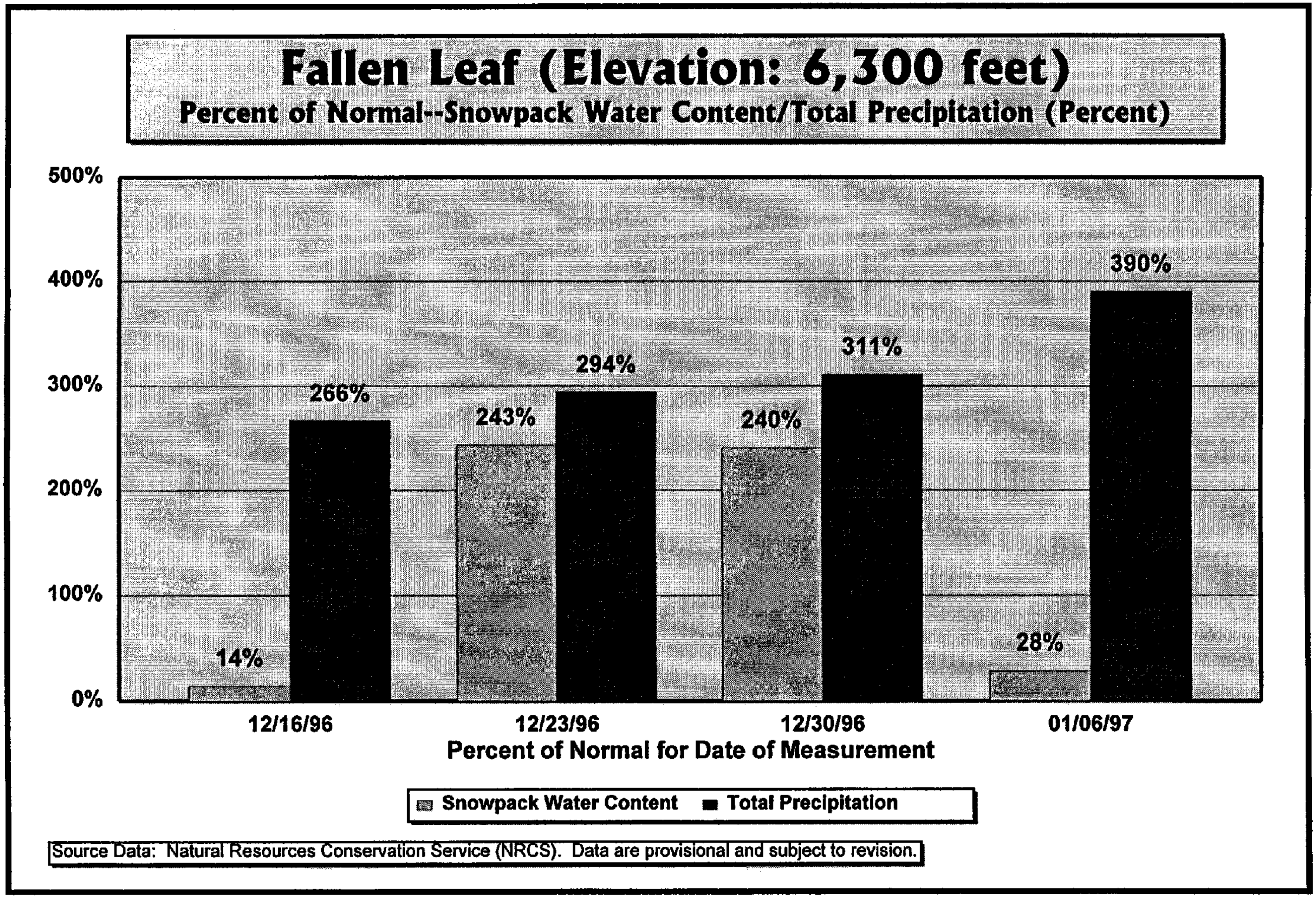


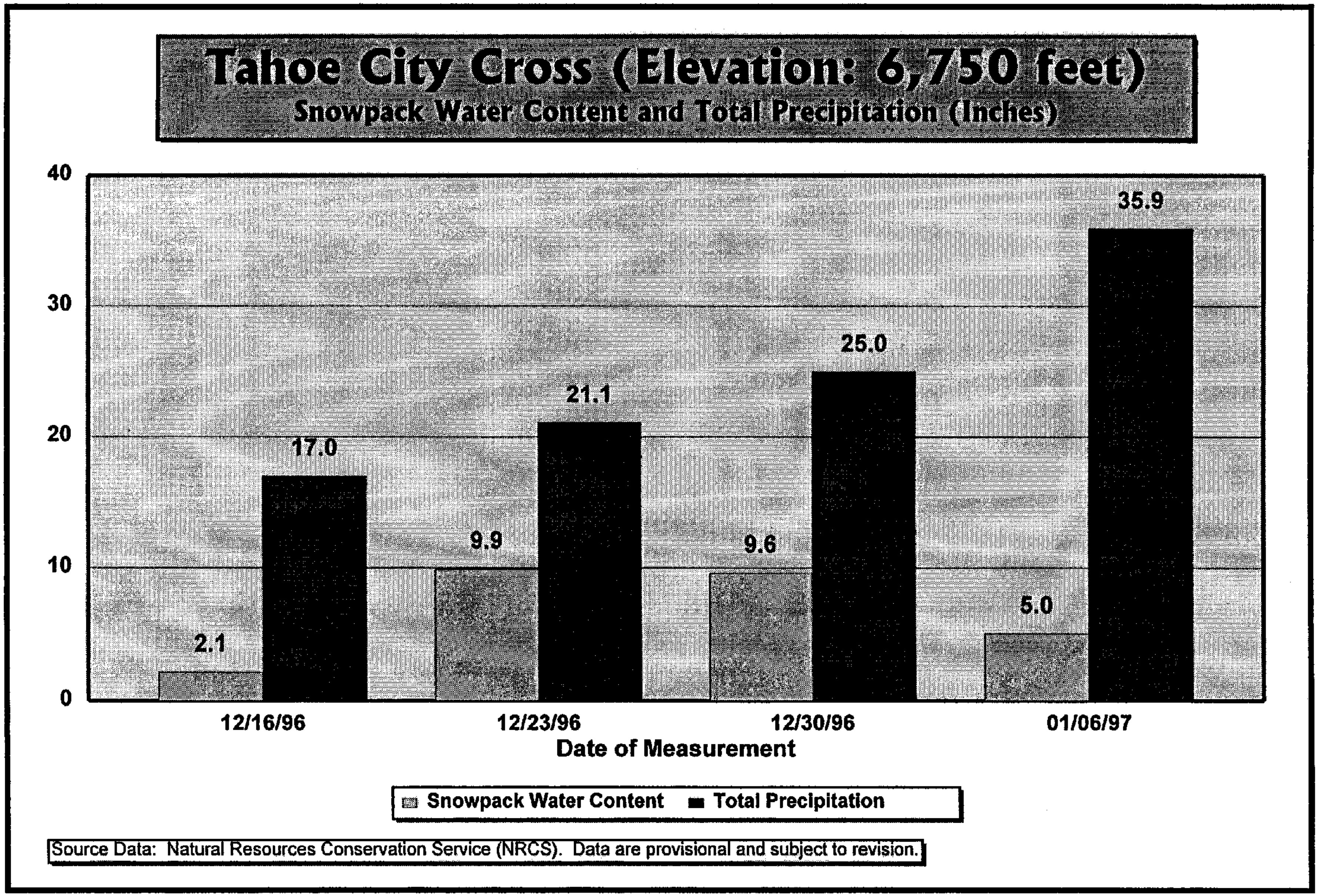
Fallen Leaf (Elevation: 6,300 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
30%
20%
10%
0%
1.6%
23.5%
21.4%
2.0%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

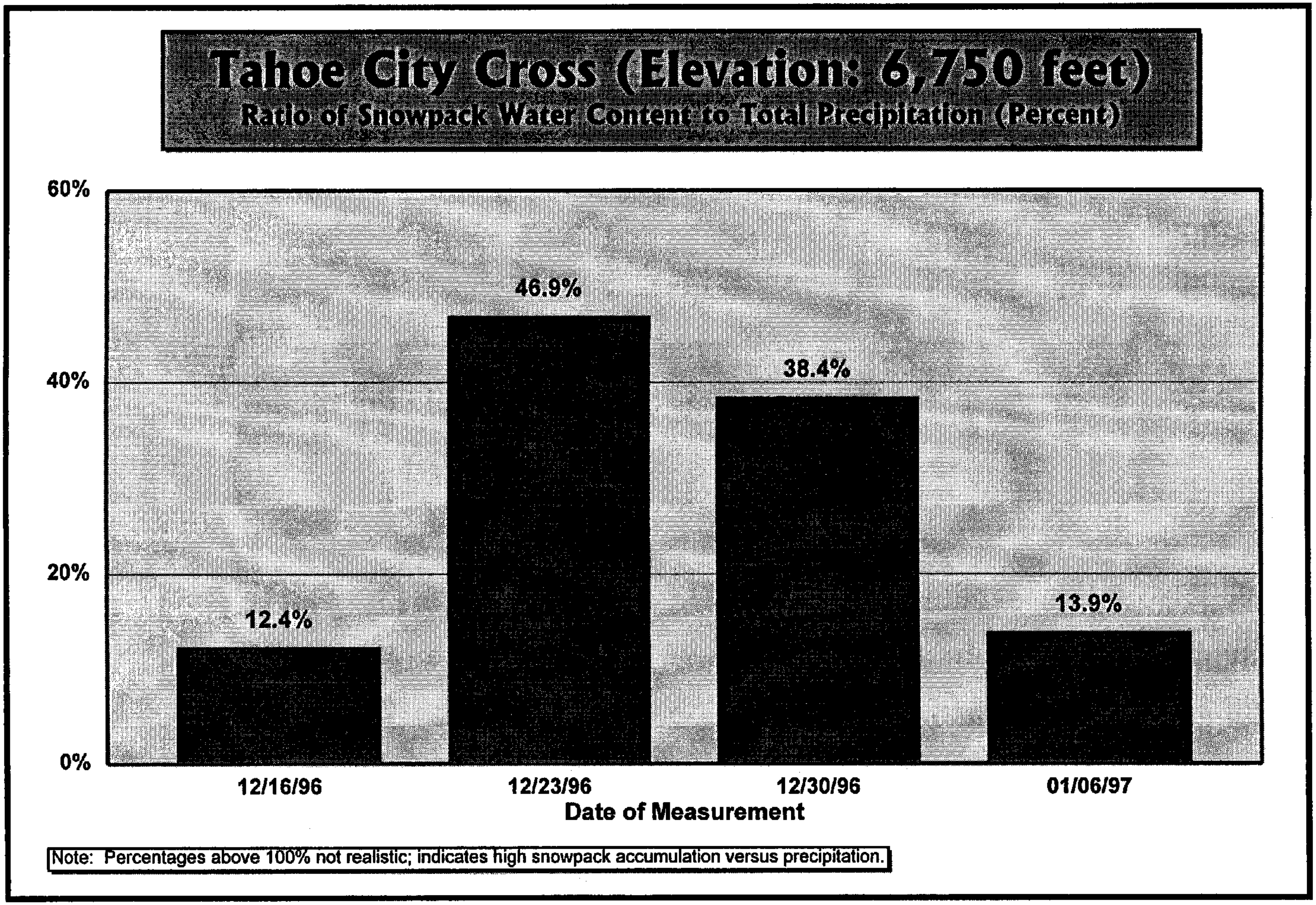


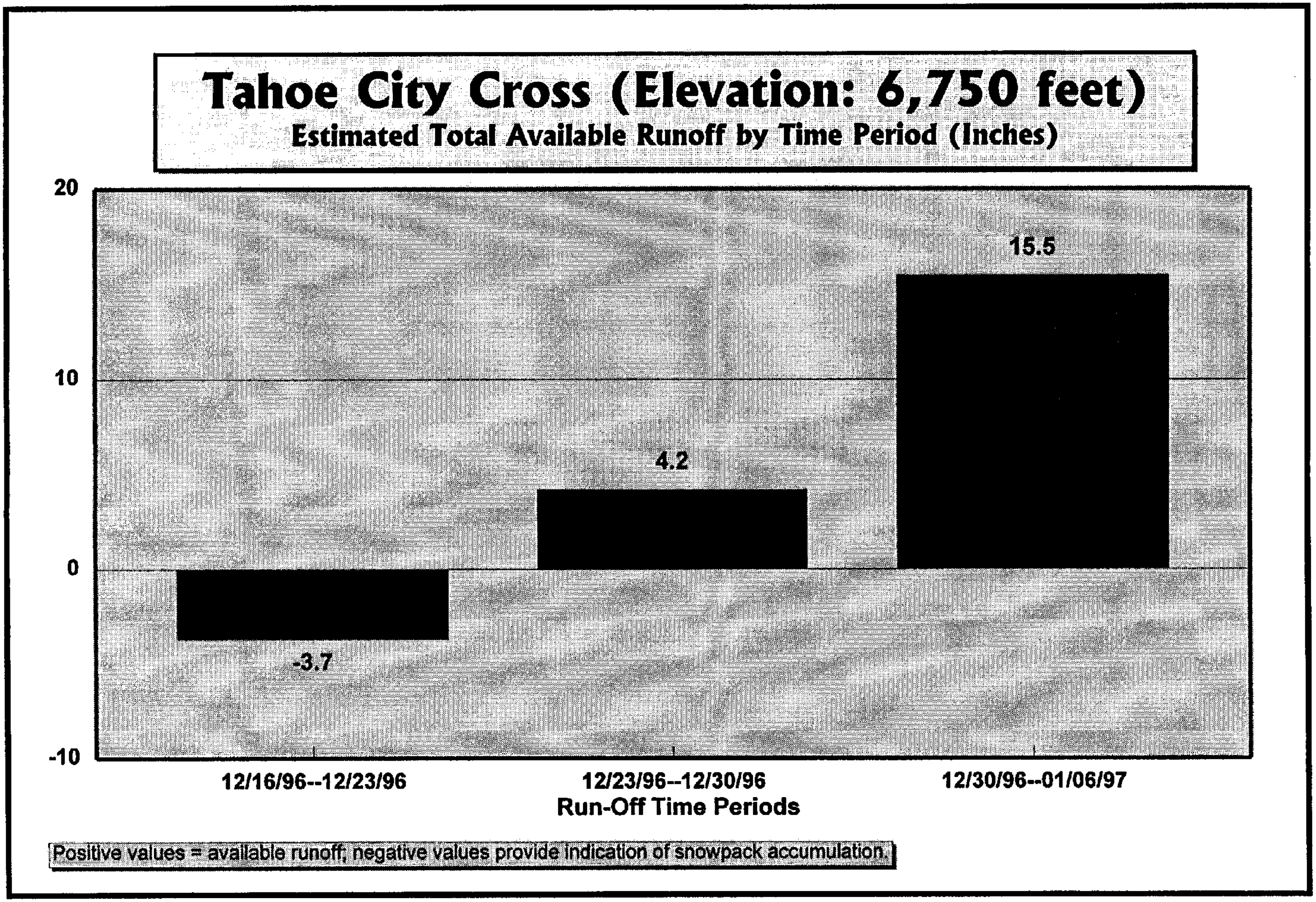
Fallen Leaf (Elevation: 6,300 feet)
Estimated Total Available Runoff by Time Period (Inches)
20
15
10
5
0
-5
17.0
3.8
-0.4
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff, negative values provide indication of snowpack accumulation.


Fallen Leaf (Elevation: 6,300 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
15
10
5
0
-5
-10
11.8
-5.2
17.0
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

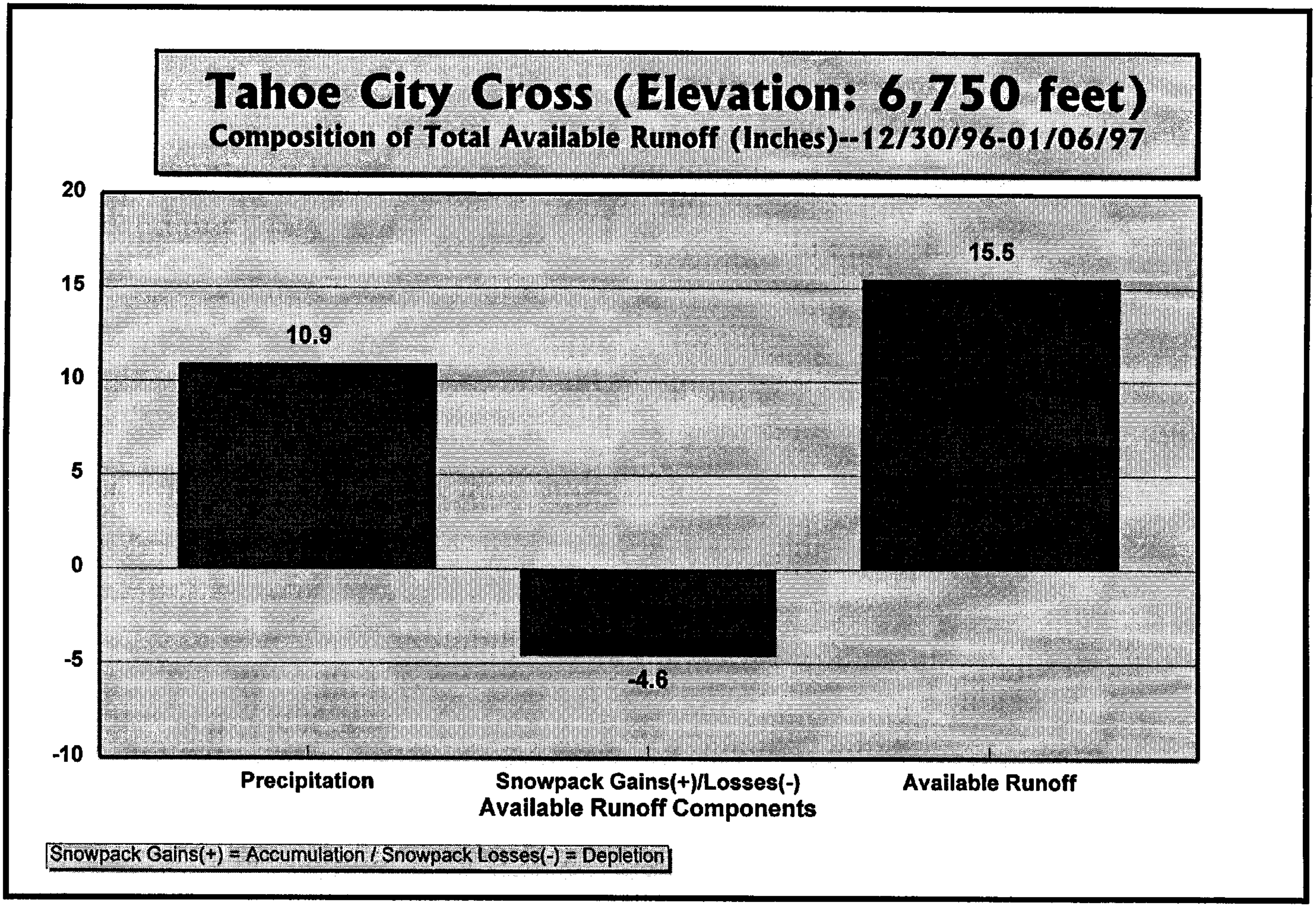

Fallen Leaf (Elevation: 6,300 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
500%
400%
300%
200%
100%
0%
14%
266%
243%
294%
240%
311%
28%
390%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Tahoe City Cross (Elevation: 6,750 feet)
Snowpack Water Content and Total Precipitation (Inches)
40
30
20
10
0
2.1
17.0
9.9
21.1
9.6
25.0
5.0
35.9
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

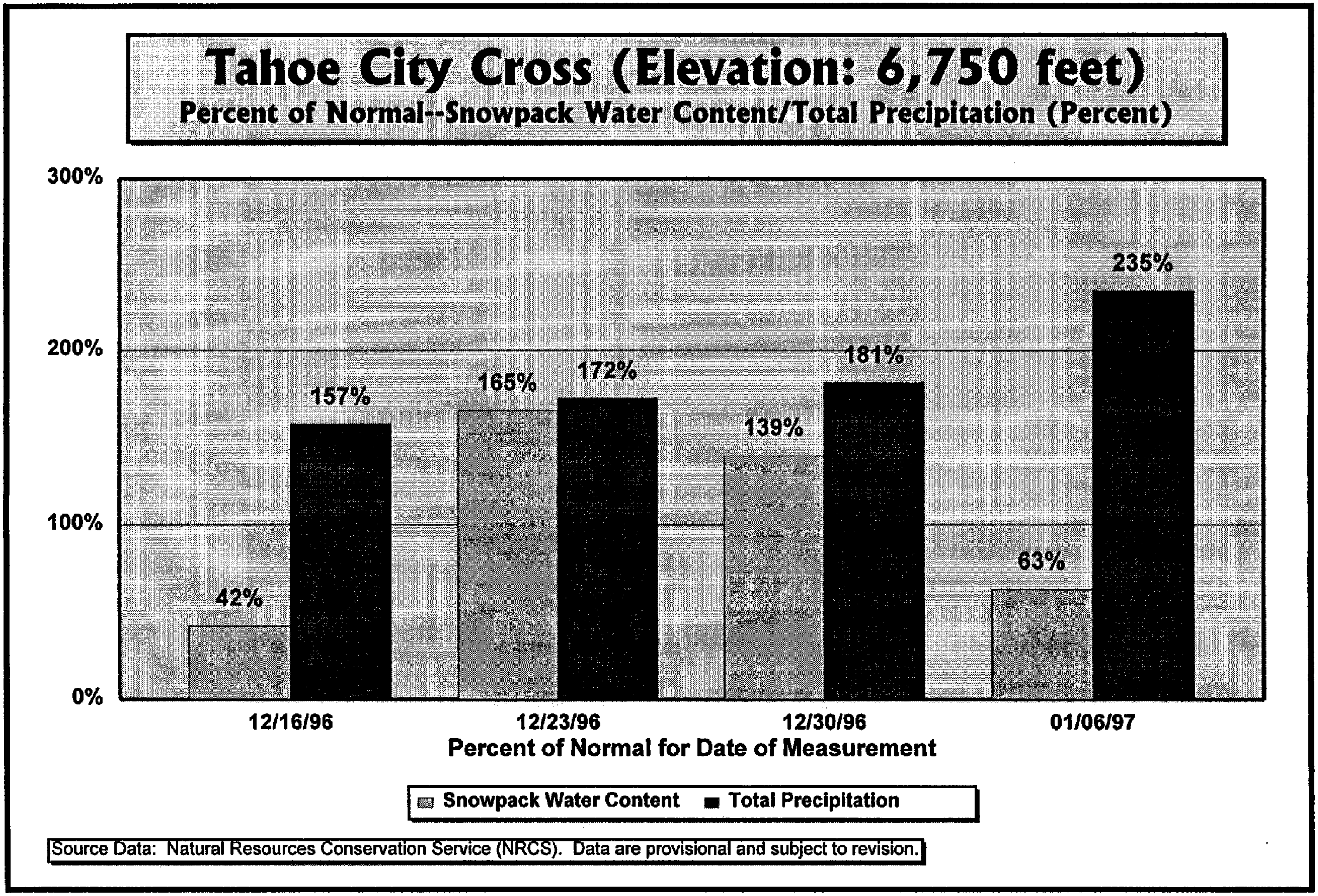

Tahoe City Cross (Elevation: 6,750 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
60%
40%
20%
0%
12.4%
46.9%
38.4%
13.9%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.



Tahoe City Cross (Elevation: 6,750 feet)
Estimated Total Available Runoff by Time Period (Inches)
20
10
0
-10
15.5
4.2
-3.7
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.



Tahoe City Cross (Elevation: 6,750 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
15
10
5
0
-5
-10
10.9
-4.6
15.5
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion


Tahoe City Cross (Elevation: 6,750 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
42%
157%
165%
172%
139%
181%
63%
235%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

Appendix C

Truckee River Basin

NRCS SNOTEL Sites

Mount Rose Ski Area
Independence Lake
Squaw Valley Gold Coast (G.C.)
Independence Camp
Independence Creek
Truckee #2

Tables

2A. Precipitation Summary

2B. Comparisons of Changes in Precipitation and Snowpack Water Content

Part I—12/16/96–12/23/96

Part II—12/30/96–01/06/97

Part III—12/16/96–01/06/97

Graphs

Snowpack Water Content and Total Precipitation (Inches)

Ratio of Snowpack Water Content and Total Precipitation (Percent)

Estimated Total Available Runoff by Time Period (Inches)

Composition of Total Available Runoff (Inches)—12/30/96–01/06/97

Percent of Normal—Snowpack Water Content/Total Precipitation (Percent)

2A--Truckee River Basin--Precipitation Summary

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97 [1]

NRCS SNOTEL Sites	SNOTEL Site Elevation (feet MSL) [2]	Change in Precipitation (Inches)	Change in Snowpack Water Content (Inches)	Precipitation/ Snowpack Difference (Inches) [3]
Mt. Rose Ski Area:	8,850			
December 16-23, 1996......................		8.8	8.7	**0.1**
December 30, 1996-January 6, 1997..		12.9	5.2	**7.7**
Independence Lake:	8,450			
December 16-23, 1996......................		2.7	5.3	**-2.6**
December 30, 1996-January 6, 1997..		12.5	4.9	**7.6**
Squaw Valley G.C.:	8,200			
December 16-23, 1996......................		7.2	11.3	**-4.1**
December 30, 1996-January 6, 1997..		22.3	-2.7	**25.0**
Independence Camp:	7,000			
December 16-23, 1996......................		4.2	4.0	**0.2**
December 30, 1996-January 6, 1997..		10.3	-2.1	**12.4**
Independence Creek:	6,500			
December 16-23, 1996......................		4.1	4.5	**-0.4**
December 30, 1996-January 6, 1997..		9.9	-1.7	**11.6**
Truckee #2:	6,400			
December 16-23, 1996......................		3.9	7.3	**-3.4**
December 30, 1996-January 6, 1997..		9.6	-3.9	**13.5**

[1] December 16, 1996--December 23, 1996 was a heavy snowfall event with significant additions to snowpack water content; December 30, 1996--January 6, 1997 was a heavy, warm rainfall event with significant runoff and snowpack depletion.

[2] MSL = Above mean sea level.

[3] Positive values for column entries under "Precipitation/Snowpack Difference" reflect available runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

Table Interpretation: Entries under "Change in Precipitation" and "Change in Snowpack Water Content" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time can the change in snowpack water content accumulated between dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content, are not realistic and along with values close to zero (0) should be interpreted only in the sense that the snowpack is absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle event) the effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

2B--TRUCKEE RIVER BASIN

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97

Site		Precipitation			Snowpack Water Content			
Part I--12/16/96-12/23/96	Elevation (feet MSL)	12/16/96	12/23/96	Change (inches of water)	12/16/96	12/23/96	Change (inches of water)	Precipitation/ Snowpack Difference [1]
Mt. Rose Ski Area............	8,850	23.0	31.8	8.8	20.3	29.0	8.7	**0.1**
Percent of Normal		155%	187%		135%	170%		
Independence Lake.........	8,450	17.4	20.1	2.7	16.6	21.9	5.3	**-2.6**
Percent of Normal		134%	136%		144%	163%		
Squaw Valley G.C............	8,200	33.3	40.5	7.2	30.1	41.4	11.3	**-4.1**
Percent of Normal		188%	186%		208%	244%		
Independence Camp........	7,000	14.5	18.7	4.2	2.8	6.8	4.0	**0.2**
Percent of Normal		139%	160%		52%	101%		
Independence Creek........	6,500	14.9	19.0	4.1	1.9	6.4	4.5	**-0.4**
Percent of Normal		138%	157%		51%	142%		
Truckee #2.......................	6,400	14.5	18.4	3.9	3.8	11.1	7.3	**-3.4**
Percent of Normal		163%	182%		84%	206%		
Part II--12/30/96-01/06/97	**Elevation (feet MSL)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**Precipitation/ Snowpack Difference [1]**
Mt. Rose Ski Area............	8,850	39.4	52.3	12.9	37.0	42.2	5.2	**7.7**
Percent of Normal		204%	243%		194%	205%		
Independence Lake.........	8,450	27.2	39.7	12.5	29.7	34.6	4.9	**7.6**
Percent of Normal		164%	216%		192%	199%		
Squaw Valley G.C............	8,200	44.1	66.4	22.3	55.2	52.5	(2.7)	**25.0**
Percent of Normal		193%	266%		283%	244%		
Independence Camp........	7,000	22.8	33.1	10.3	11.5	9.4	(2.1)	**12.4**
Percent of Normal		175%	228%		146%	103%		
Independence Creek........	6,500	23.1	33.0	9.9	8.5	6.8	(1.7)	**11.6**
Percent of Normal		174%	223%		157%	111%		
Truckee #2.......................	6,400	23.4	33.0	9.6	13.0	9.1	(3.9)	**13.5**
Percent of Normal		205%	258%		206%	125%		

2B--TRUCKEE RIVER BASIN

For the Entire Period: 12/16/96--01/06/97

Site		Precipitation			Snowpack Water Content			
Part III--12/16/96-01/06/97	Elevation (feet MSL)	12/16/96	01/06/97	Change (inches of water)	12/16/96	01/06/97	Change (inches of water)	Precipitation/ Snowpack Difference [1]
Mt. Rose Ski Area............	8,850	23.0	52.3	29.3	20.3	42.2	21.9	**7.4**
Percent of Normal		155%	243%		135%	205%		
Independence Lake..........	8,450	17.4	39.7	22.3	16.6	34.6	18.0	**4.3**
Percent of Normal		134%	216%		144%	199%		
Squaw Valley G.C............	8,200	33.3	66.4	33.1	30.1	52.5	22.4	**10.7**
Percent of Normal		188%	266%		208%	244%		
Independence Camp........	7,000	14.5	33.1	18.6	2.8	9.4	6.6	**12.0**
Percent of Normal		139%	228%		52%	103%		
Independence Creek........	6,500	14.9	33.0	18.1	1.9	6.8	4.9	**13.2**
Percent of Normal		138%	223%		51%	111%		
Truckee #2.......................	6,400	14.5	33.0	18.5	3.8	9.1	5.3	**13.2**
Percent of Normal		163%	258%		84%	125%		

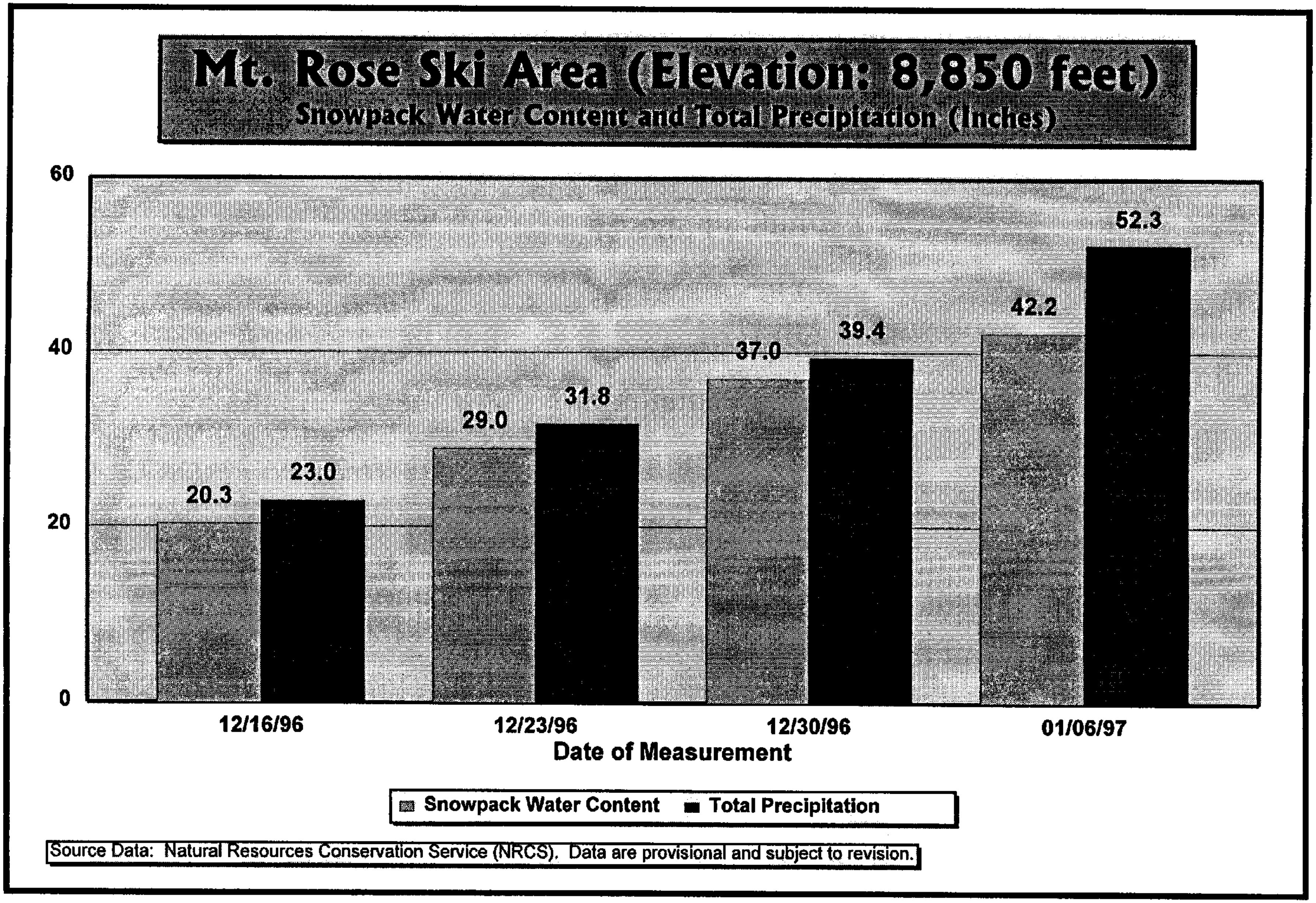
[1] Positive values for column entries under "Precipitation/Snowpack Difference" reflect direct runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

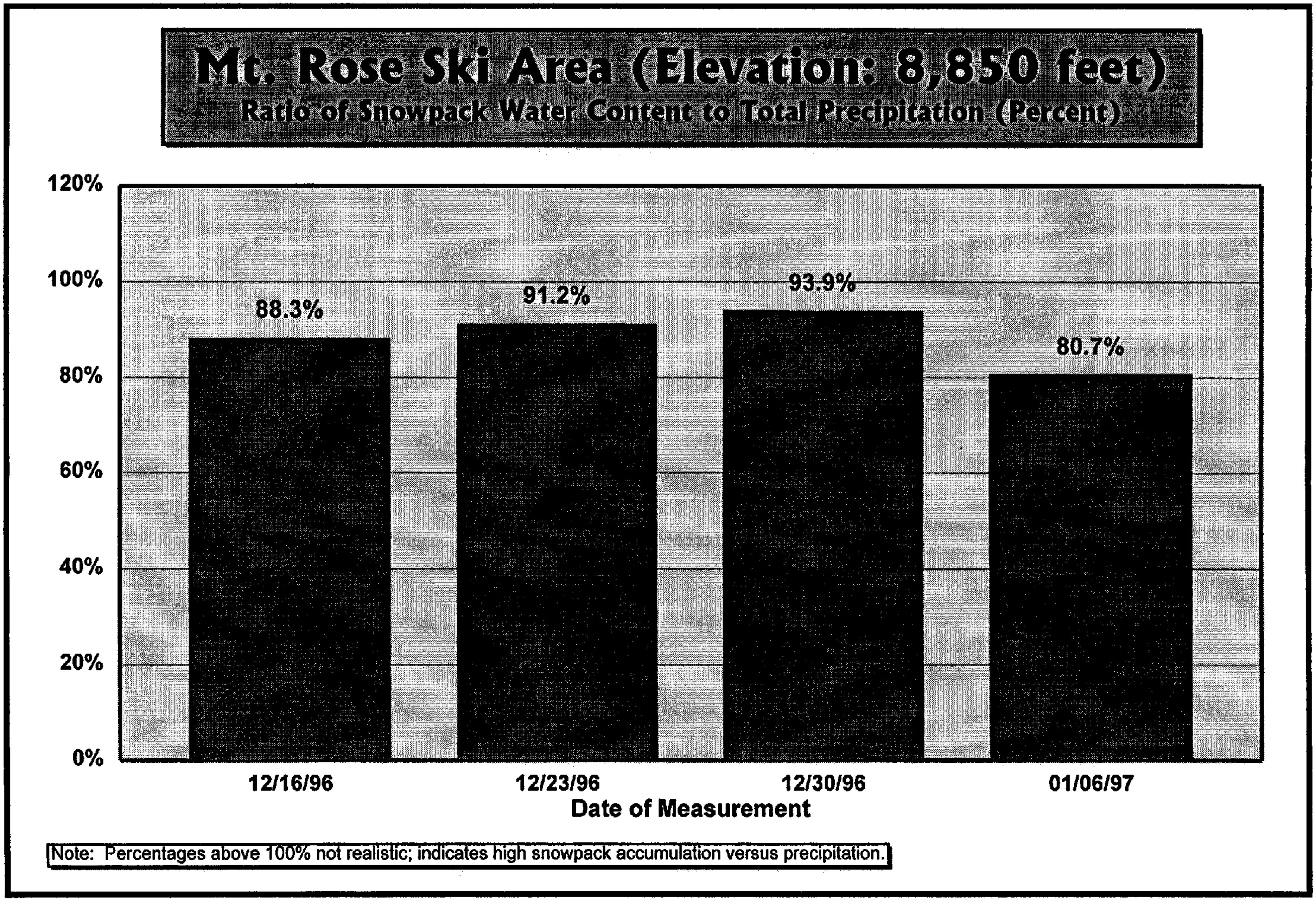
MSL = Above mean sea level.

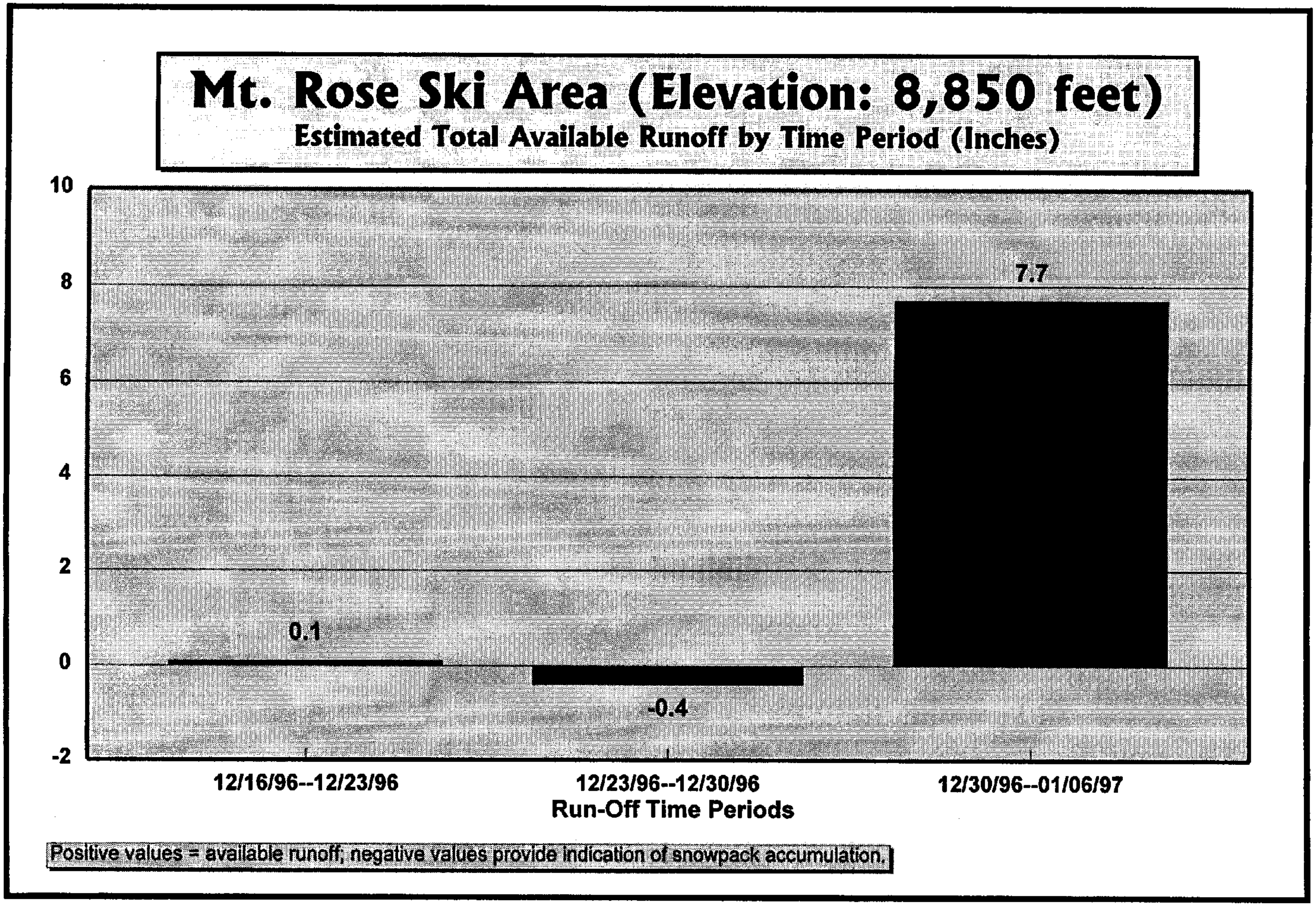
NOTE: 12/23/94 precipitation measures for Squaw Valley G.C. are actually for 12/27/96.

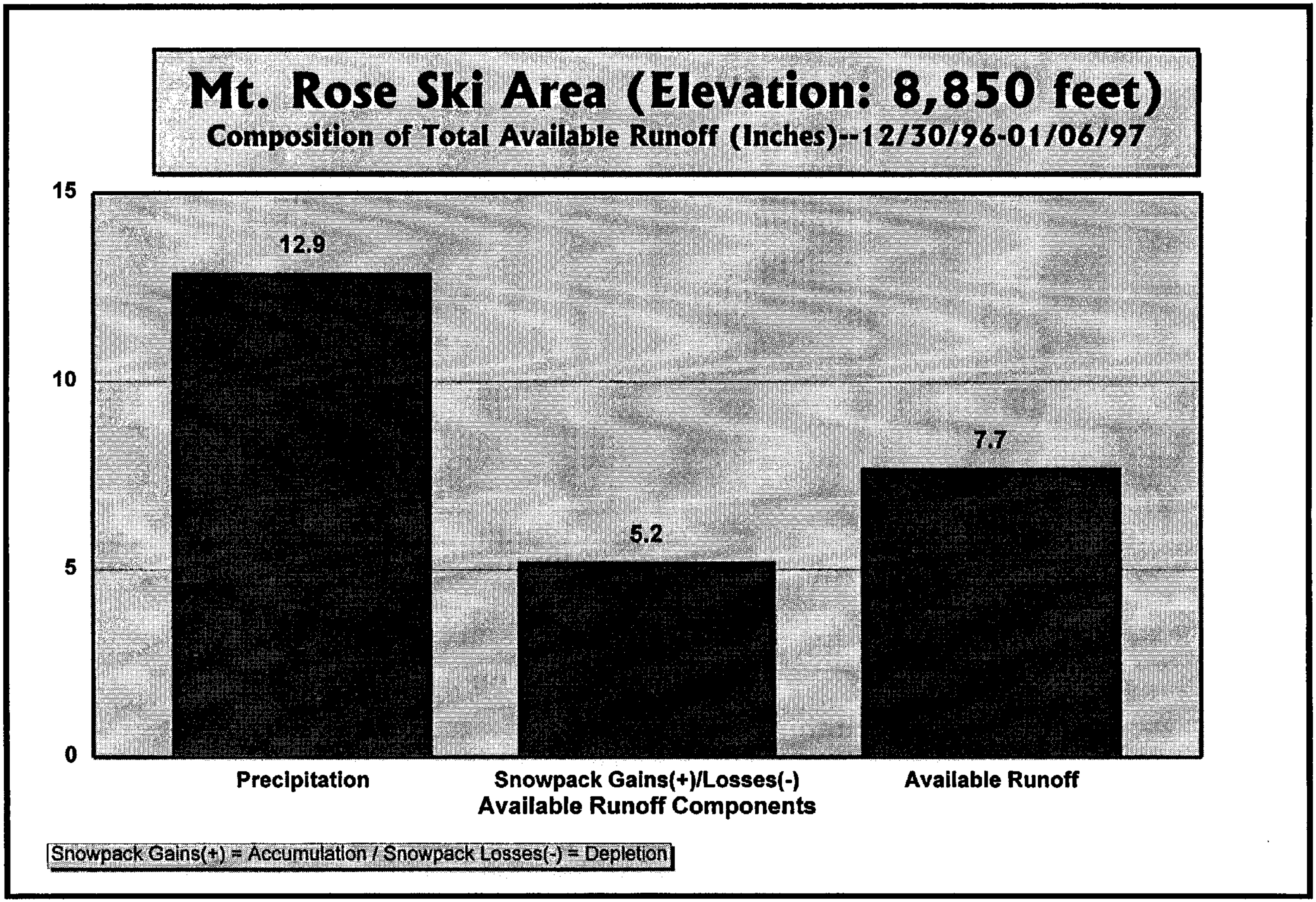
Table Interpretation: Entries under "Precipitation Change" and "Snowpack Water Content Change" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time should the change in snowpack water content accumulated between two dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content are therefore not realistic and should be interpreted only in the sense that the snowpack appears to be absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle) effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

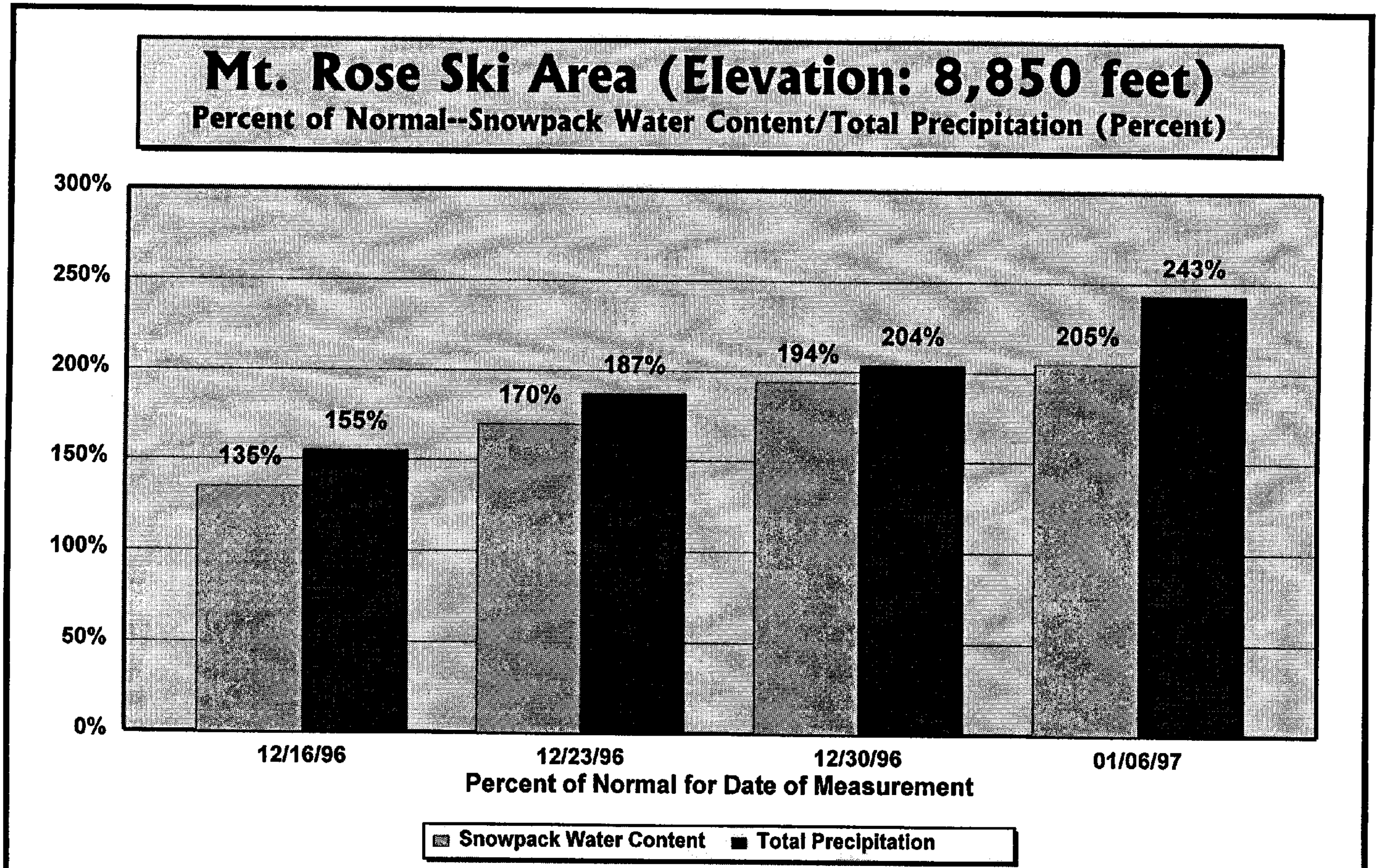

Mt. Rose Ski Area (Elevation: 8,850 feet)
Snowpack Water Content and Total Precipitation (Inches)
60
40
20
0
20.3
23.0
29.0
31.8
37.0
39.4
42.2
52.3
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Mt. Rose Ski Area (Elevation: 8,850 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
120%
100%
80%
60%
40%
20%
0%
88.3%
91.2%
93.9%
80.7%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

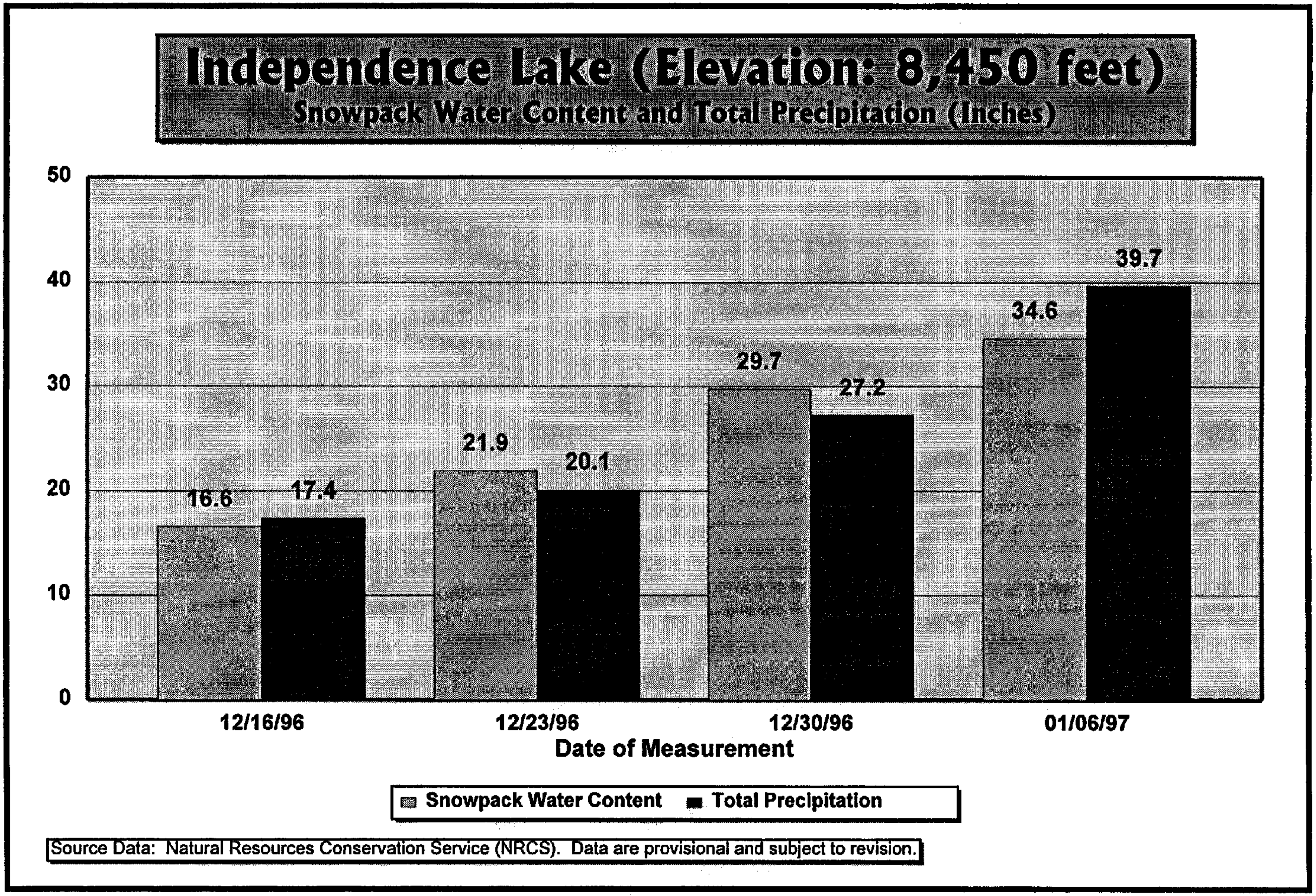

Mt. Rose Ski Area (Elevation: 8,850 feet)
Estimated Total Available Runoff by Time Period (Inches)
10
8
6
4
2
0
-2
0.1
-0.4
7.7
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff, negative values provide indication of snowpack accumulation.

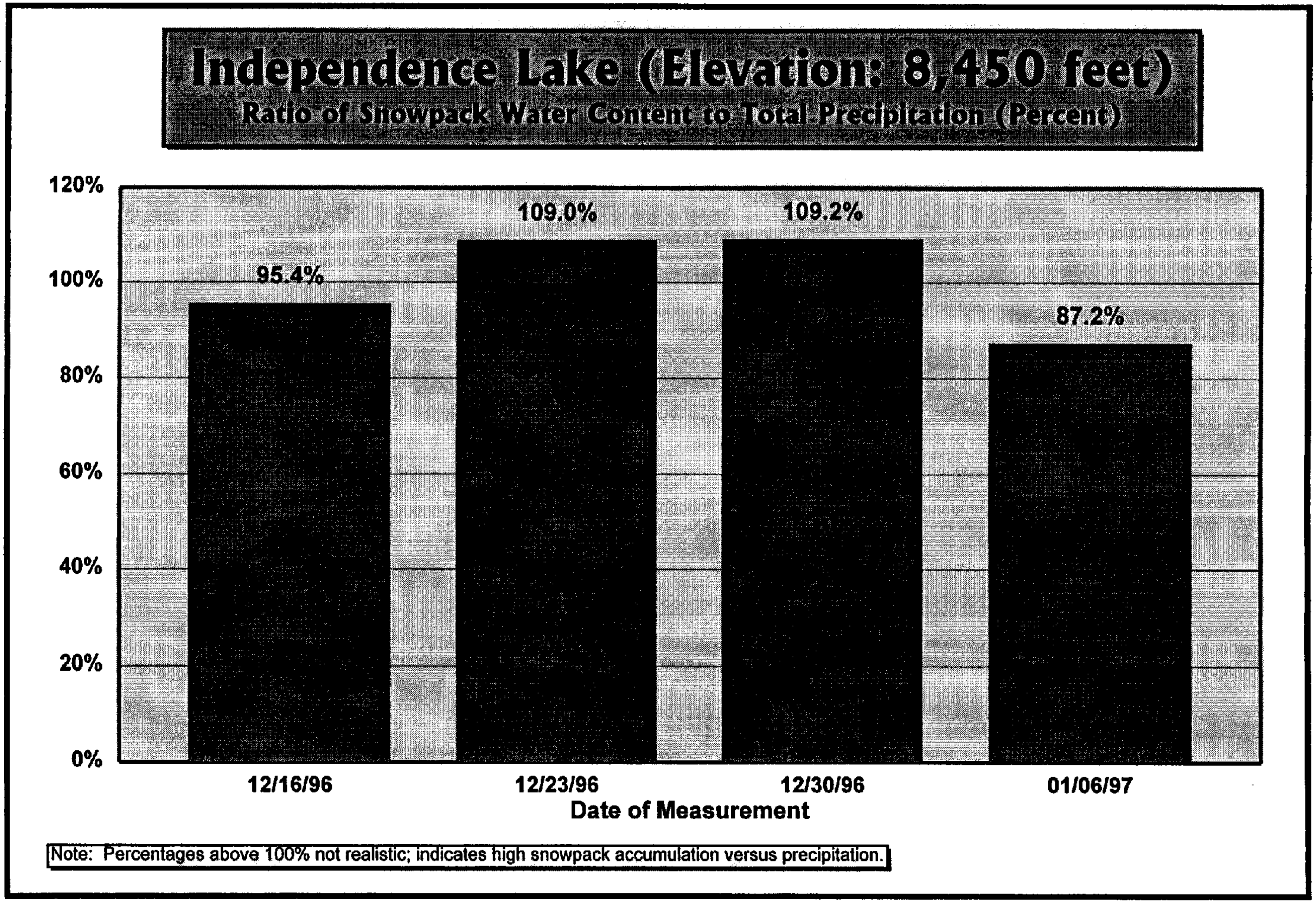


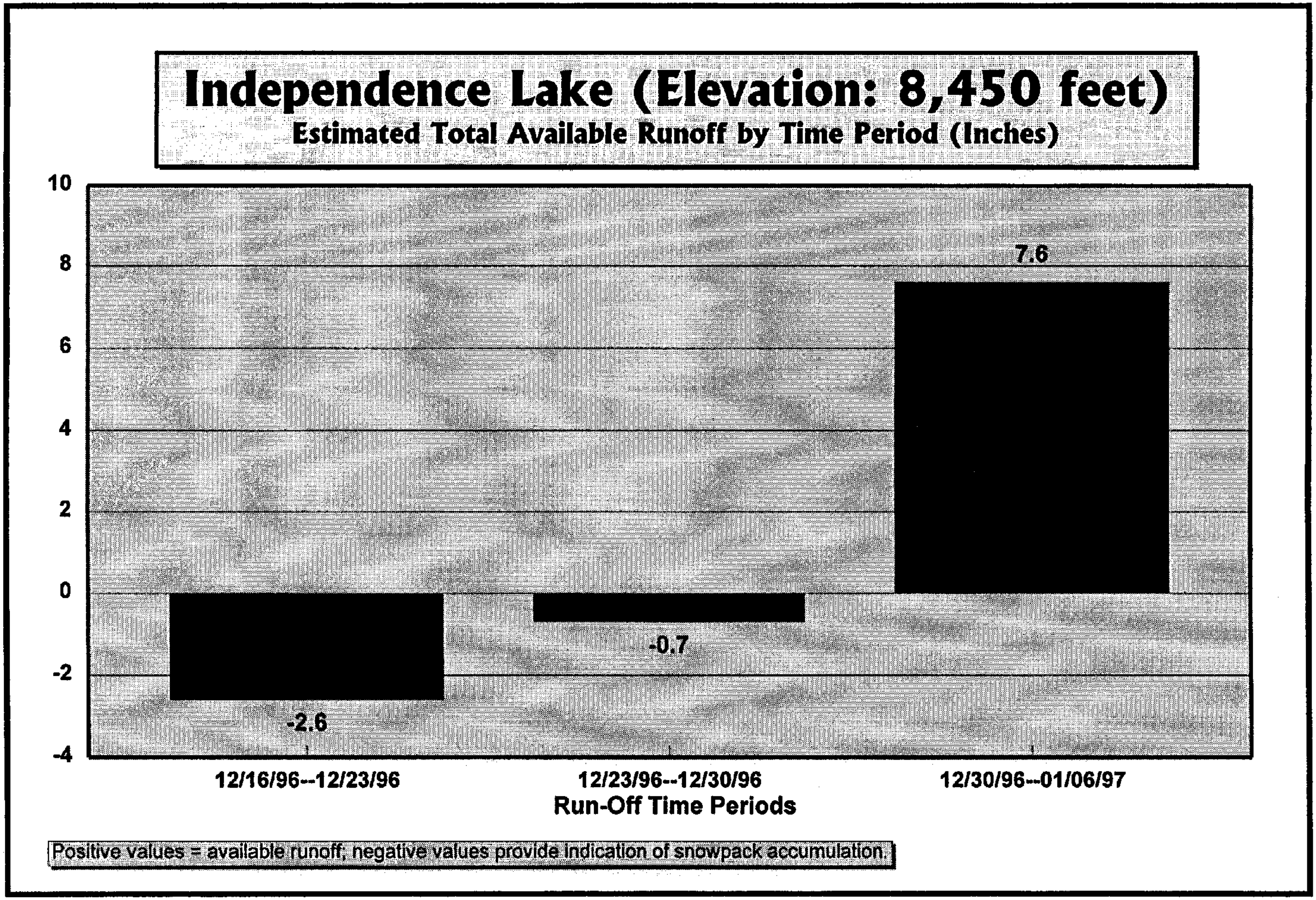
Mt. Rose Ski Area (Elevation: 8,850 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
15
10
5
0
12.9
5.2
7.7
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

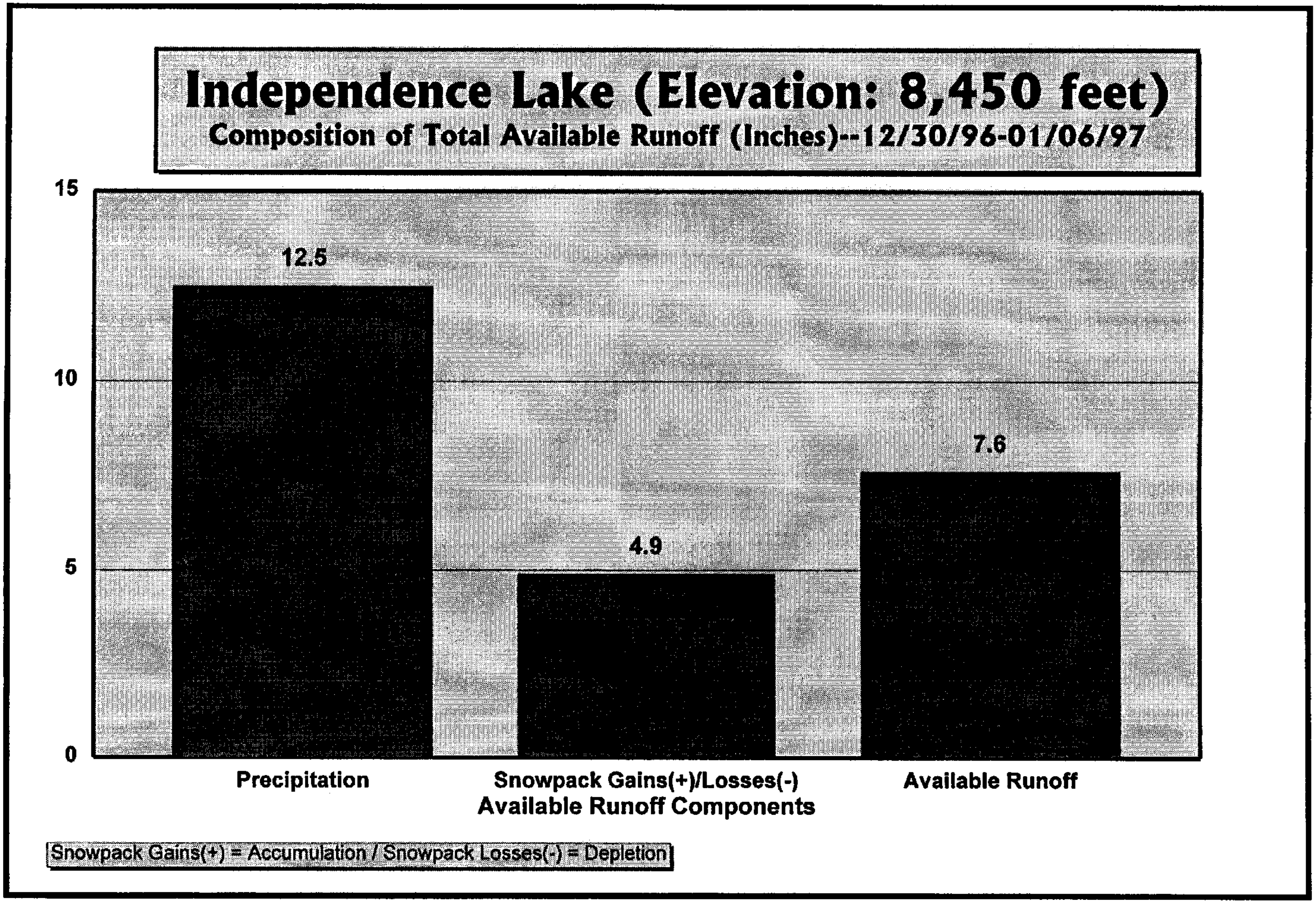


Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

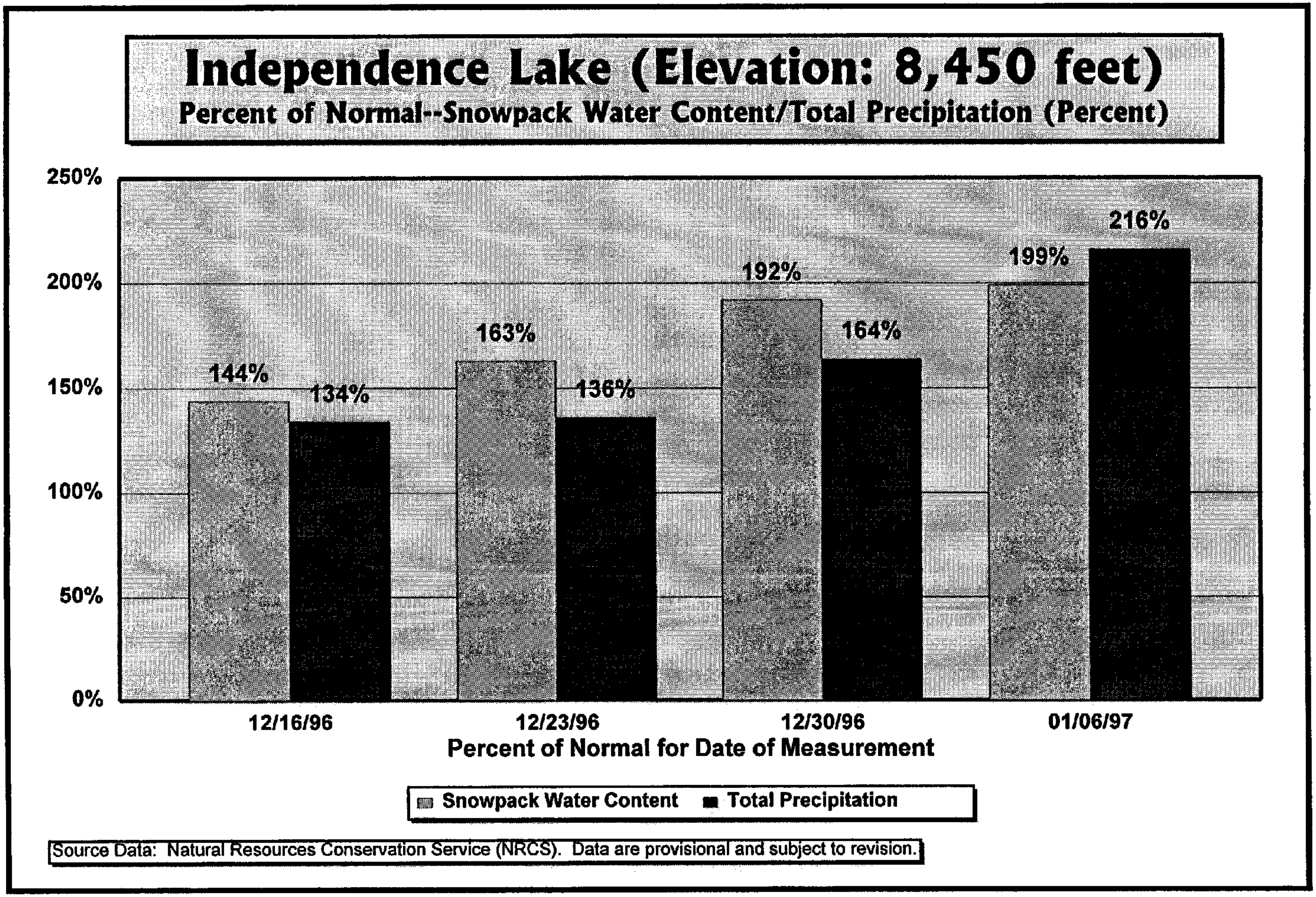

Independence Lake (Elevation: 8,450 feet)
Snowpack Water Content and Total Precipitation (Inches)
50
40
30
20
10
0
16.6
17.4
21.9
20.1
29.7
27.2
34.6
39.7
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

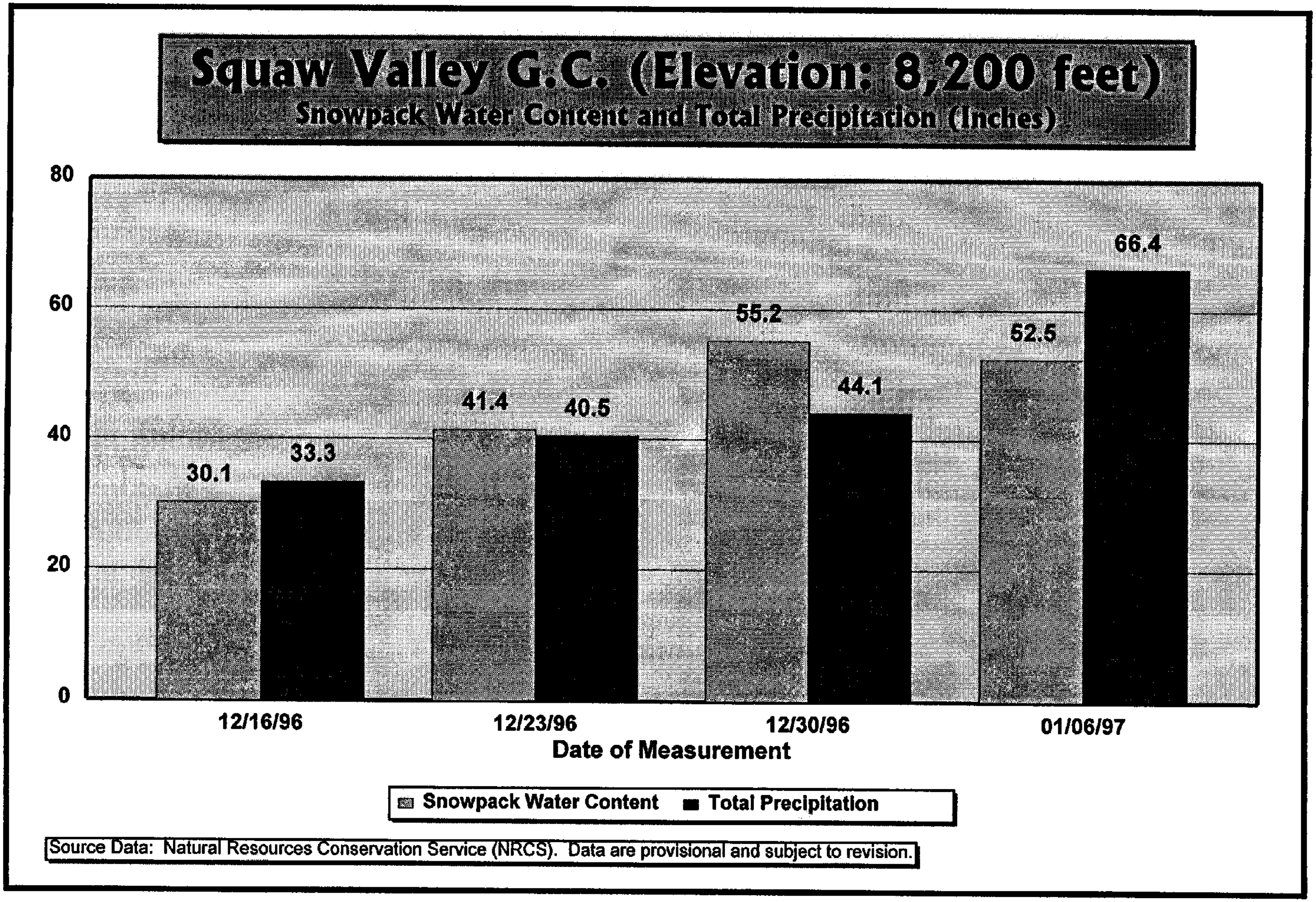

Independence Lake (Elevation: 8,450 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
120%
100%
80%
60%
40%
20%
0%
95.4%
109.0%
109.2%
87.2%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

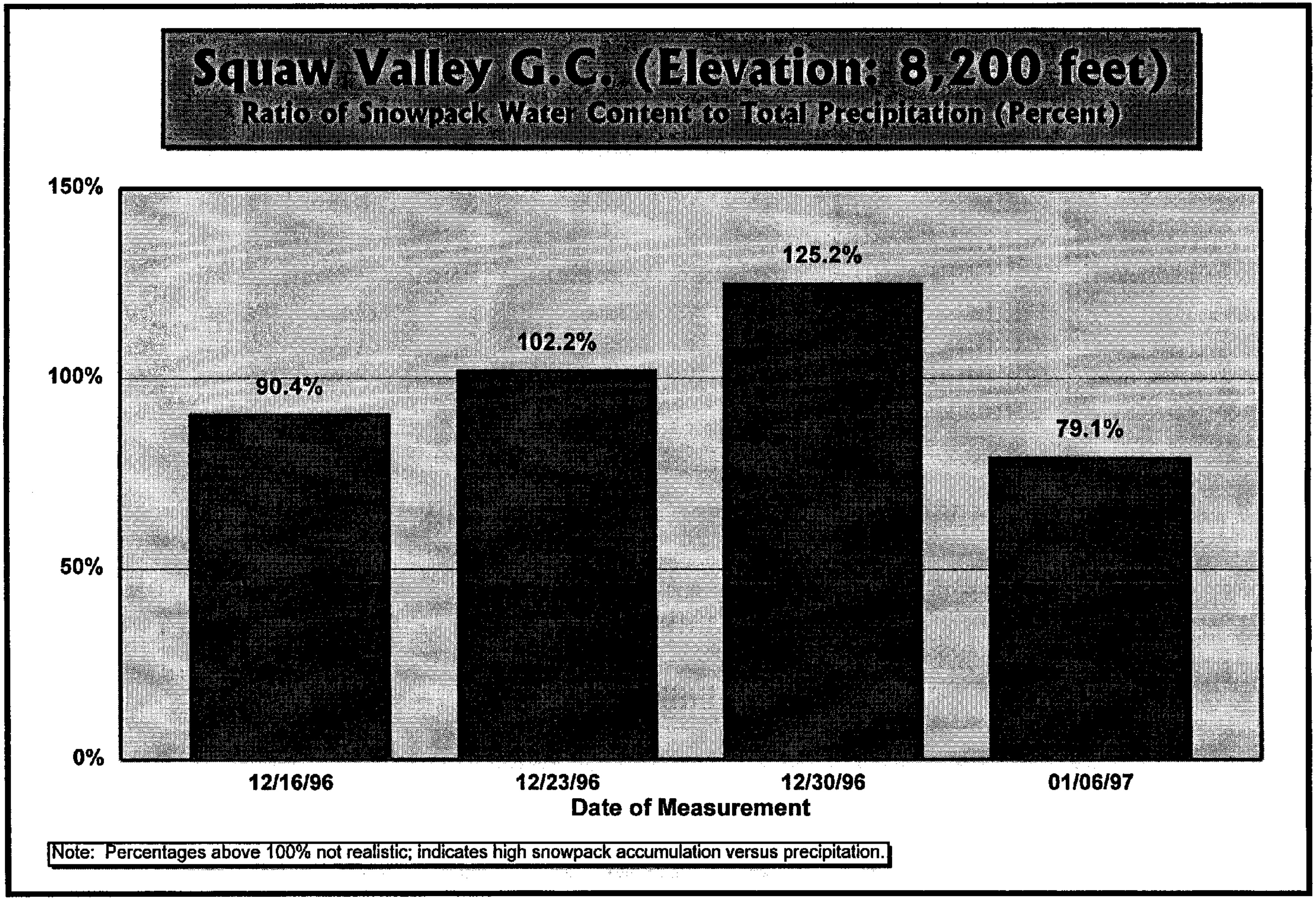

Independence Lake (Elevation: 8,450 feet)
Estimated Total Available Runoff by Time Period (Inches)
10
8
6
4
2
0
-2
-4
7.6
-0.7
-2.6
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff, negative values provide indication of snowpack accumulation.



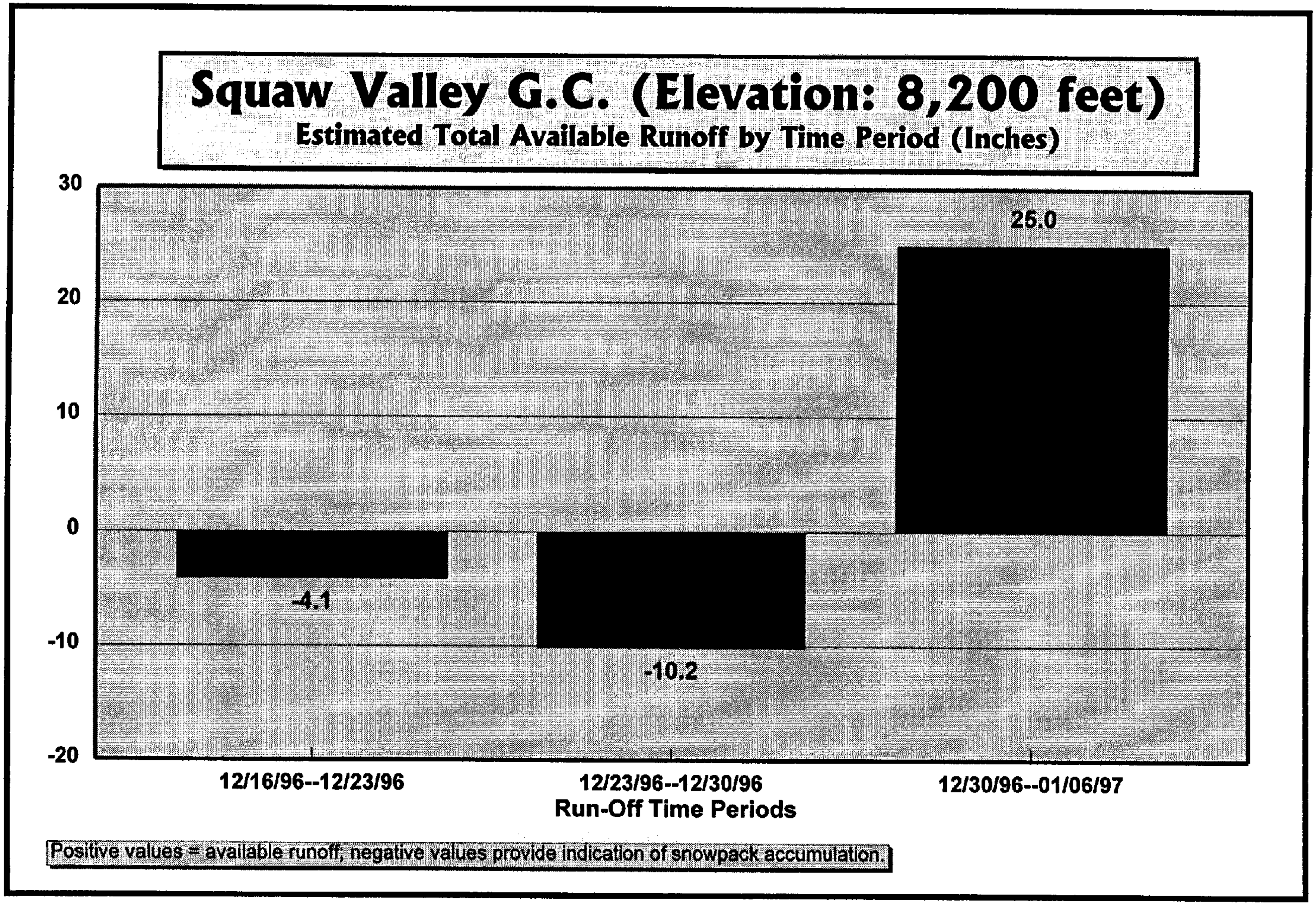
Independence Lake (Elevation: 8,450 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
15
10
5
0
12.5
4.9
7.6
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

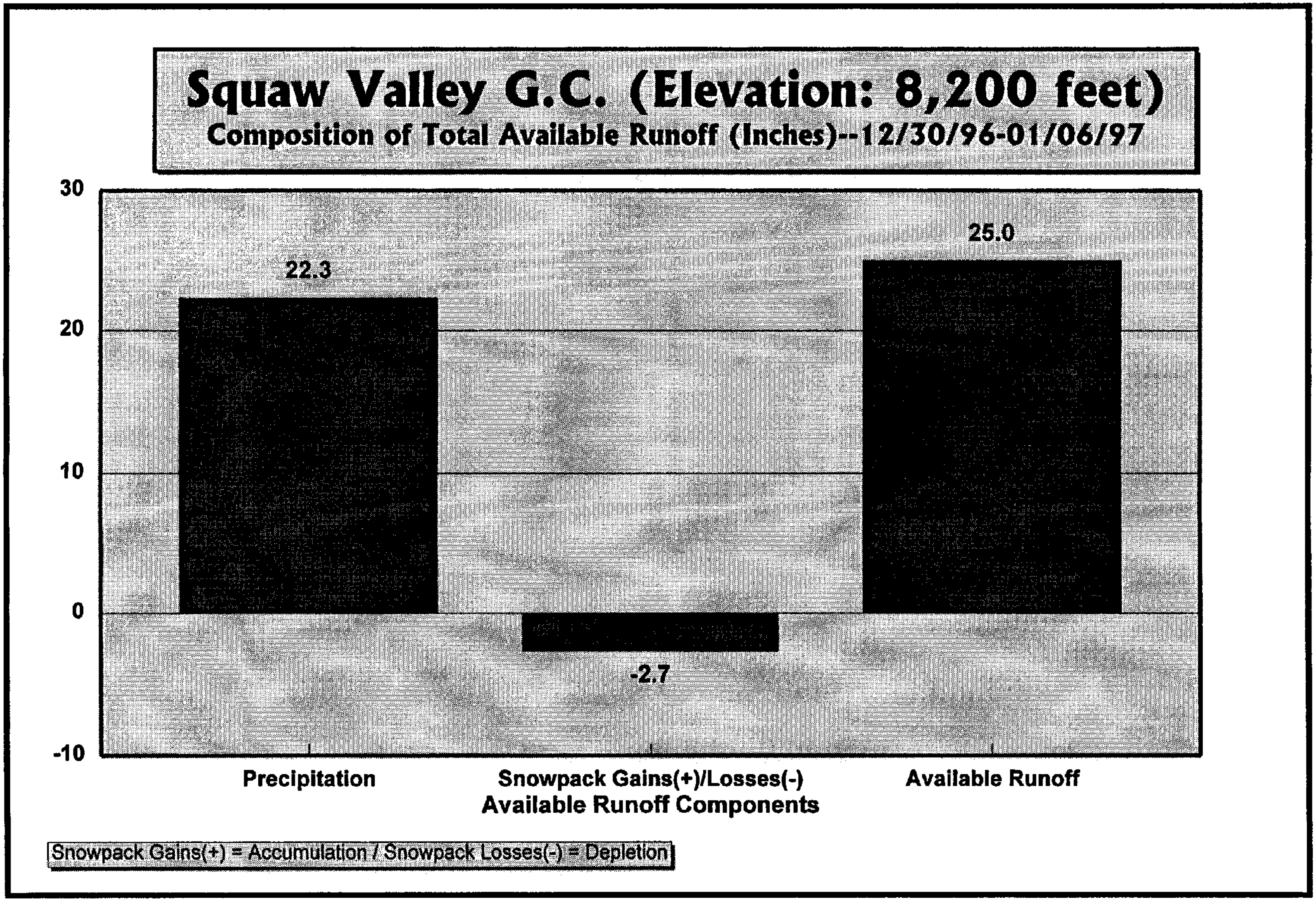

Independence Lake (Elevation: 8,450 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
250%
200%
150%
100%
50%
0%
144%
134%
163%
136%
192%
164%
199%
216%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Squaw Valley G.C. (Elevation: 8,200 feet)
Snowpack Water Content and Total Precipitation (Inches)
80
60
40
20
0
30.1
33.3
41.4
40.5
55.2
44.1
52.5
66.4
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

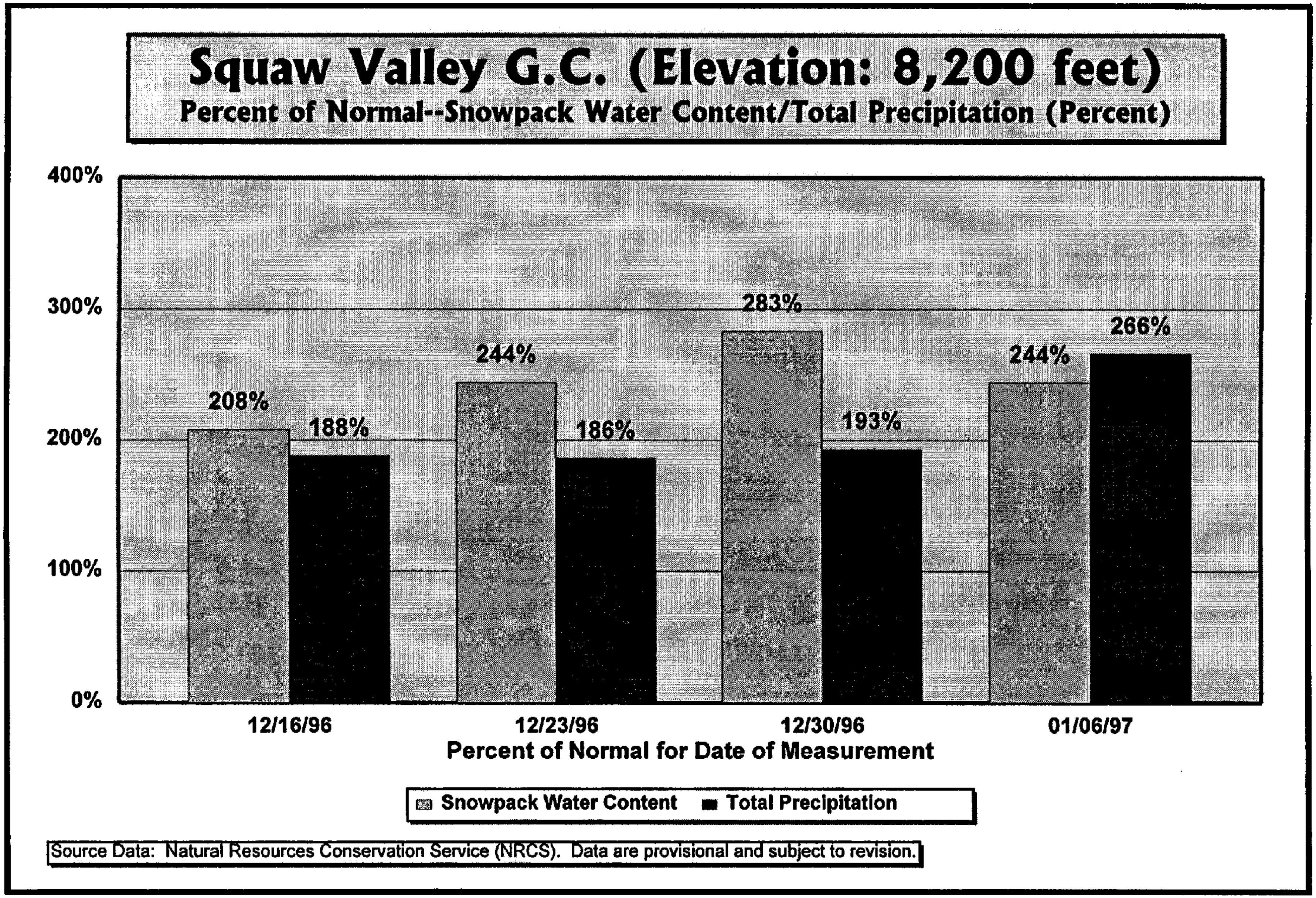


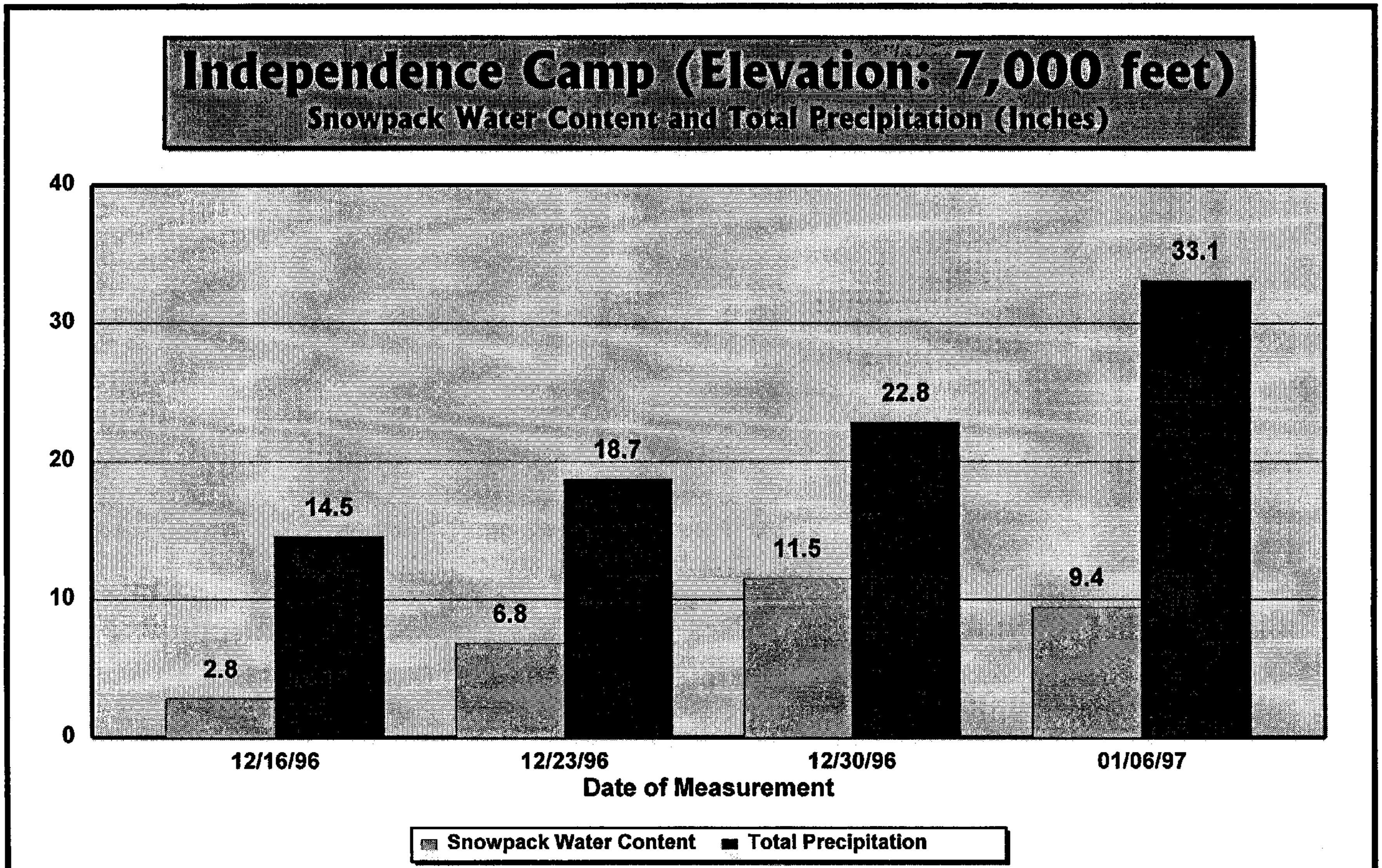
Squaw Valley G.C. (Elevation: 8,200 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
150%
100%
50%
0%
90.4%
102.2%
125.2%
79.1%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.


Squaw Valley G.C. (Elevation: 8,200 feet)
Estimated Total Available Runoff by Time Period (Inches)
30
20
10
0
-10
-20
25.0
-4.1
-10.2
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

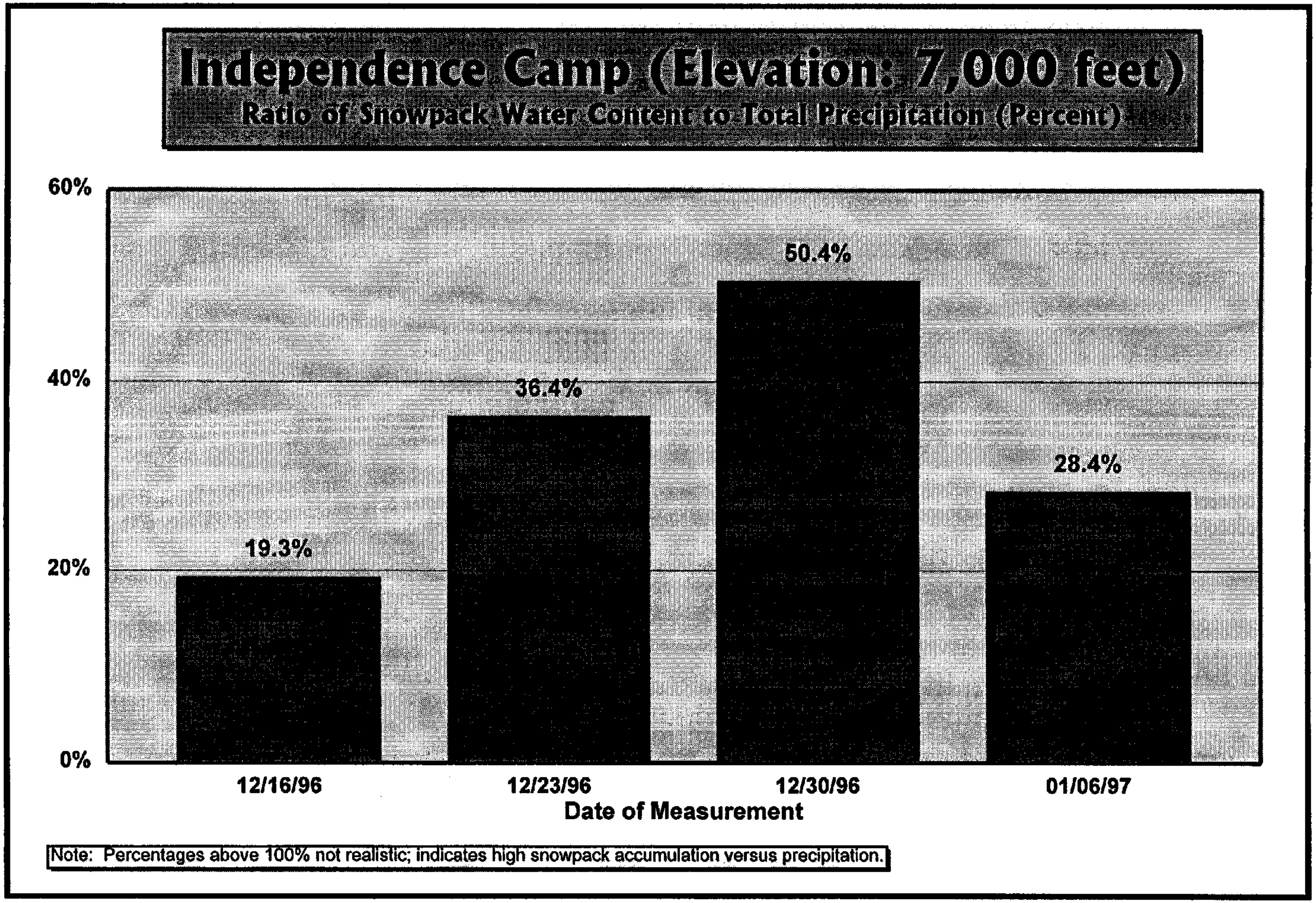


Squaw Valley G.C. (Elevation: 8,200 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
30
20
10
0
-10
22.3
-2.7
25.0
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

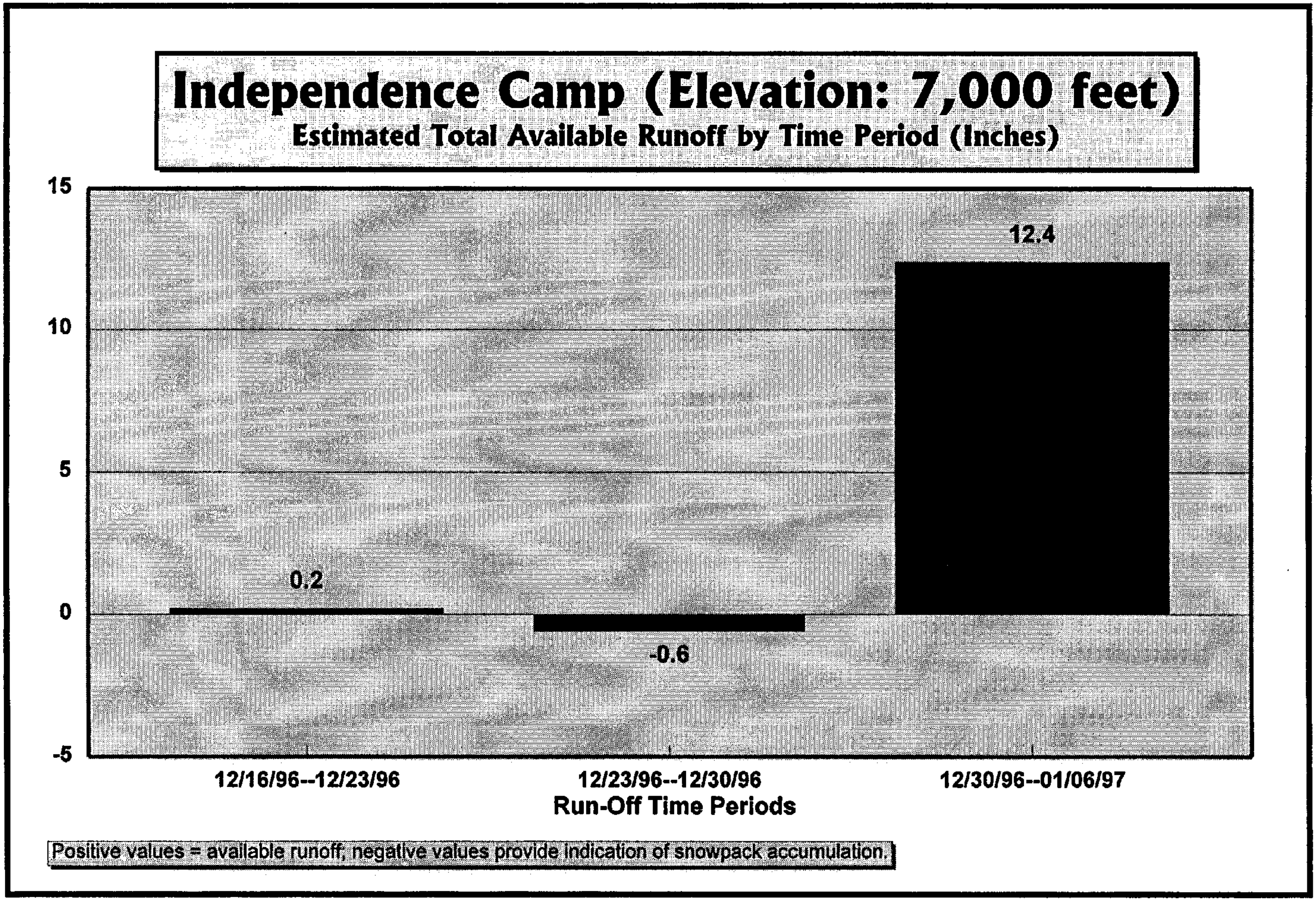

Squaw Valley G.C. (Elevation: 8,200 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
400%
300%
200%
100%
0%
208%
188%
244%
186%
283%
193%
244%
266%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

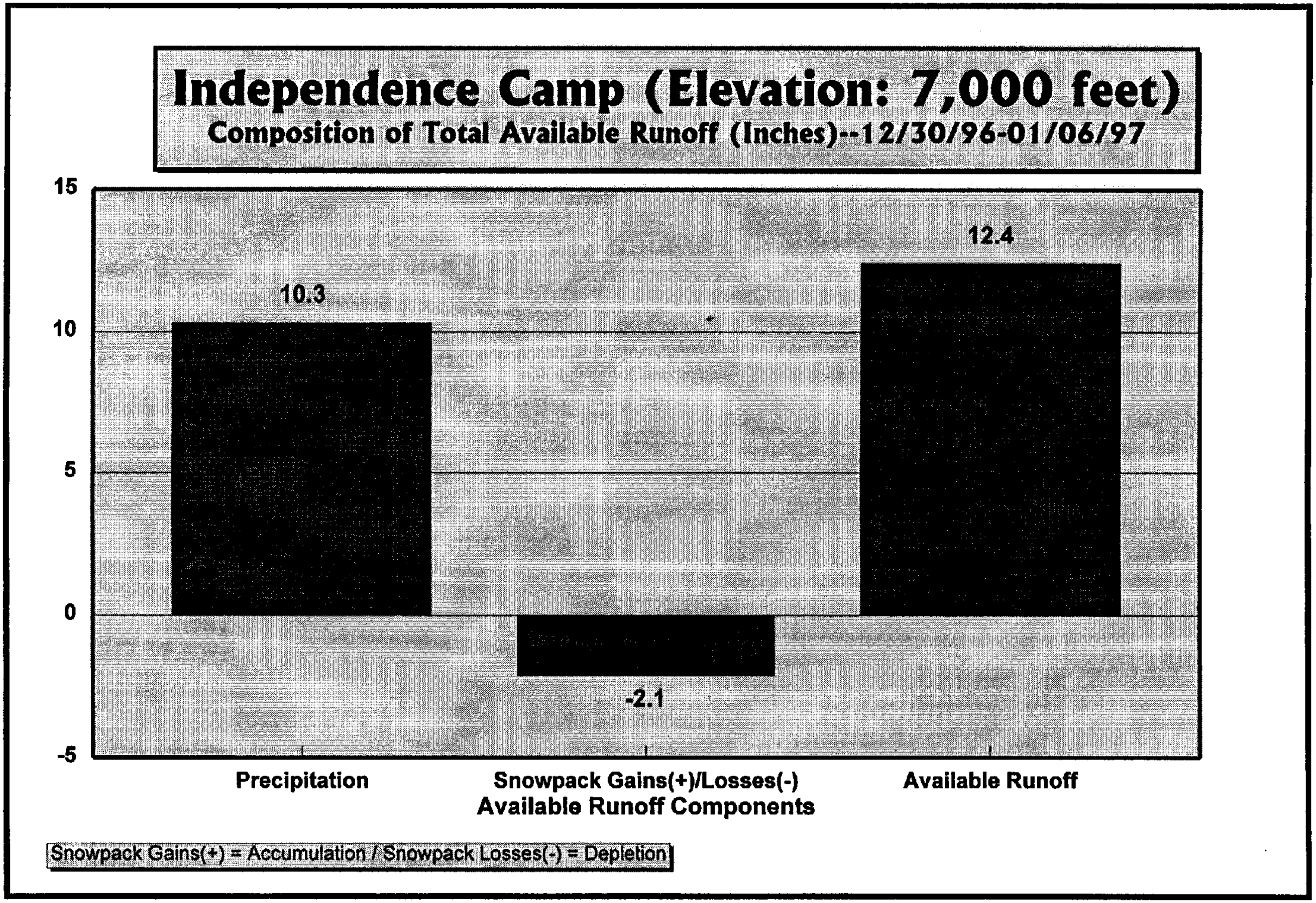


Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

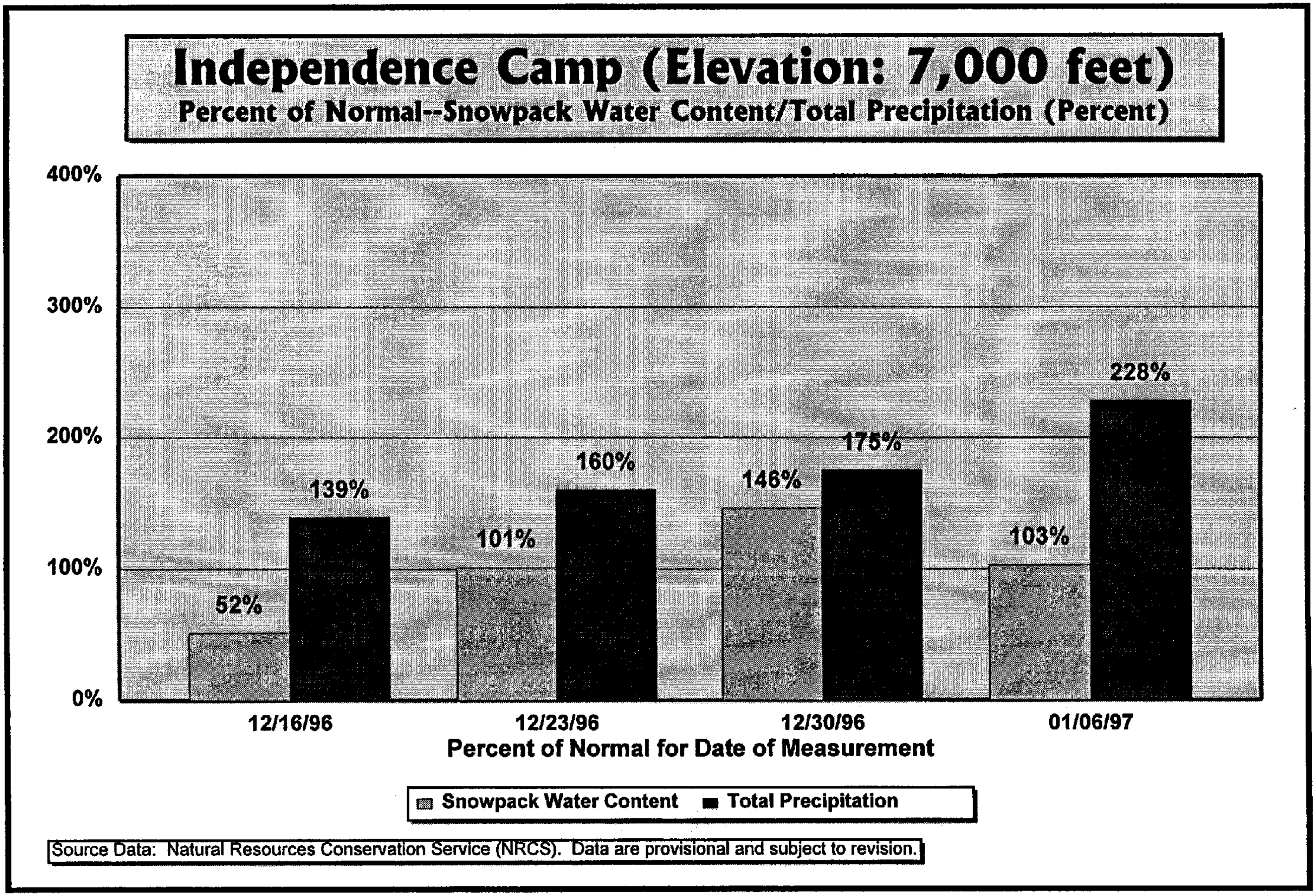


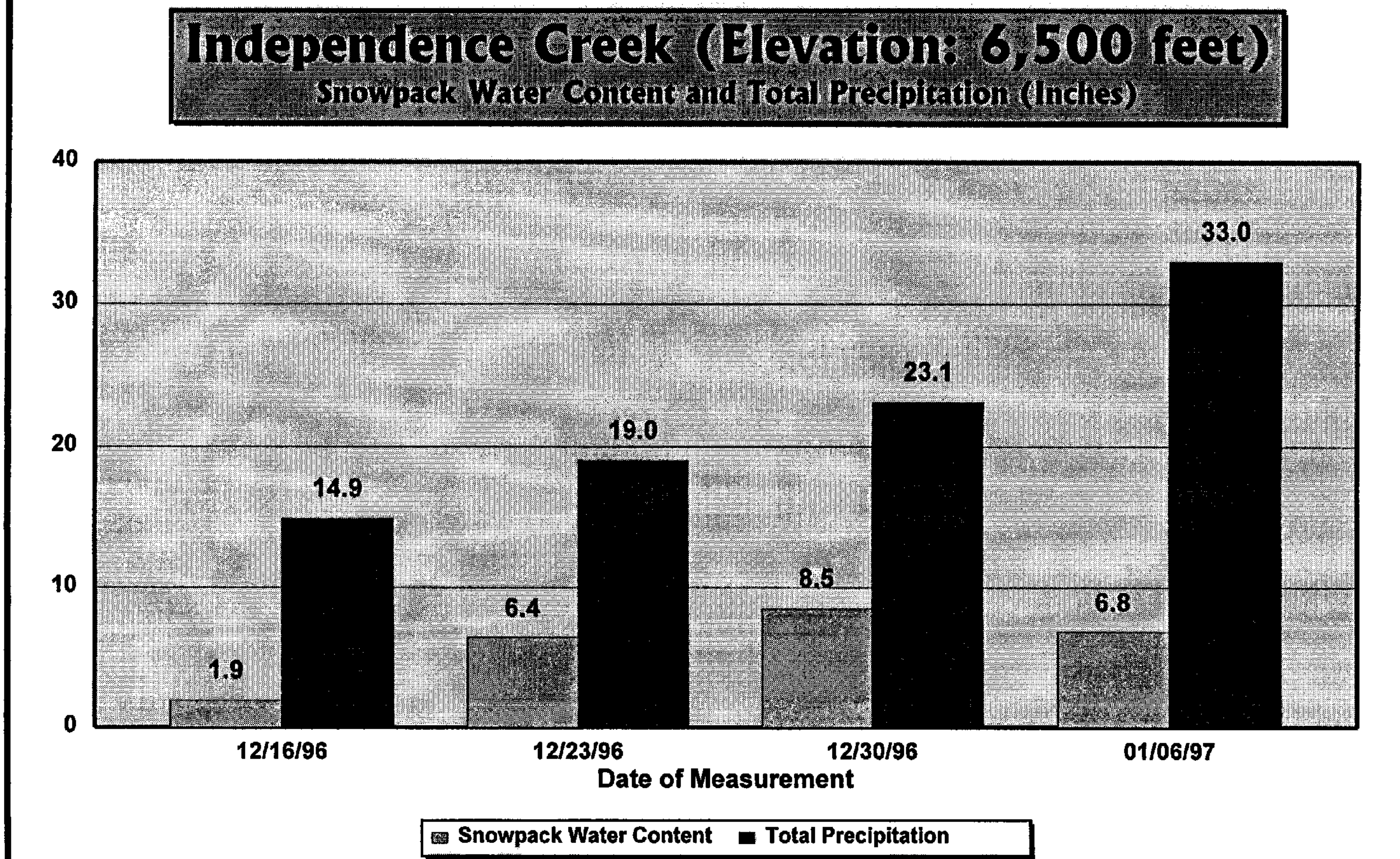
Independence Camp (Elevation: 7,000 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
60%
40%
20%
0%
19.3%
36.4%
50.4%
28.4%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.


Independence Camp (Elevation: 7,000 feet)
Estimated Total Available Runoff by Time Period (Inches)
15
10
5
0
-5
0.2
-0.6
12.4
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

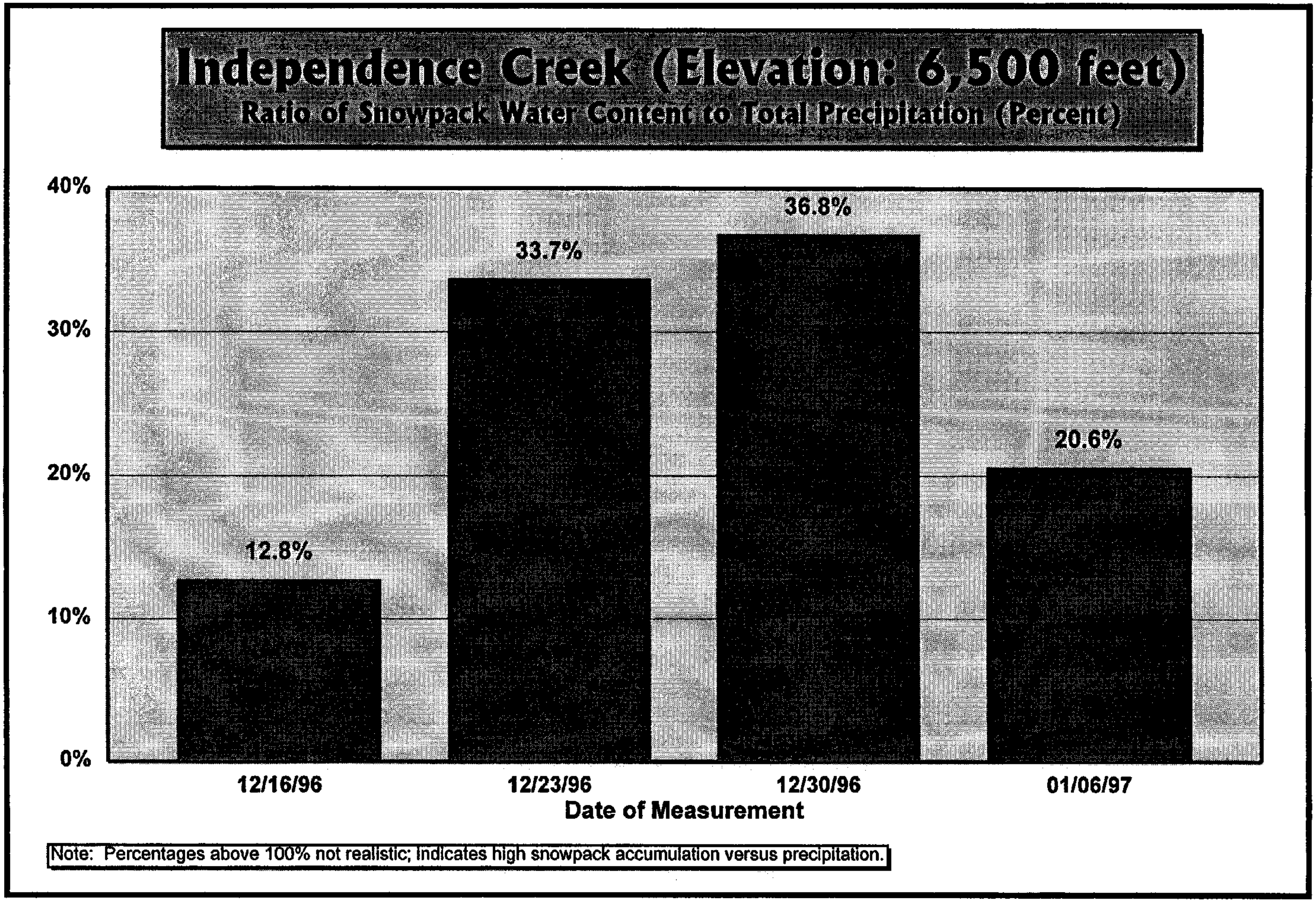


Independence Camp (Elevation: 7,000 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
15
10
5
0
-5
10.3
-2.1
12.4
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

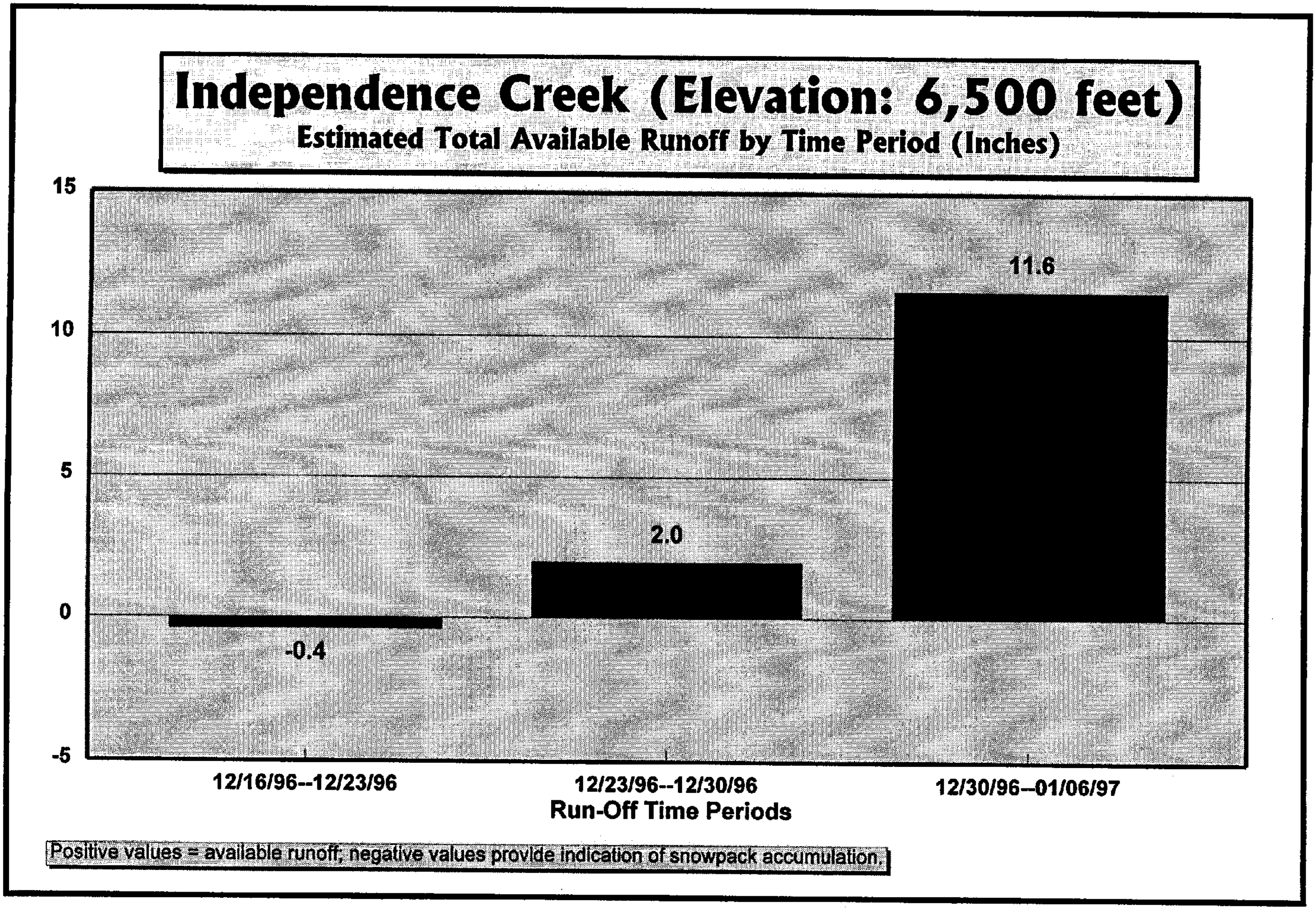

Independence Camp (Elevation: 7,000 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
400%
300%
200%
100%
0%
52%
139%
101%
160%
146%
175%
103%
228%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

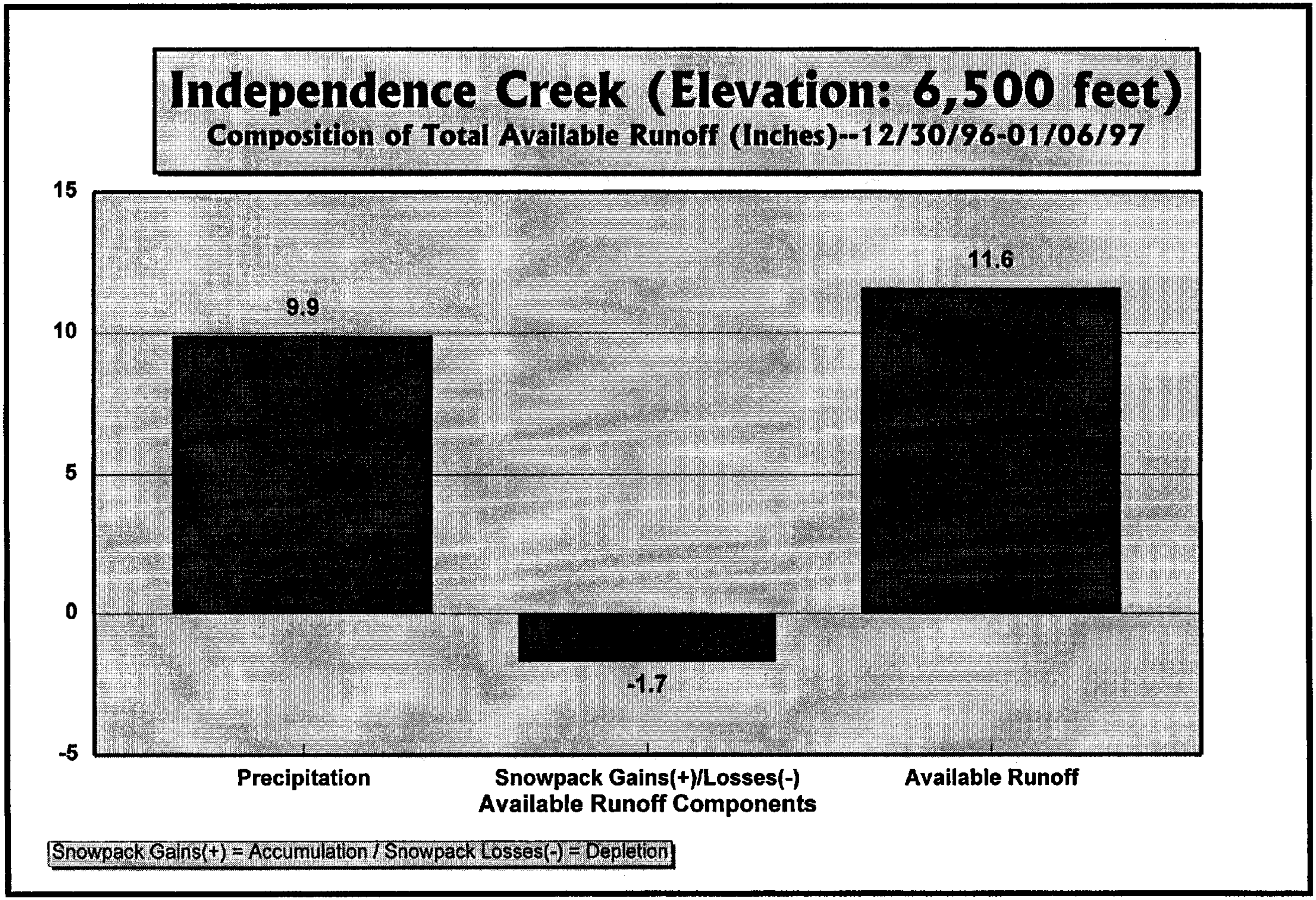


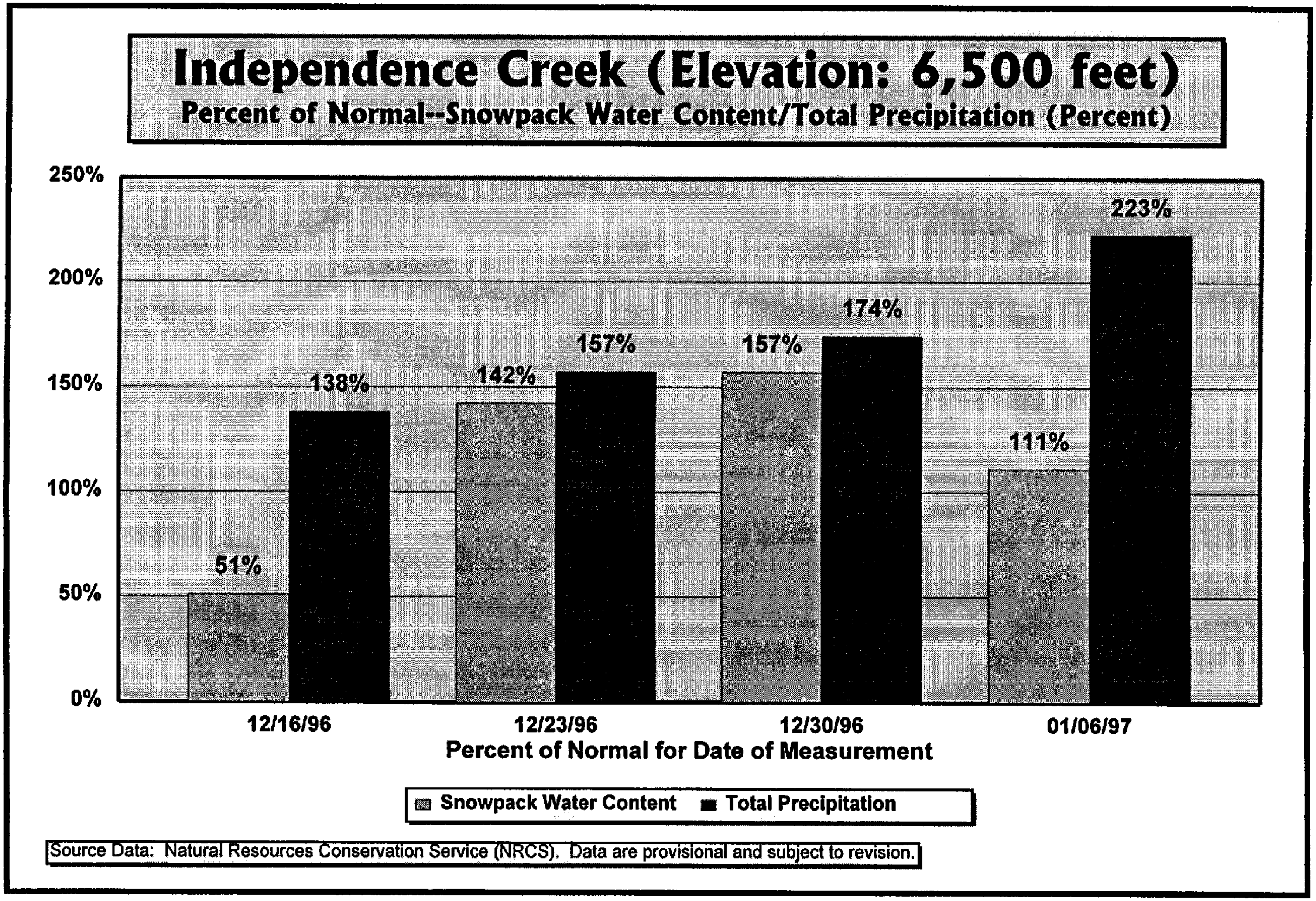
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

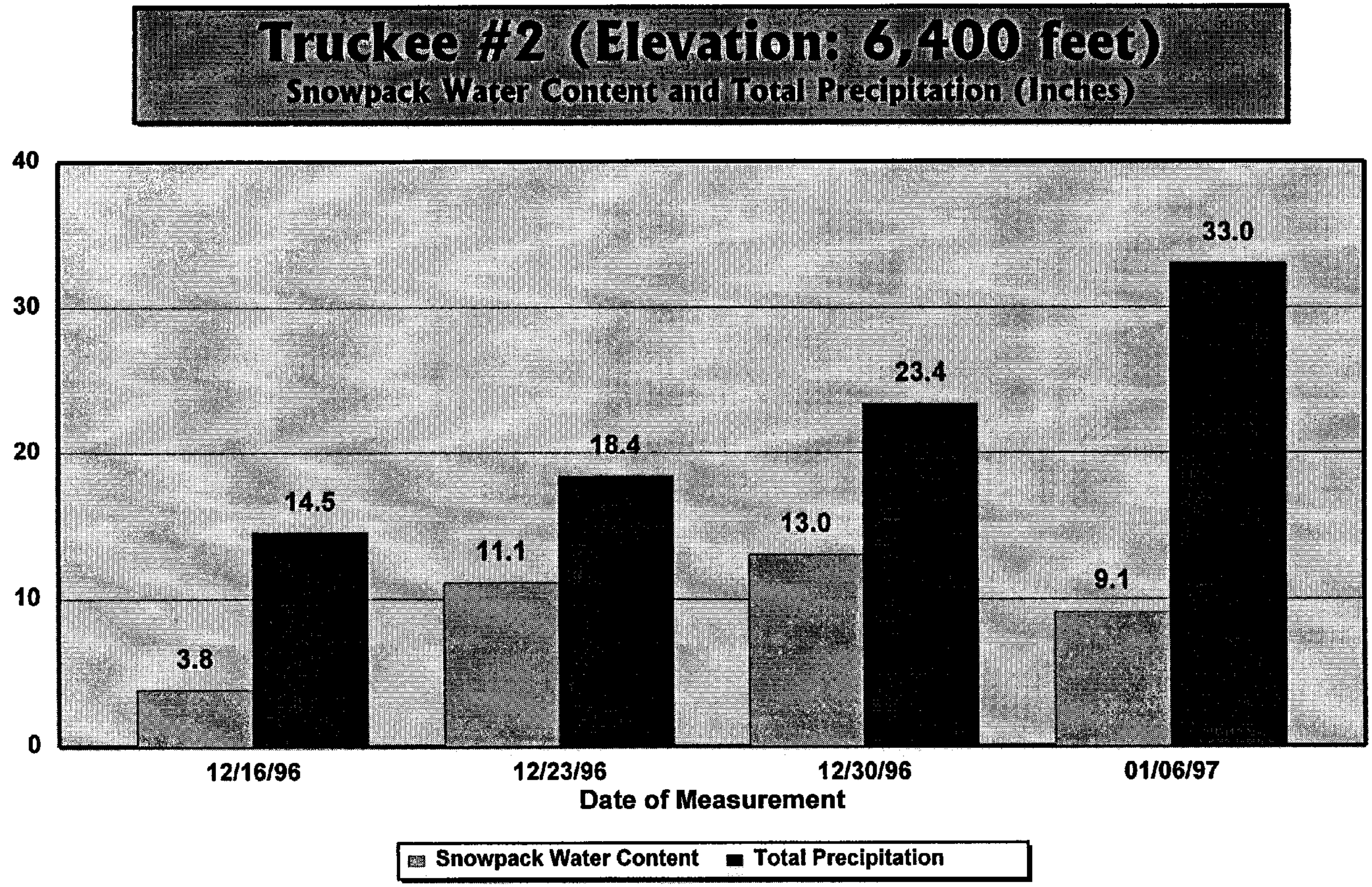


Independence Creek (Elevation: 6,500 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
40%
30%
20%
10%
0%
12.8%
33.7%
36.8%
20.6%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

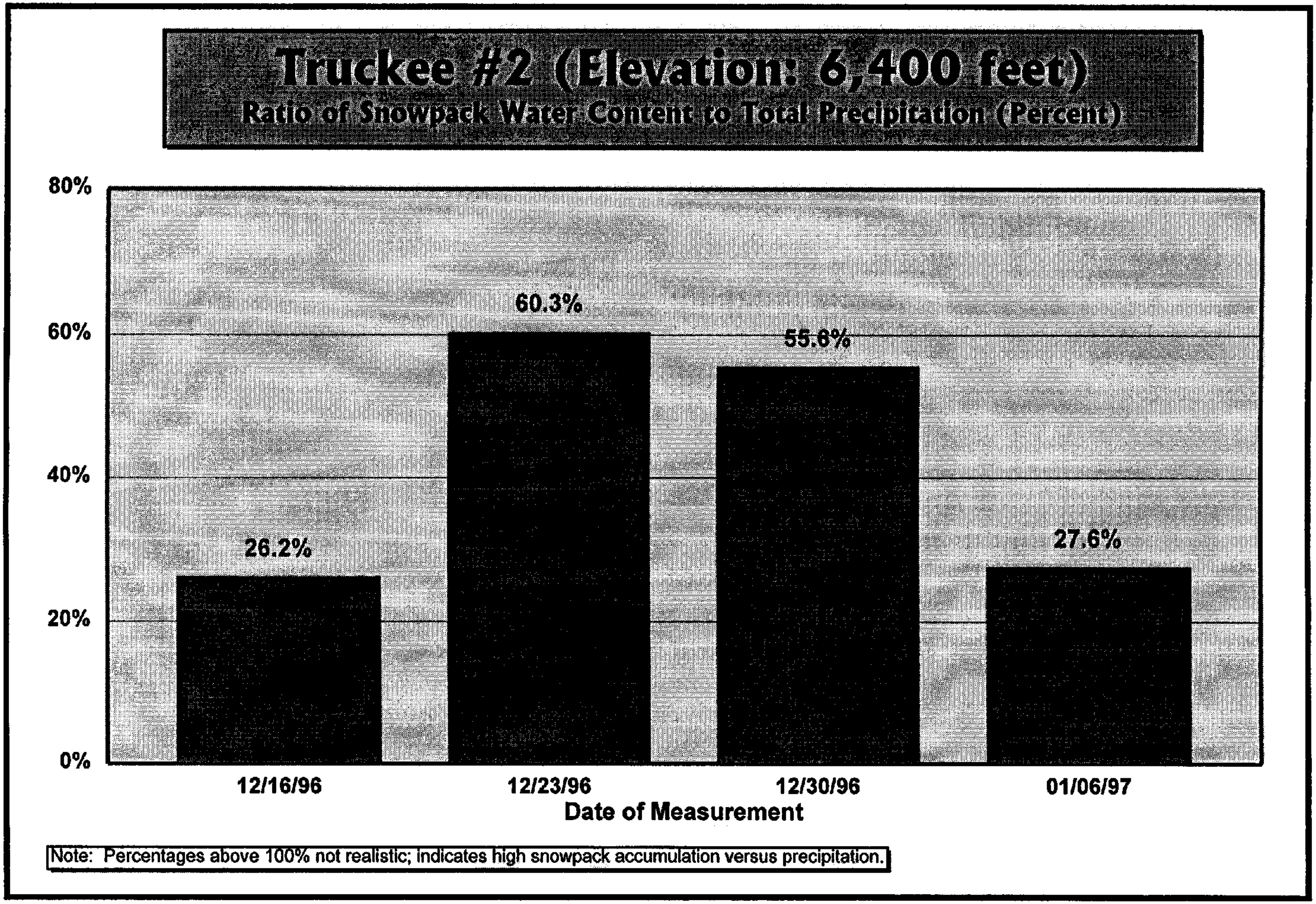

Independence Creek (Elevation: 6,500 feet)
Estimated Total Available Runoff by Time Period (Inches)
15
10
5
0
-5
11.6
2.0
-0.4
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

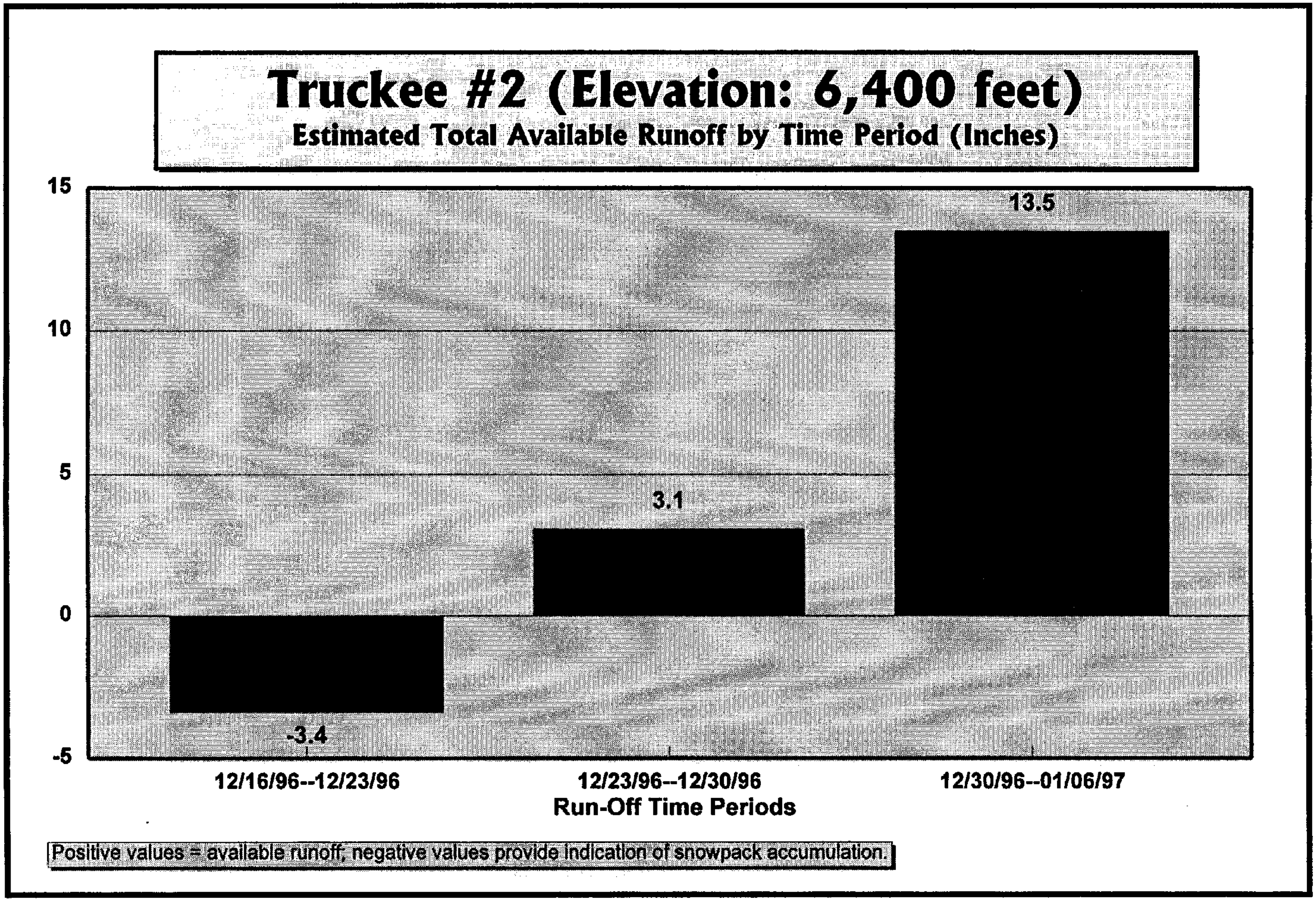

Independence Creek (Elevation: 6,500 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
15
10
5
0
-5
9.9
-1.7
11.6
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion


Independence Creek (Elevation: 6,500 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
250%
200%
150%
100%
50%
0%
51%
138%
142%
157%
157%
174%
111%
223%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

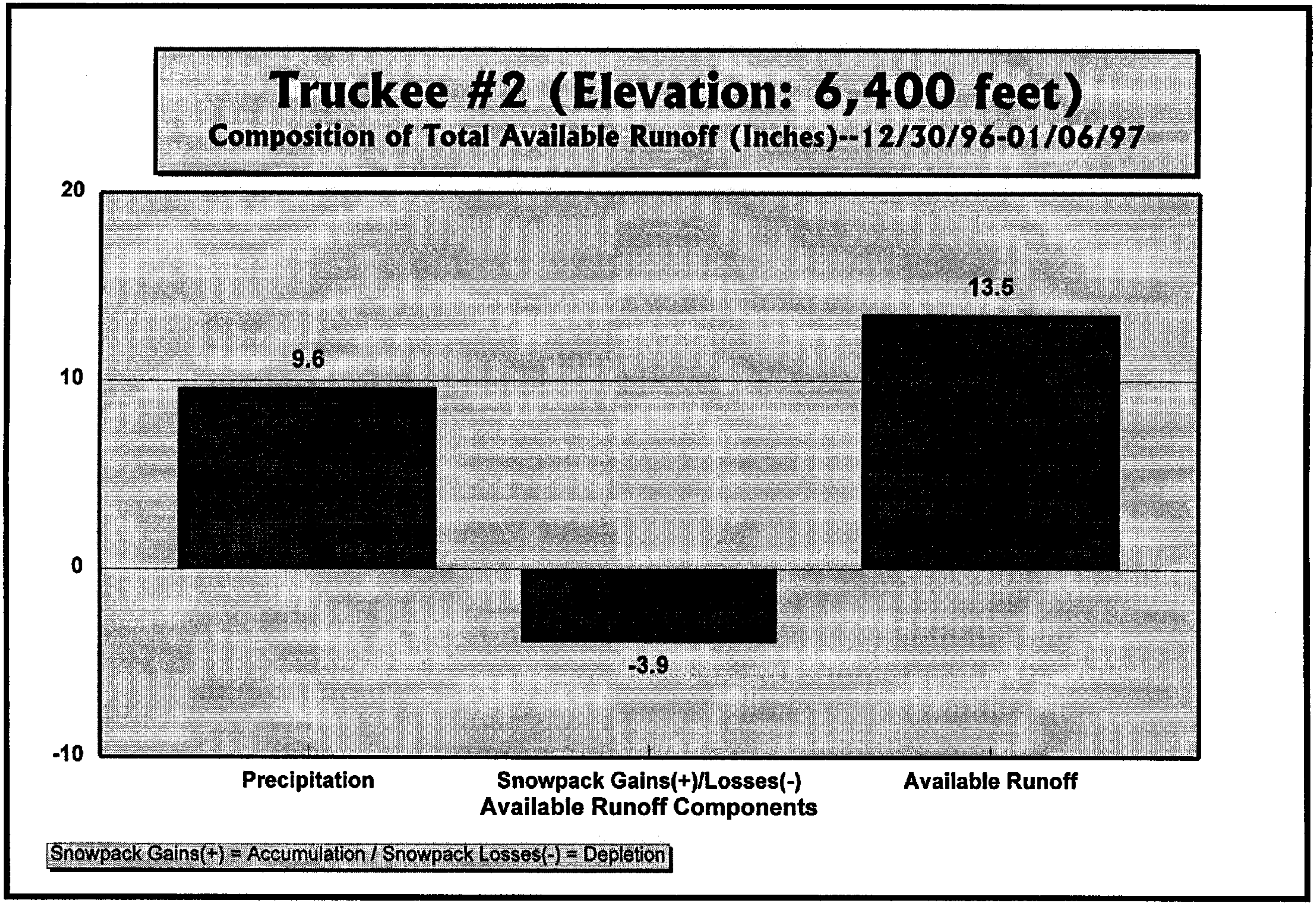


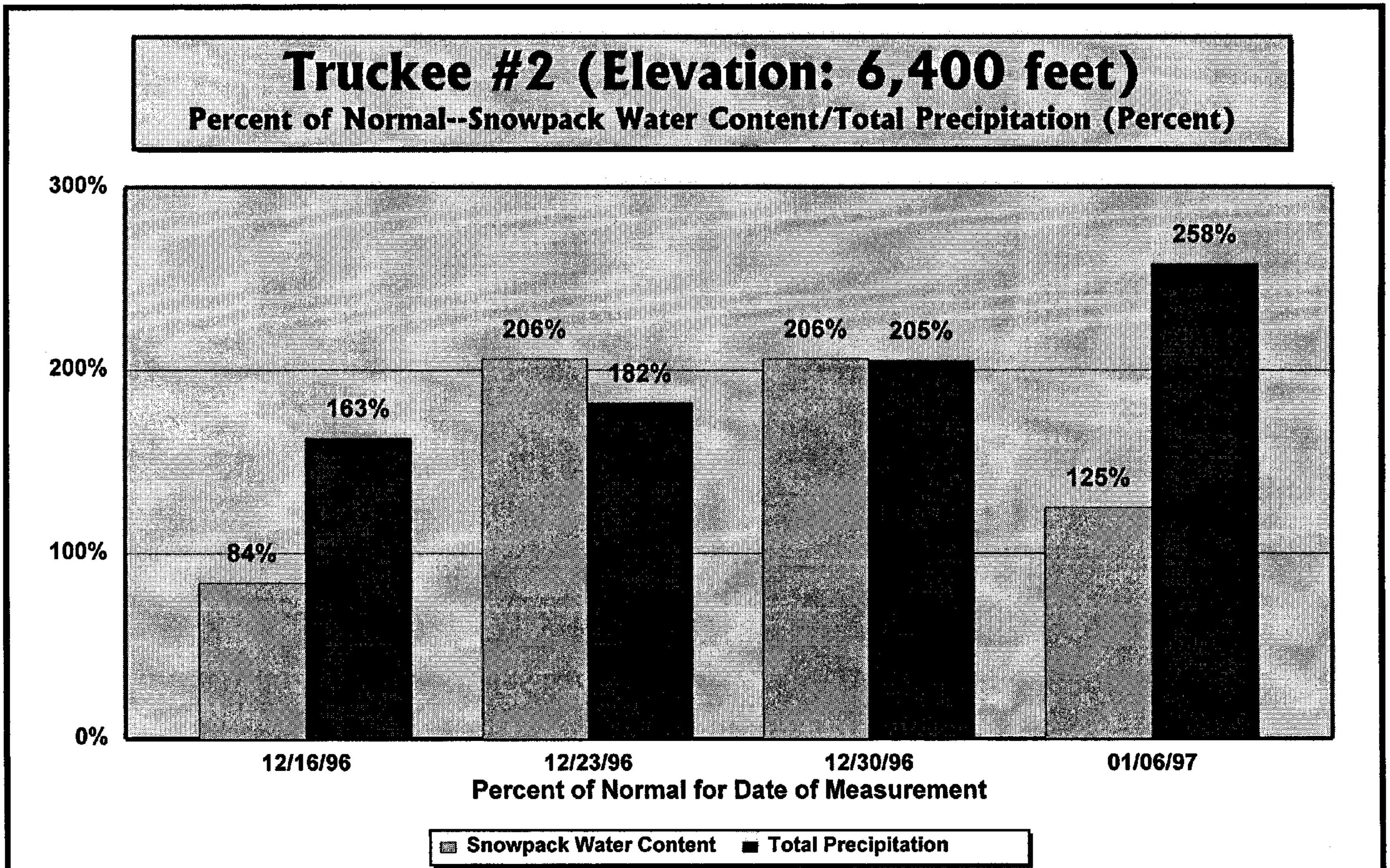
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Truckee #2 (Elevation: 6,400 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
80%
60%
40%
20%
0%
60.3%
55.6%
26.2%
27.6%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.



Truckee #2 (Elevation: 6,400 feet)
Estimated Total Available Runoff by Time Period (Inches)
15
10
5
0
-5
13.5
3.1
-3.4
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff, negative values provide indication of snowpack accumulation.


Truckee #2 (Elevation: 6,400 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
10
0
-10
9.6
-3.9
13.5
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion



Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

Appendix D

Carson River Basin

NRCS SNOTEL Sites

Ebbetts Pass
Monitor Pass
Poison Flat
Spratt Creek

Tables

3A. Precipitation Summary

3B. Comparisons of Changes in Precipitation and Snowpack Water Content

Part I—12/16/96–12/23/96

Part II—12/30/96–01/06/97

Part III—12/16/96–01/06/97

Graphs

Snowpack Water Content and Total Precipitation (Inches)

Ratio of Snowpack Water Content and Total Precipitation (Percent)

Estimated Total Available Runoff by Time Period (Inches)

Composition of Total Available Runoff (Inches)—12/30/96–01/06/97

Percent of Normal—Snowpack Water Content/Total Precipitation (Percent)

3A--Carson River Basin--Precipitation Summary

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97 [1]

NRCS SNOTEL Sites	SNOTEL Site Elevation (feet MSL) [2]	Change in Precipitation (Inches)	Change in Snowpack Water Content (Inches)	Precipitation/ Snowpack Difference (Inches) [3]
Ebbetts Pass:	8,700			
December 16-23, 1996........................		5.6	6.3	**-0.7**
December 30, 1996-January 6, 1997..		16.8	4.8	**12.0**
Monitor Pass:	8,350			
December 16-23, 1996........................		3.4	3.7	**-0.3**
December 30, 1996-January 6, 1997..		4.5	0.6	**3.9**
Poison Flat:	7,900			
December 16-23, 1996........................		4.6	5.9	**-1.3**
December 30, 1996-January 6, 1997..		10.3	-0.7	**11.0**
Spratt Creek:	6,200			
December 16-23, 1996........................		2.3	3.4	**-1.1**
December 30, 1996-January 6, 1997..		8.8	-2.4	**11.2**

[1] December 16, 1996--December 23, 1996 was a heavy snowfall event with significant additions to snowpack water content; December 30, 1996--January 6, 1997 was a heavy, warm rainfall event with significant runoff and snowpack depletion.

[2] MSL = Above mean sea level.

[3] Positive values for column entries under "Precipitation/Snowpack Difference" reflect available runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

Table Interpretation: Entries under "Change in Precipitation" and "Change in Snowpack Water Content" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time can the change in snowpack water content accumulated between dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content, are not realistic and along with values close to zero (0) should be interpreted only in the sense that the snowpack is absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle event) the effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

3B--CARSON RIVER BASIN

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97

Site		Precipitation			Snowpack Water Content			
Part I--12/16/96-12/23/96	**Elevation (feet MSL)**	**12/16/96**	**12/23/96**	**Change (inches of water)**	**12/16/96**	**12/23/96**	**Change (inches of water)**	**Precipitation/ Snowpack Difference [1]**
Ebbetts Pass....................	8,700	22.2	27.8	5.6	17.2	23.5	6.3	**-0.7**
Percent of Normal		148%	164%		167%	193%		
Monitor Pass....................	8,350	8.0	11.4	3.4	5.9	9.6	3.7	**-0.3**
Percent of Normal		--	--		--	--		
Poison Flat.......................	7,900	14.2	18.8	4.6	9.6	15.5	5.9	**-1.3**
Percent of Normal		139%	168%		155%	212%		
Spratt Creek....................	6,200	14.8	17.1	2.3	0.0	3.4	3.4	**-1.1**
Percent of Normal		155%	161%		0%	155%		
Part II--12/30/96-01/06/97	**Elevation (feet MSL)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**Precipitation/ Snowpack Difference [1]**
Ebbetts Pass....................	8,700	31.9	48.7	16.8	28.4	33.2	4.8	**12.0**
Percent of Normal		168%	231%		201%	206%		
Monitor Pass....................	8,350	12.9	17.4	4.5	11.8	12.4	0.6	**3.9**
Percent of Normal		--	--		--	--		
Poison Flat.......................	7,900	21.0	31.3	10.3	18.0	17.3	(0.7)	**11.0**
Percent of Normal		172%	234%		217%	182%		
Spratt Creek....................	6,200	20.0	28.8	8.8	2.6	0.2	(2.4)	**11.2**
Percent of Normal		169%	222%		100%	6%		

3B--CARSON RIVER BASIN

For the Entire Period: 12/16/96--01/06/97

Site		Precipitation			Snowpack Water Content			
Part III--12/16/96-01/06/97	Elevation (feet MSL)	12/16/96	01/06/97	Change (inches of water)	12/16/96	01/06/97	Change (inches of water)	Precipitation/ Snowpack Difference [1]
Ebbetts Pass....................	8,350	22.2	48.7	26.5	17.2	33.2	16.0	**10.5**
Percent of Normal		148%	231%		167%	206%		
Monitor Pass....................	7,900	8.0	17.4	9.4	5.9	12.4	6.5	**2.9**
Percent of Normal		--	--		--	--		
Poison Flat.......................	6,200	14.2	31.3	17.1	9.6	17.3	7.7	**9.4**
Percent of Normal		139%	234%		155%	182%		
Spratt Creek.....................	0	14.8	28.8	14.0	0.0	0.2	0.2	**13.8**
Percent of Normal		155%	222%		0%	6%		

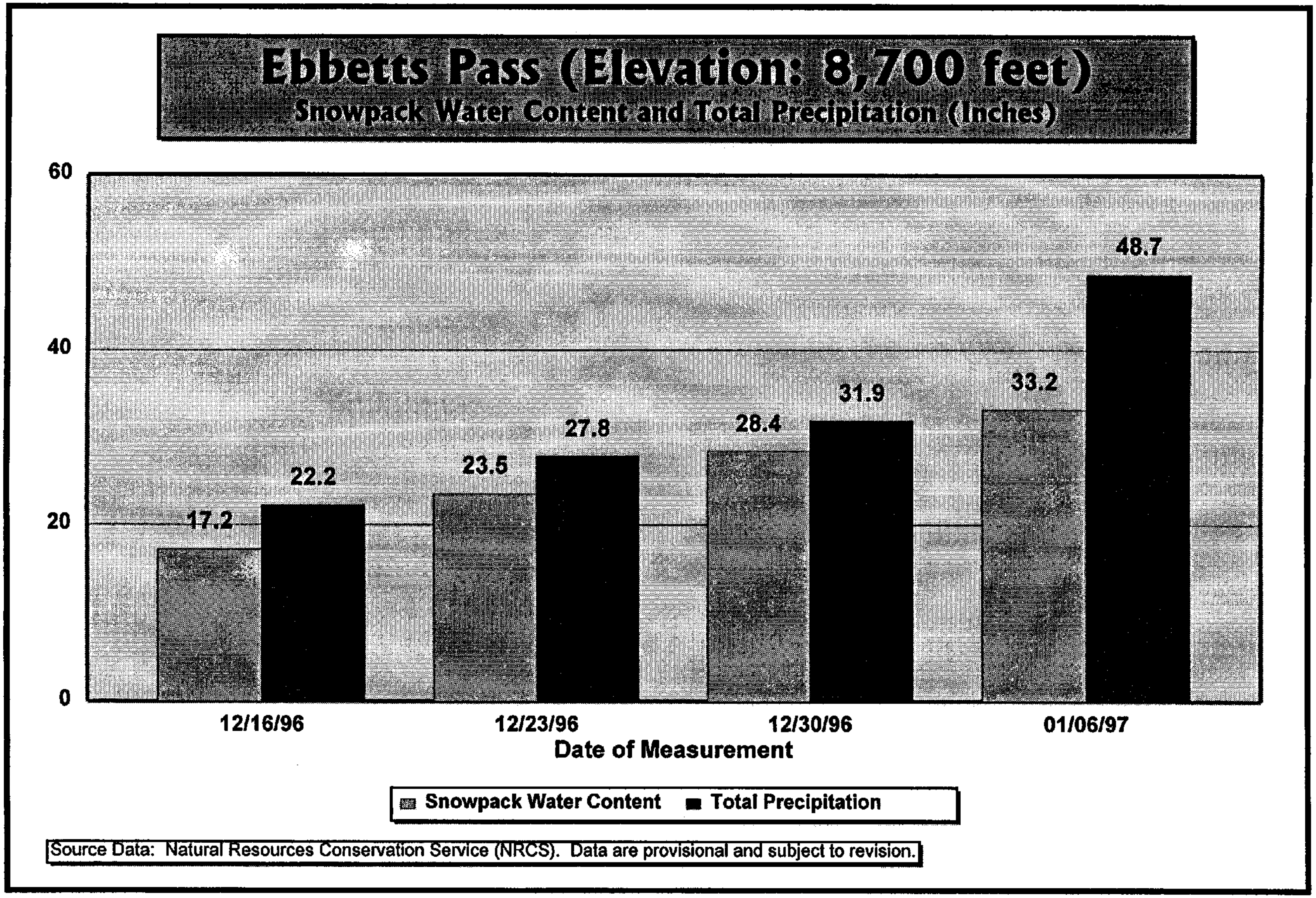
[1] Positive values for column entries under "Precipitation/Snowpack Difference" reflect direct runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

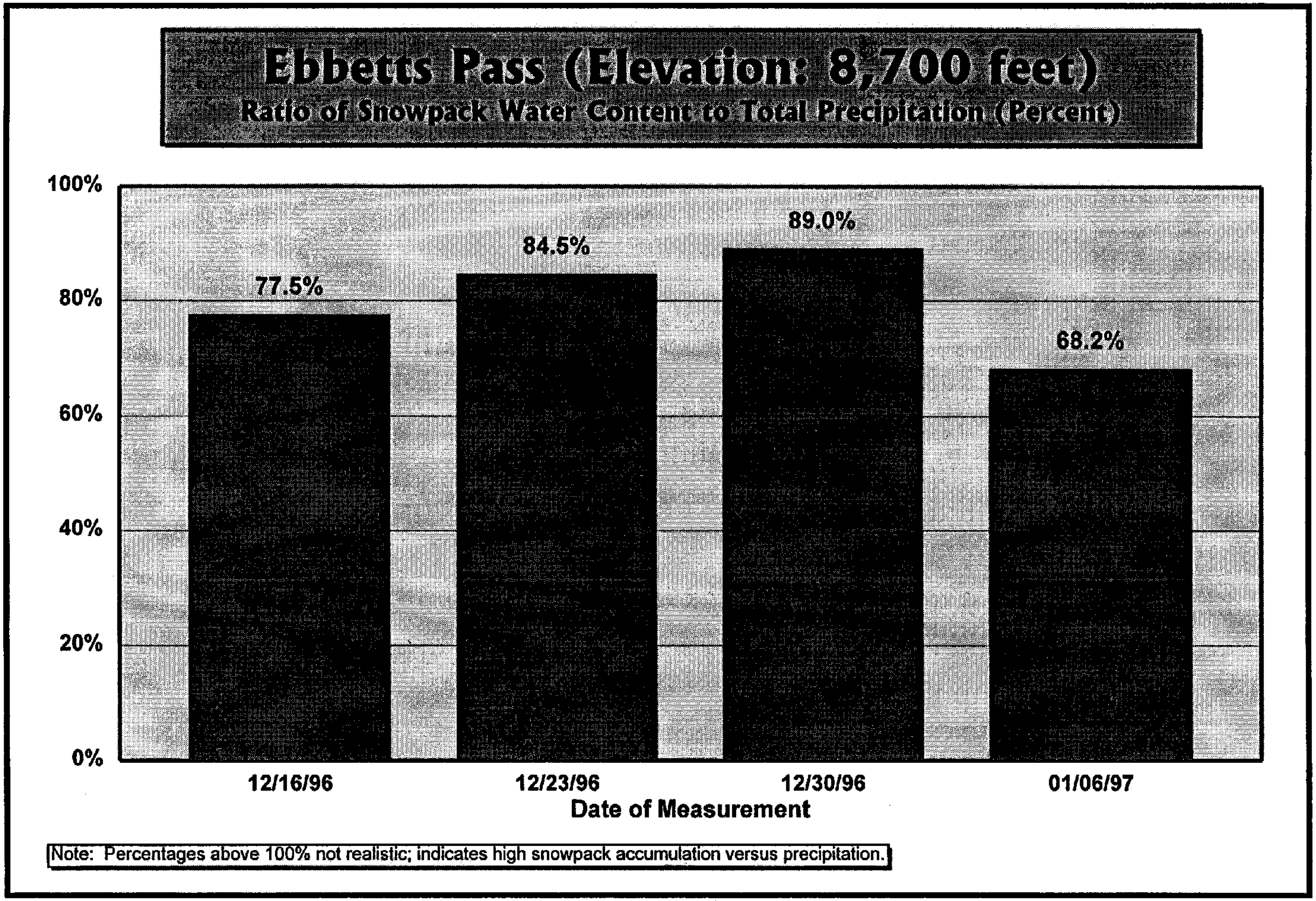
MSL = Above mean sea level.

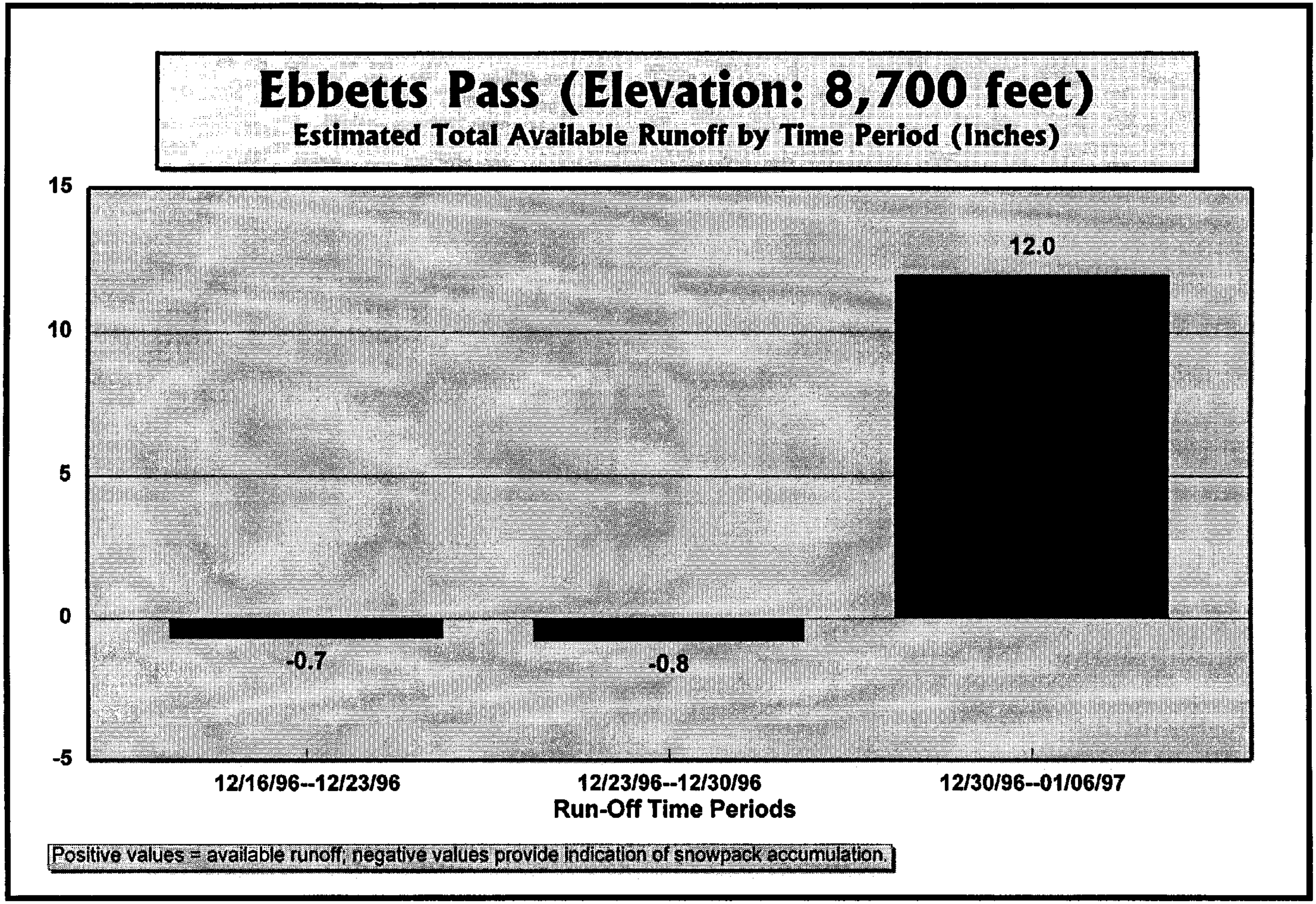
NOTE: Entries showing a "--" indicate no comparable "Percent of Normal" has been established.

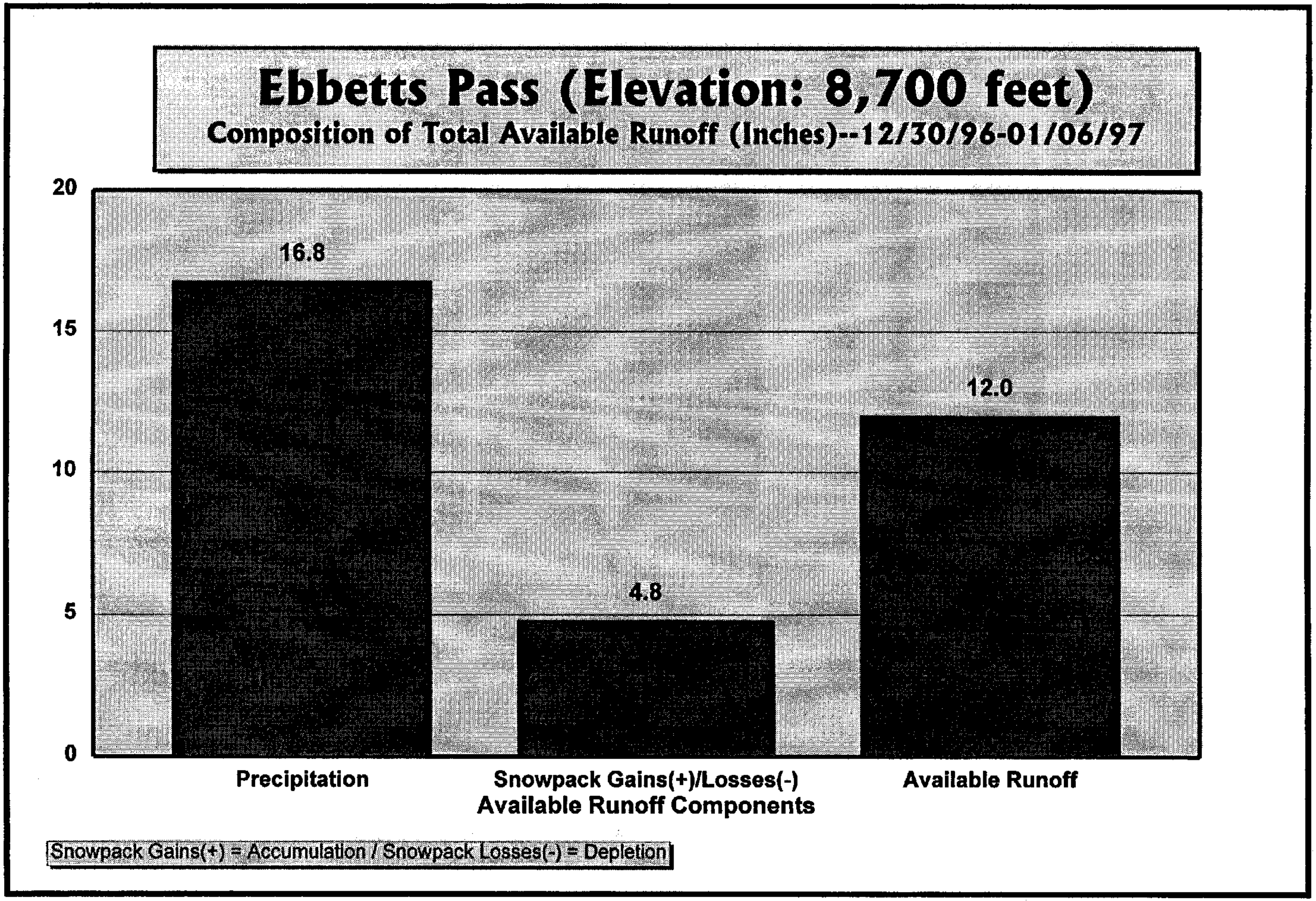
Table Interpretation: Entries under "Precipitation Change" and "Snowpack Water Content Change" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time should the change in snowpack water content accumulated between two dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content are therefore not realistic and should be interpreted only in the sense that the snowpack appears to be absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle) effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

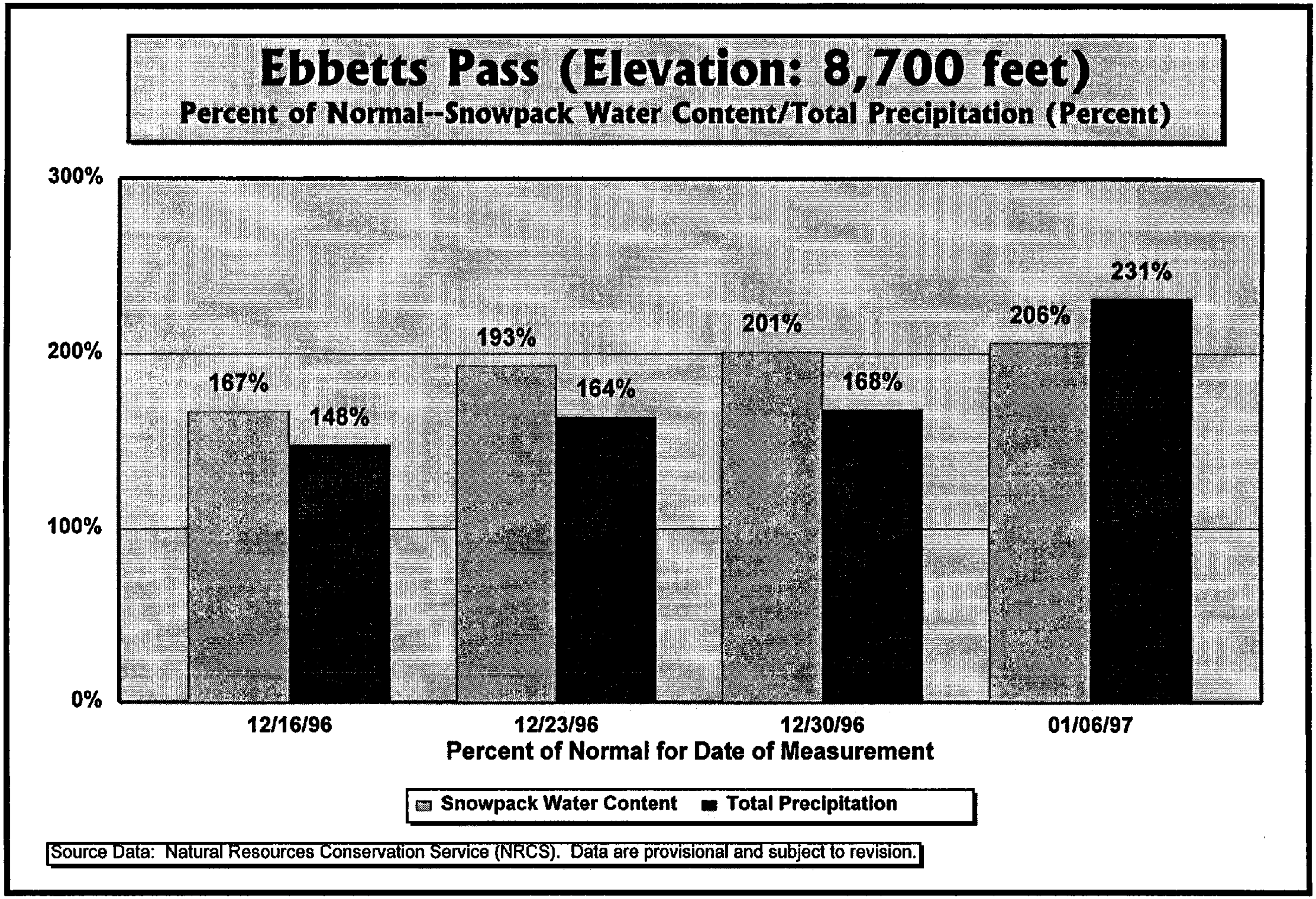

Ebbetts Pass (Elevation: 8,700 feet)
Snowpack Water Content and Total Precipitation (Inches)
60
40
20
0
17.2
22.2
23.5
27.8
28.4
31.9
33.2
48.7
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Ebbetts Pass (Elevation: 8,700 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
100%
80%
60%
40%
20%
0%
77.5%
84.5%
89.0%
68.2%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

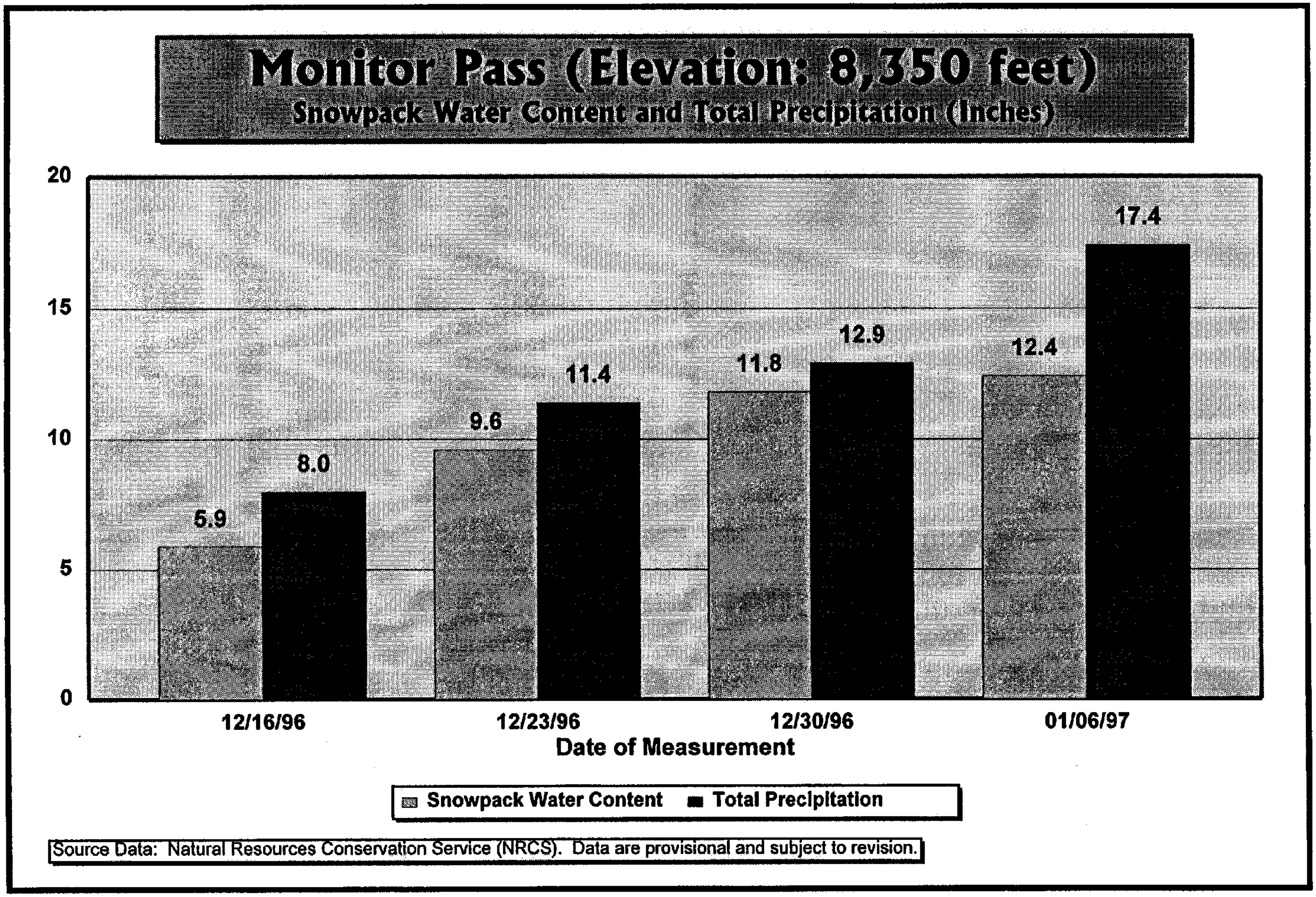

Ebbetts Pass (Elevation: 8,700 feet)
Estimated Total Available Runoff by Time Period (Inches)
15
10
5
0
-5
12.0
-0.7
-0.8
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

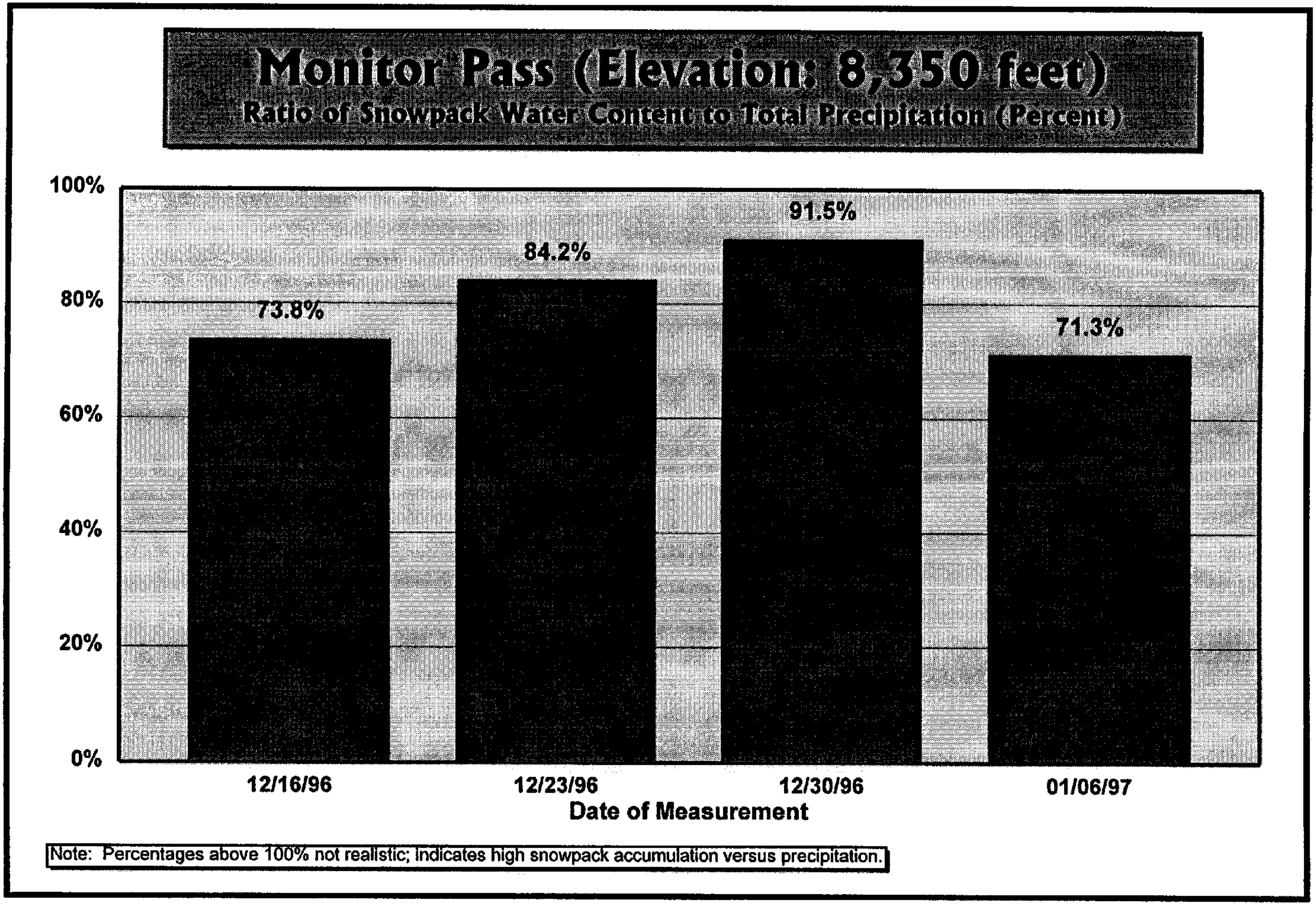


Ebbetts Pass (Elevation: 8,700 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
15
10
5
0
16.8
4.8
12.0
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

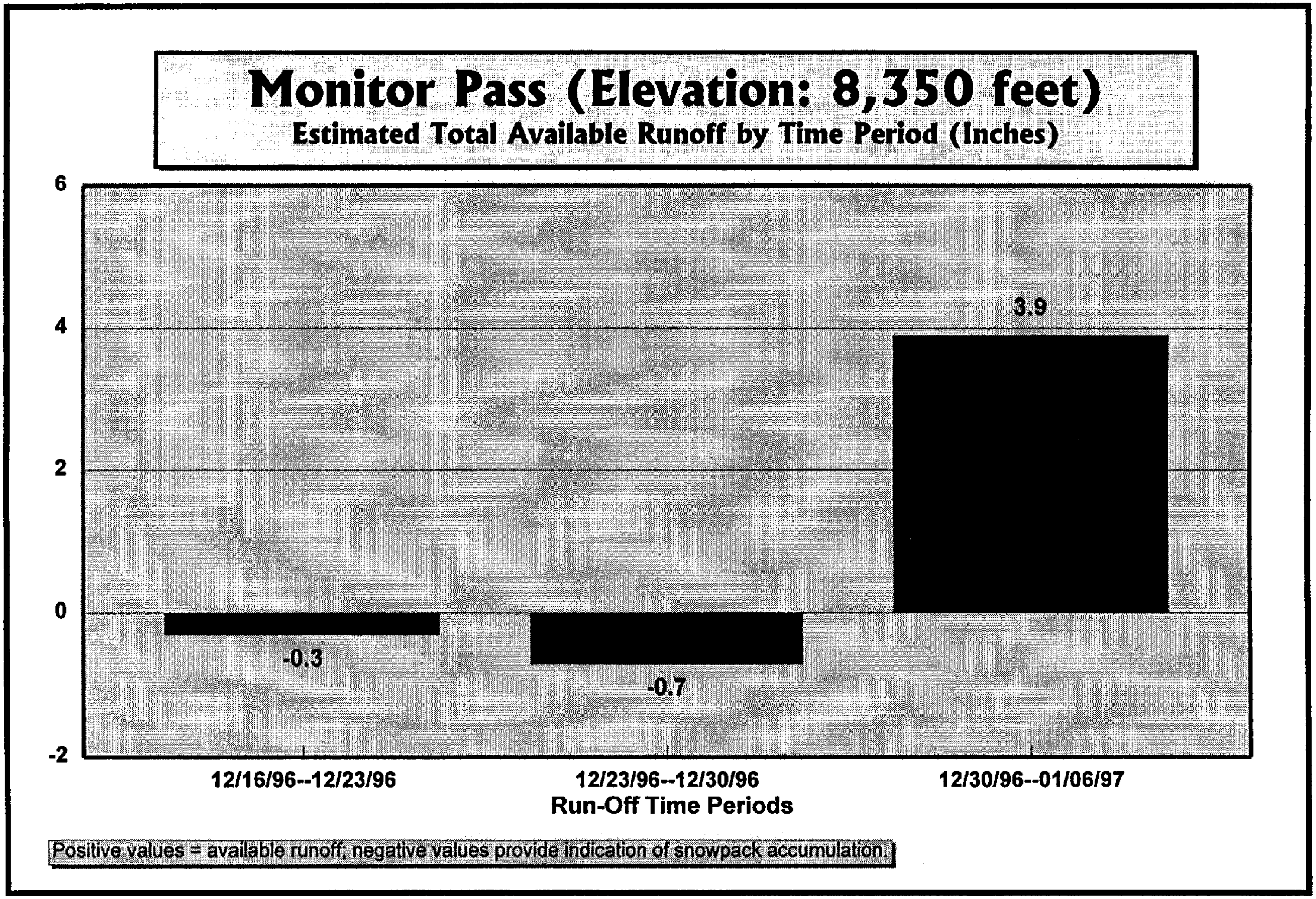


Ebbetts Pass (Elevation: 8,700 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
167%
148%
193%
164%
201%
168%
206%
231%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

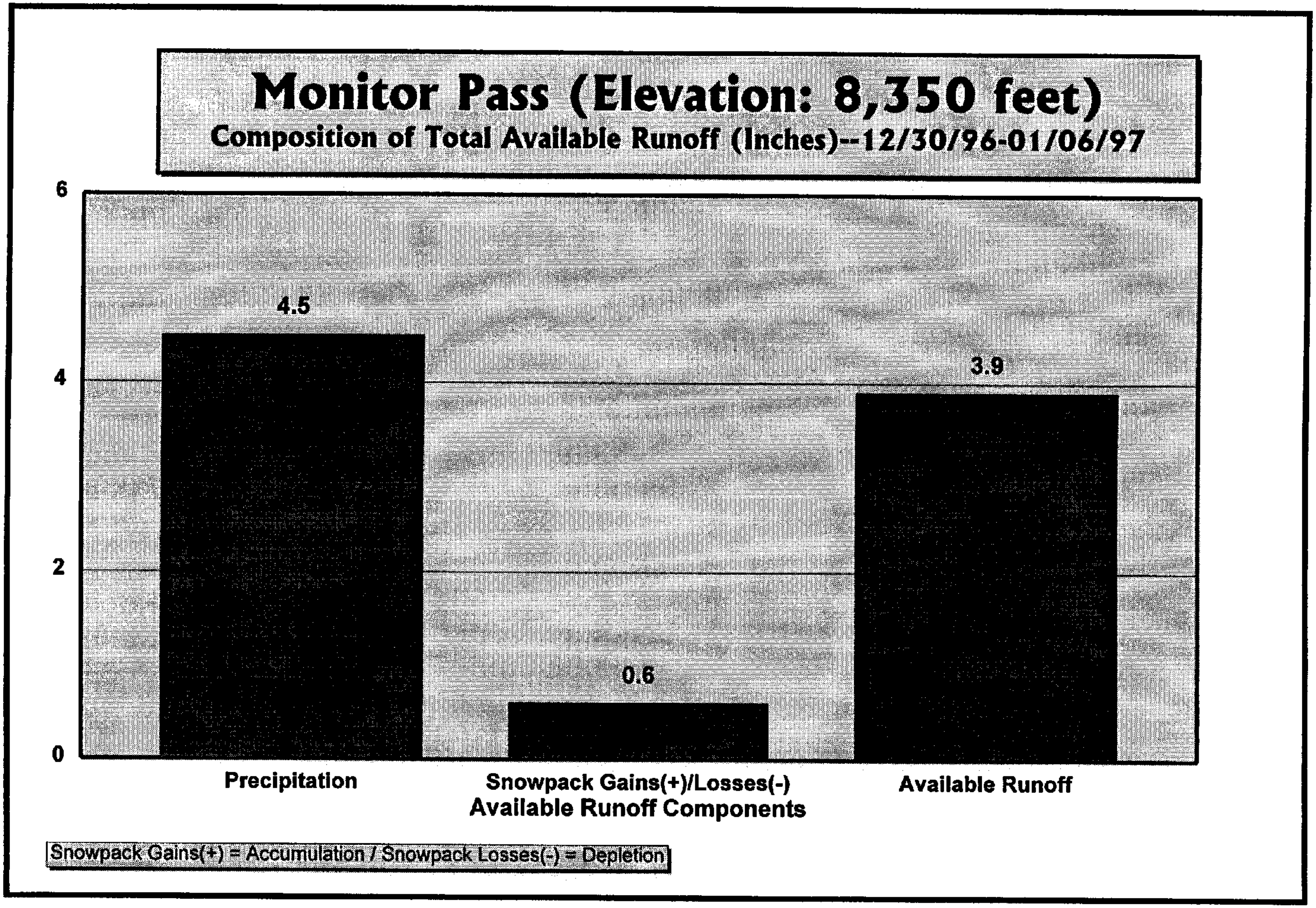

Monitor Pass (Elevation: 8,350 feet)
Snowpack Water Content and Total Precipitation (Inches)
20
15
10
5
0
5.9
8.0
9.6
11.4
11.8
12.9
12.4
17.4
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.



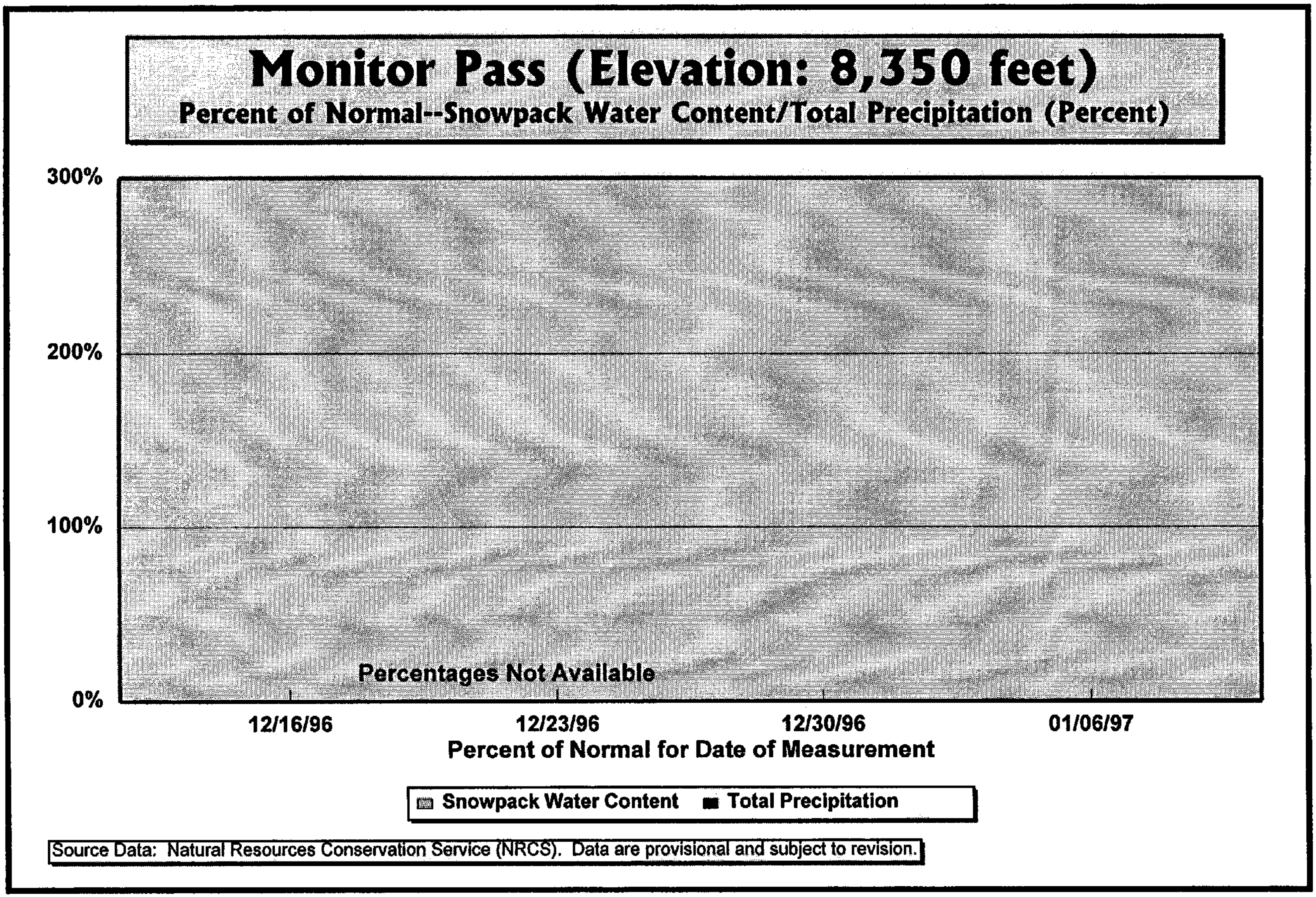
Monitor Pass (Elevation: 8,350 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
100%
80%
60%
40%
20%
0%
73.8%
84.2%
91.5%
71.3%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

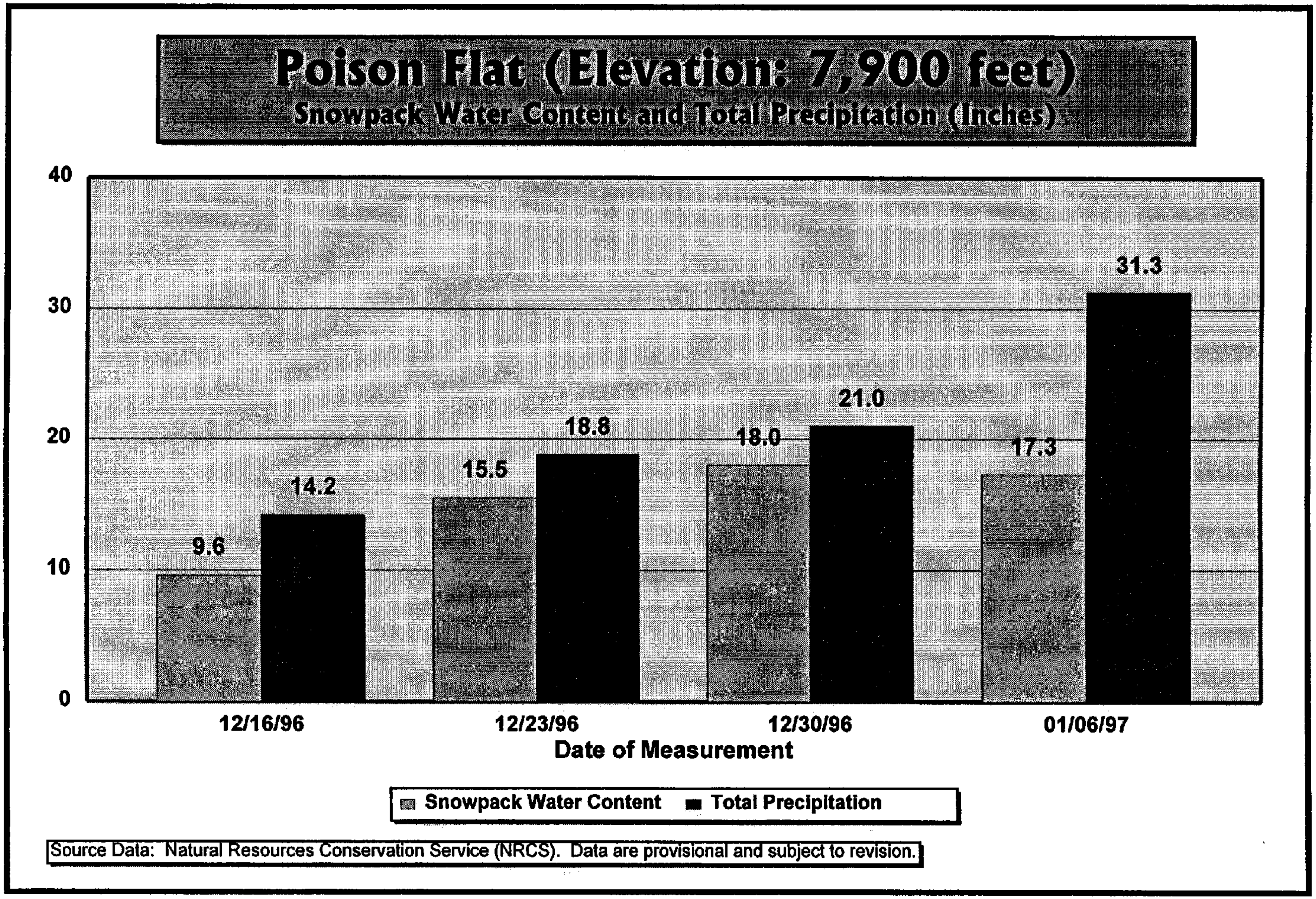


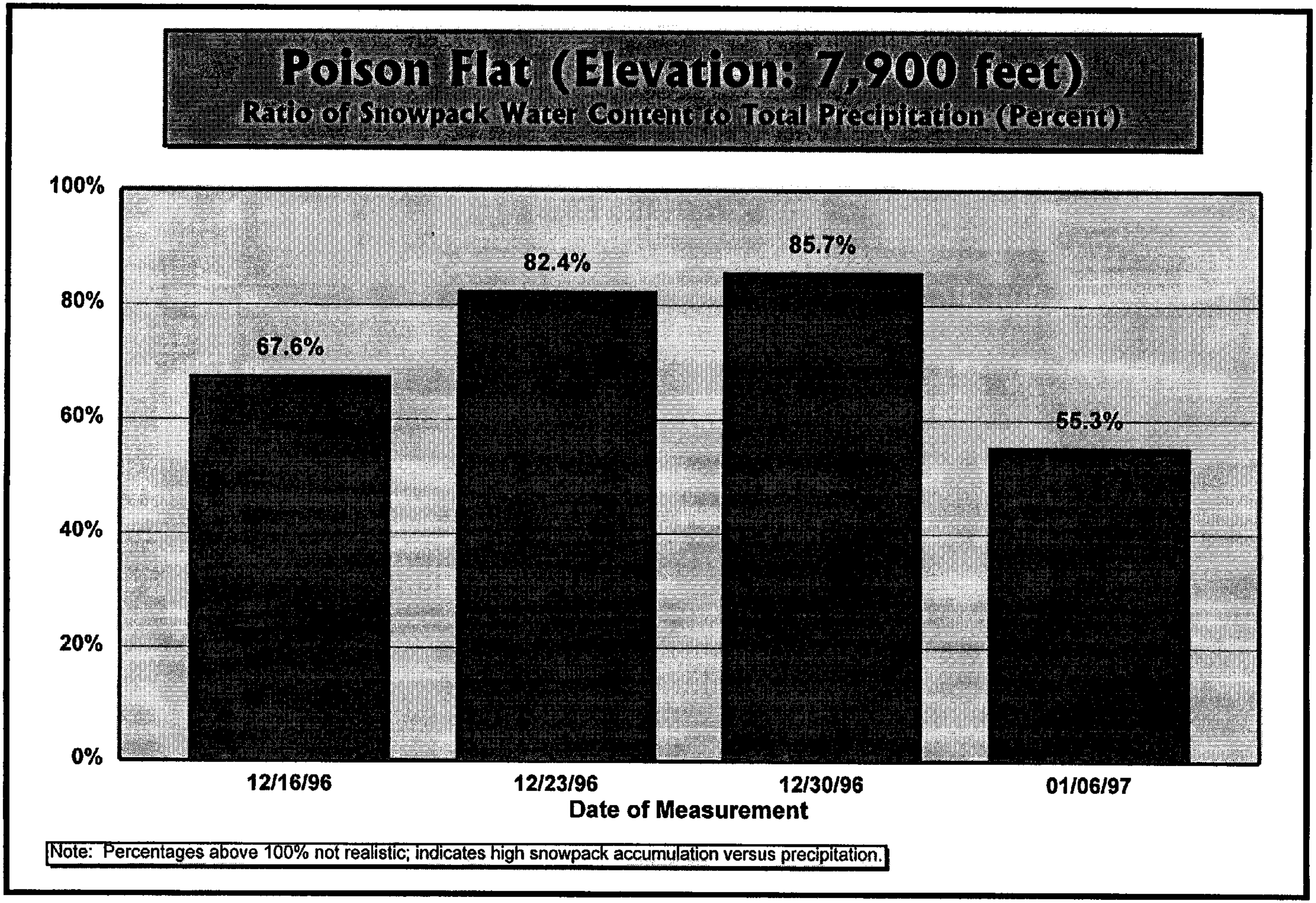
Monitor Pass (Elevation: 8,350 feet)
Estimated Total Available Runoff by Time Period (Inches)
6
4
2
0
-2
3.9
-0.3
-0.7
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

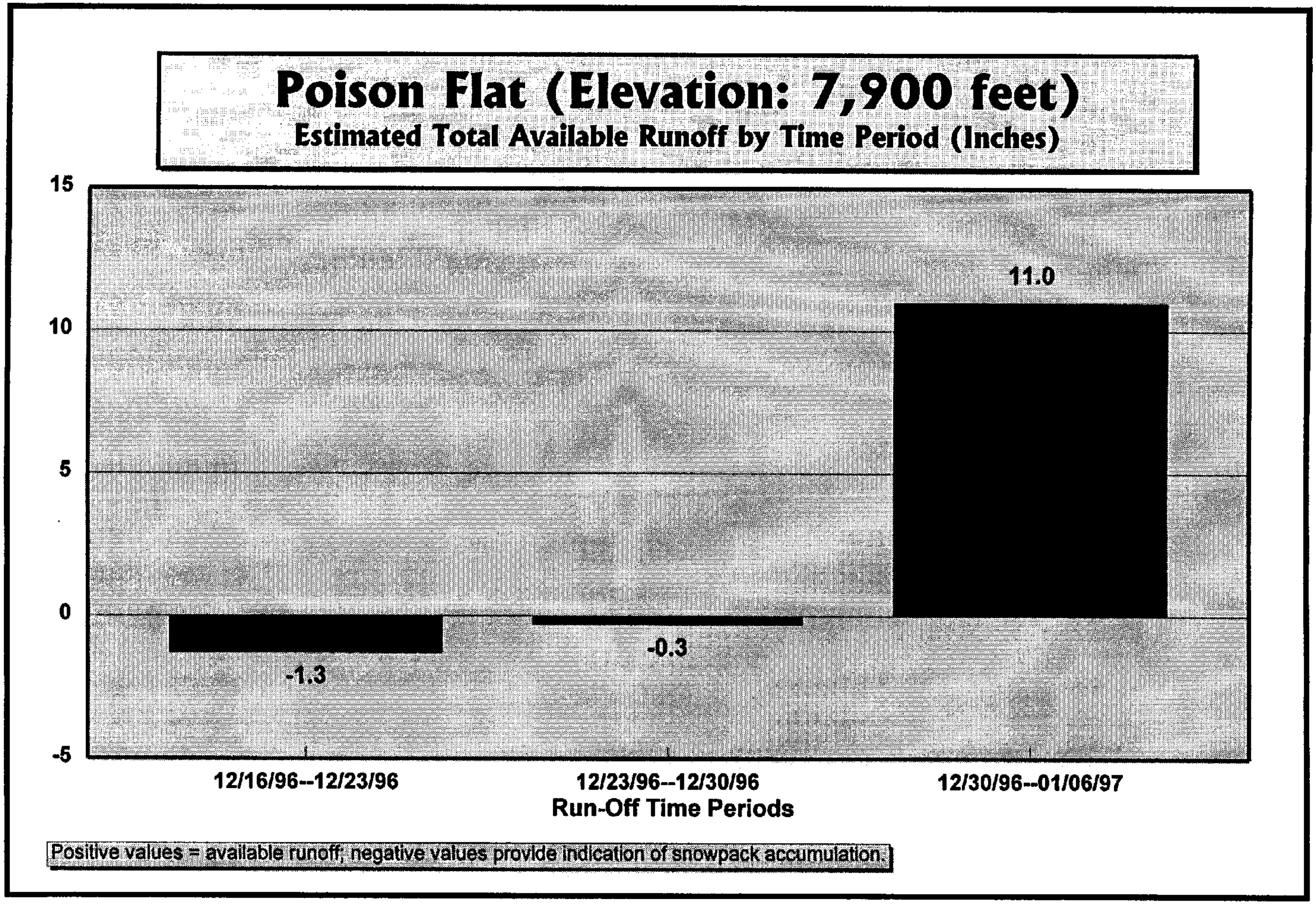


Monitor Pass (Elevation: 8,350 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
6
4
2
0
4.5
0.6
3.9
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

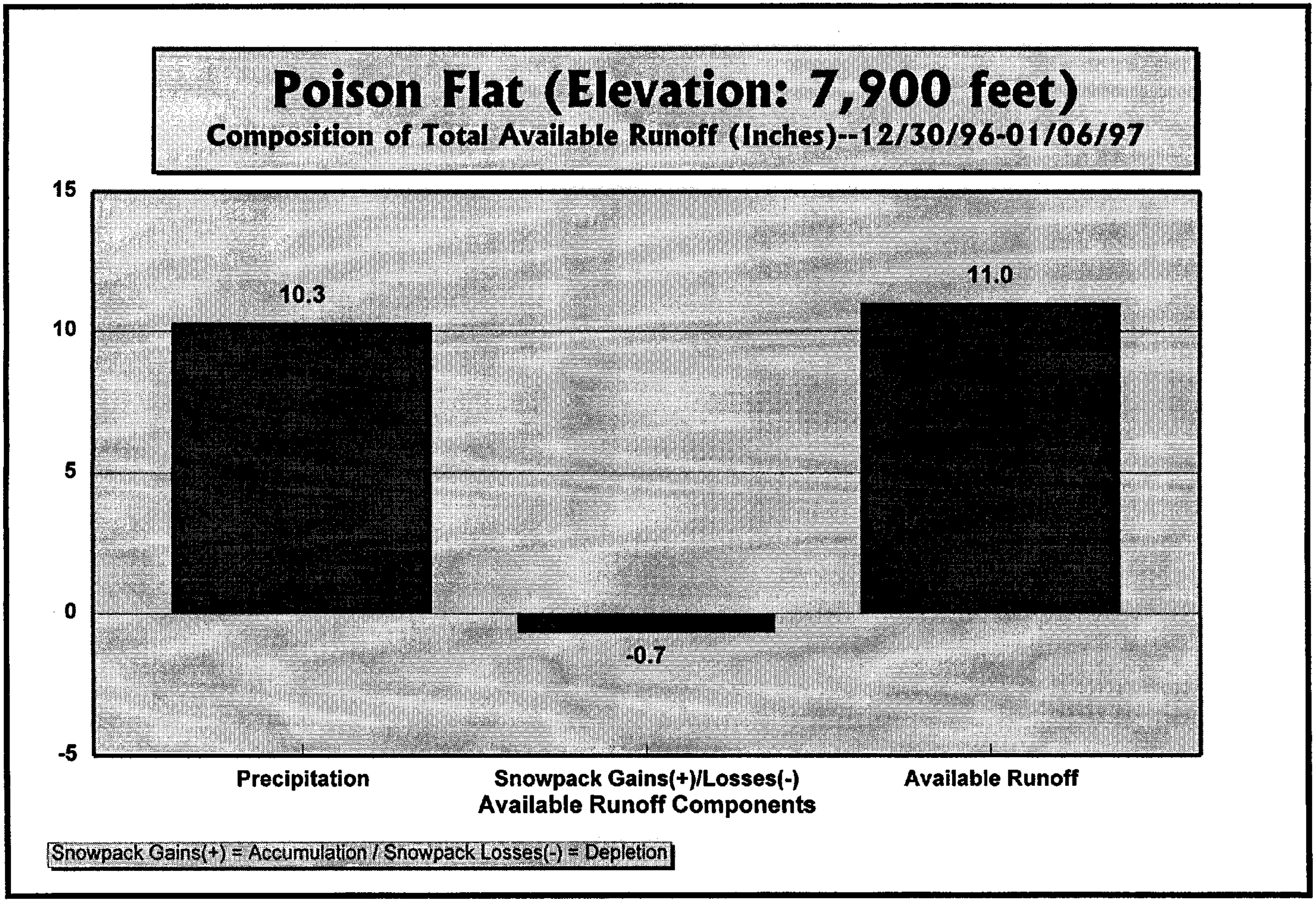

Monitor Pass (Elevation: 8,350 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
Percentages Not Available
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

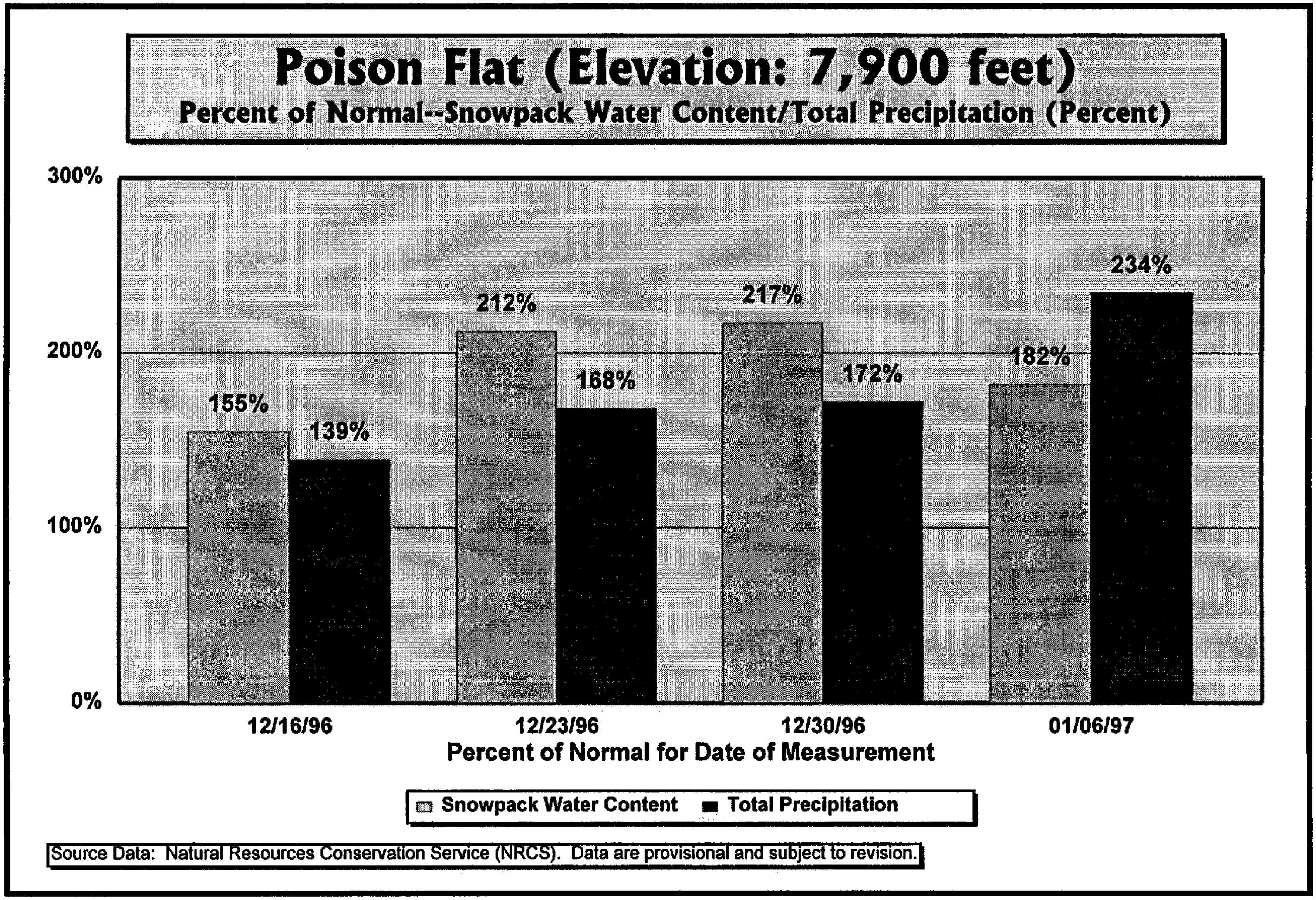

Poison Flat (Elevation: 7,900 feet)
Snowpack Water Content and Total Precipitation (Inches)
40
30
20
10
0
9.6
14.2
15.5
18.8
18.0
21.0
17.3
31.3
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

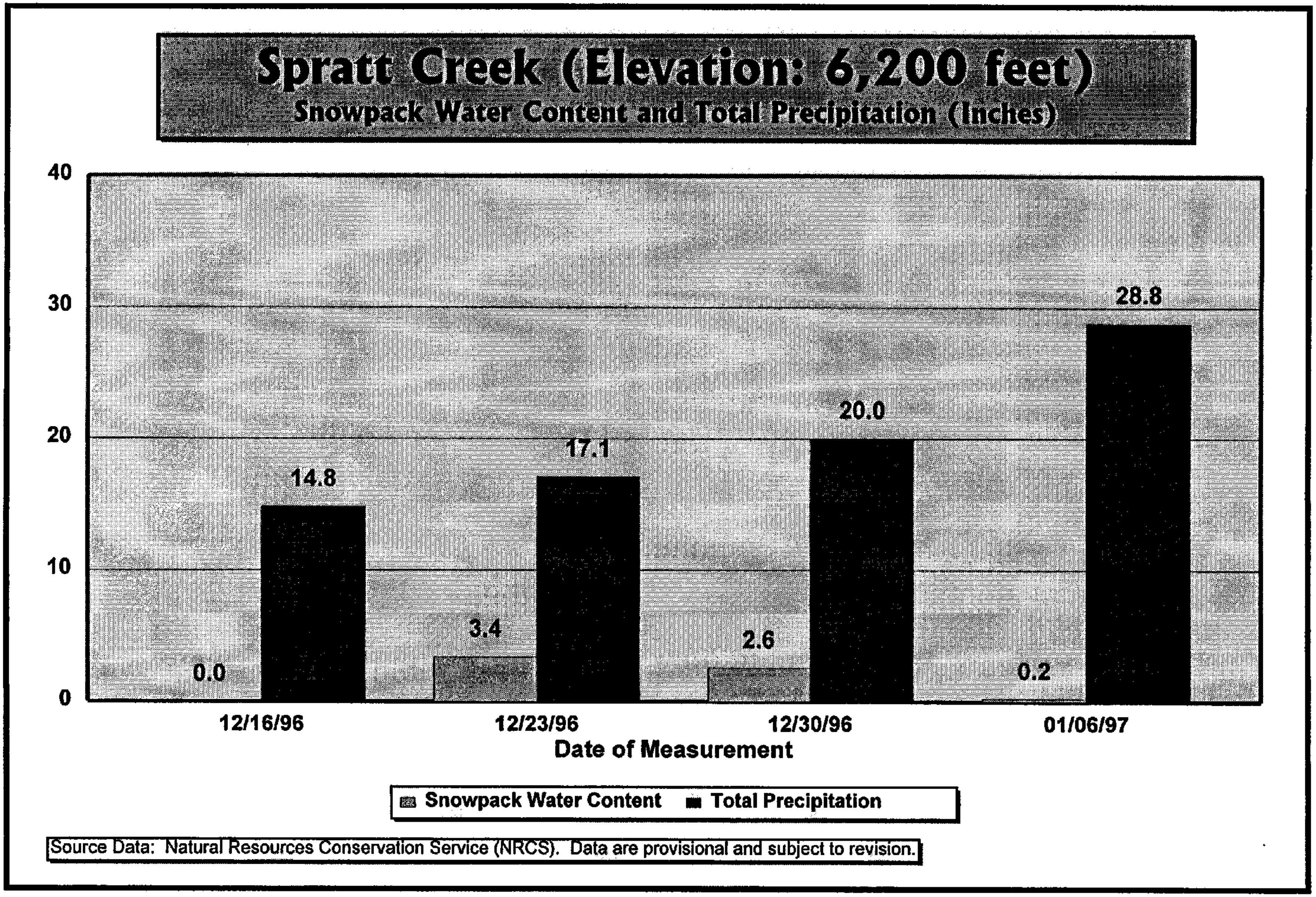

Poison Flat (Elevation: 7,900 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
100%
80%
60%
40%
20%
0%
67.6%
82.4%
85.7%
55.3%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.



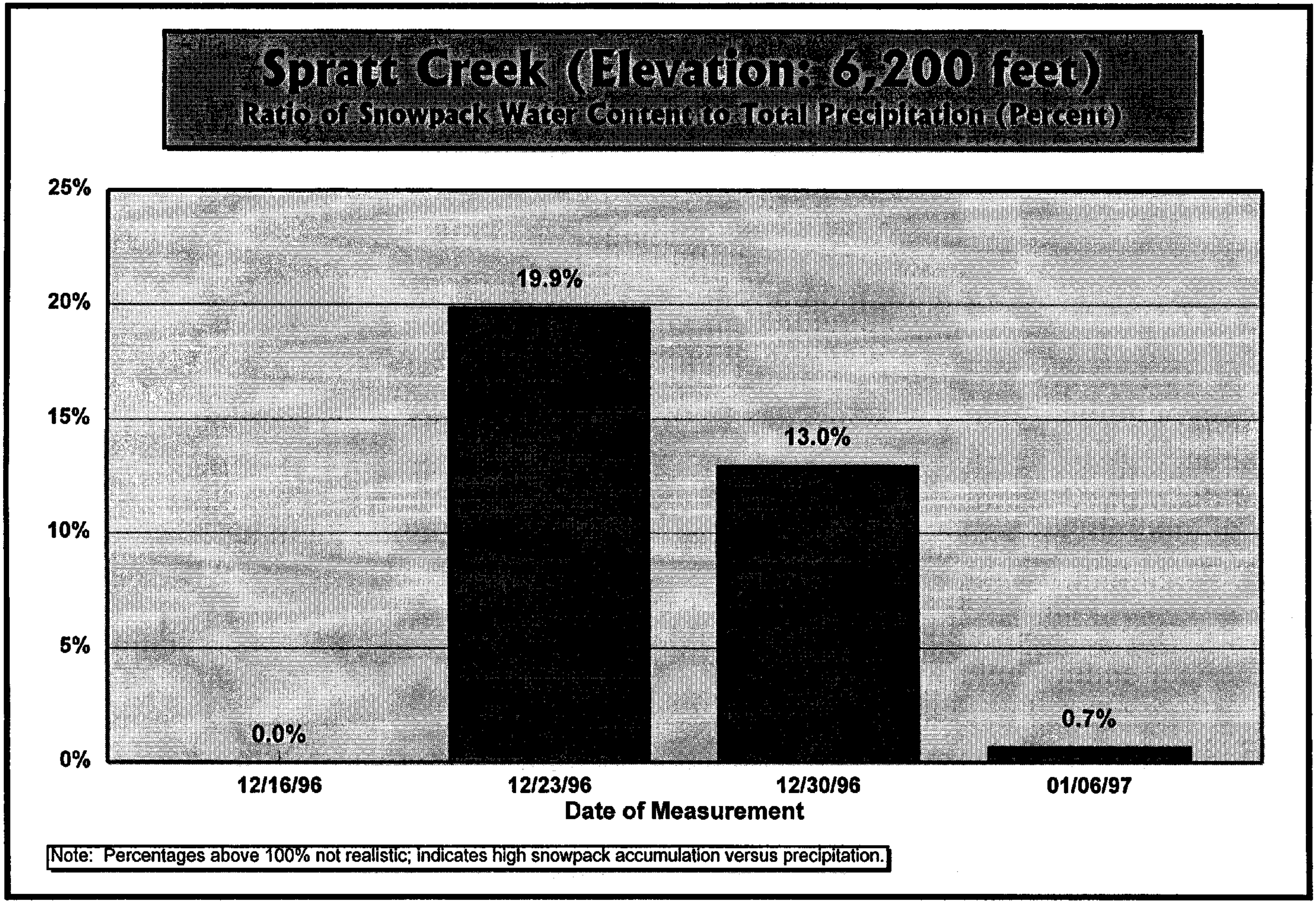
Poison Flat (Elevation: 7,900 feet)
Estimated Total Available Runoff by Time Period (Inches)
15
10
5
0
-5
11.0
-1.3
-0.3
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.


Poison Flat (Elevation: 7,900 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
15
10
5
0
-5
10.3
-0.7
11.0
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

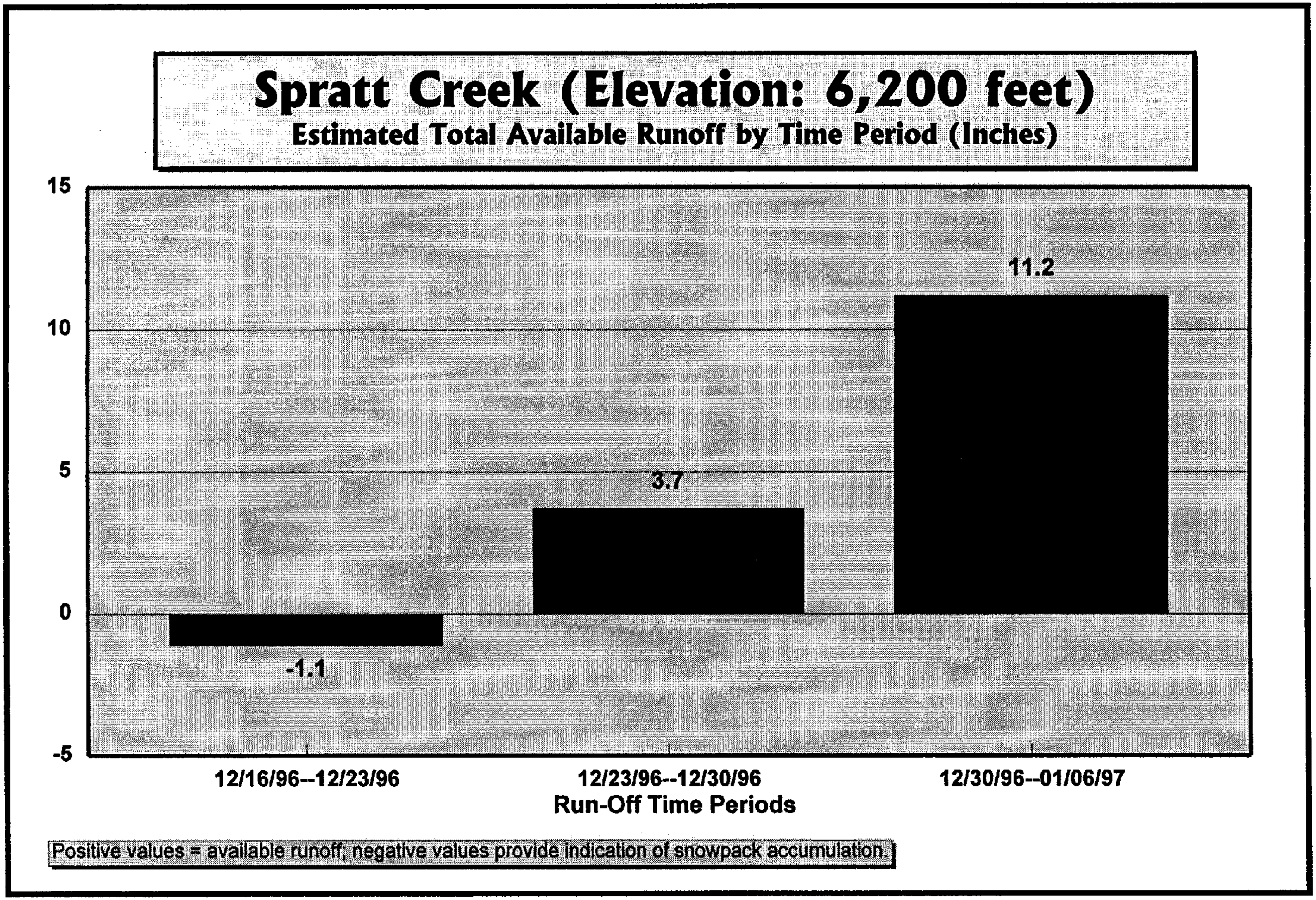

Poison Flat (Elevation: 7,900 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
155%
139%
212%
168%
217%
172%
182%
234%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.



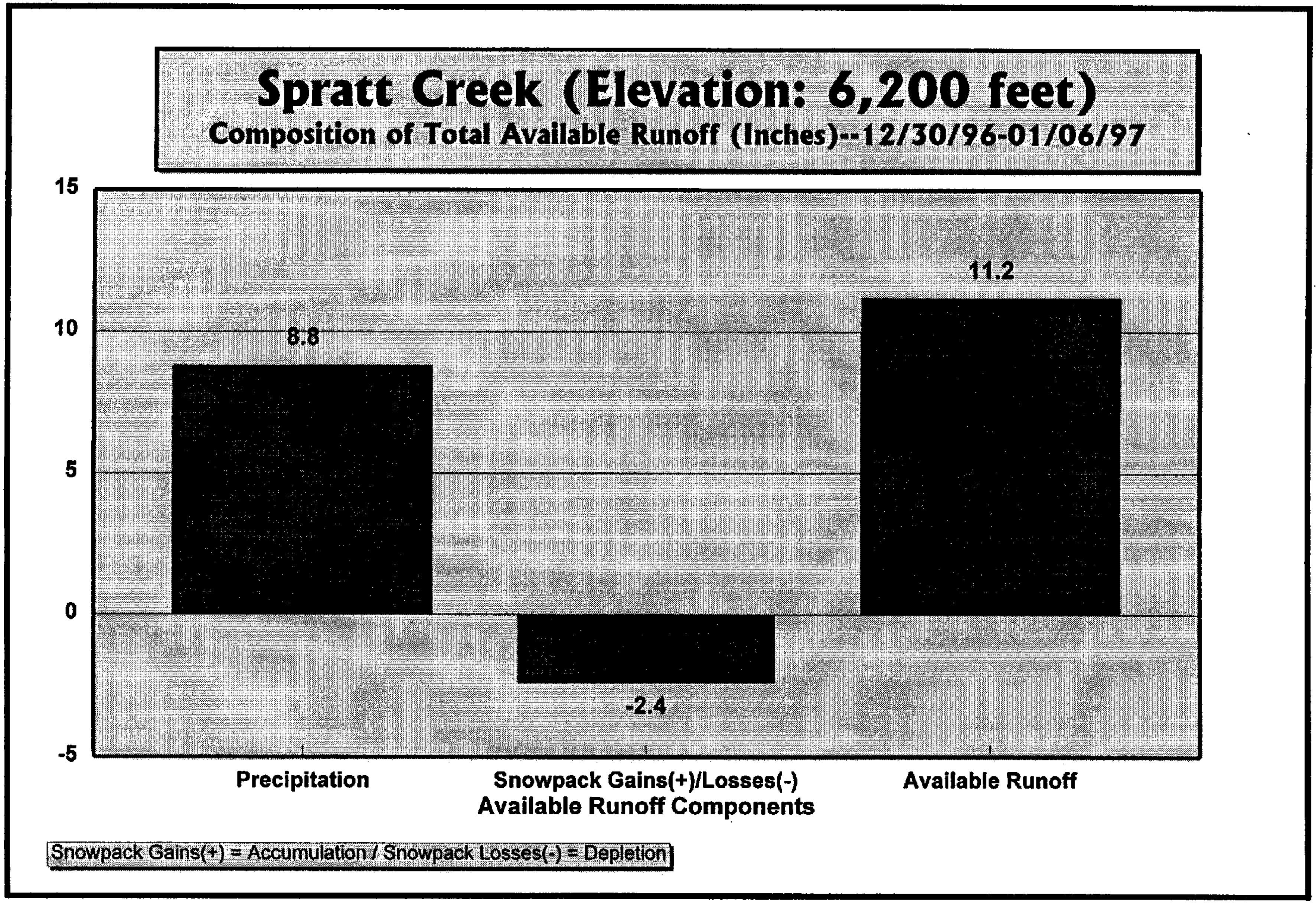
Spratt Creek (Elevation: 6,200 feet)
Snowpack Water Content and Total Precipitation (Inches)
40
30
20
10
0
0.0
14.8
3.4
17.1
2.6
20.0
0.2
28.8
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

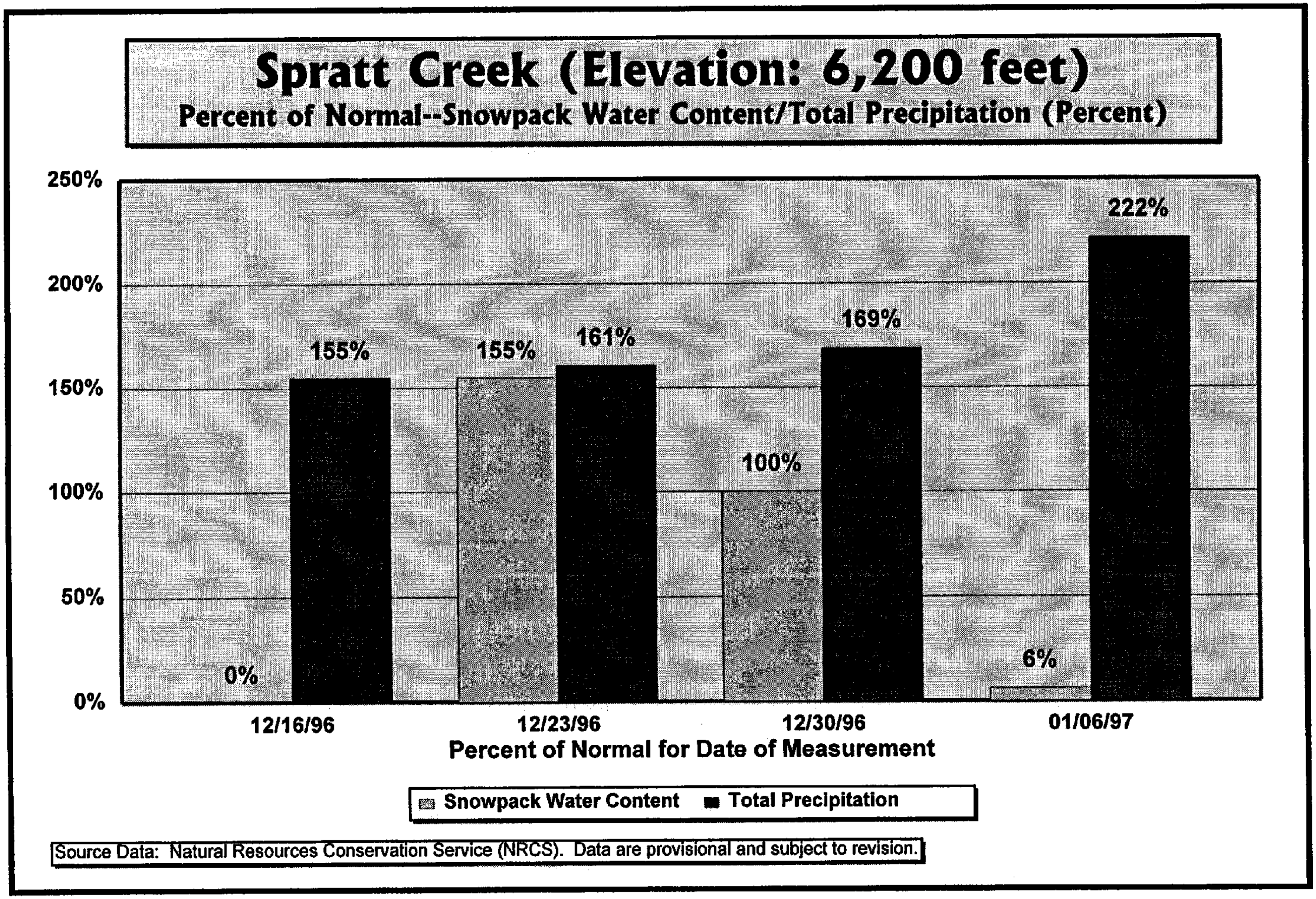


Spratt Creek (Elevation: 6,200 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
25%
20%
15%
10%
5%
0%
0.0%
19.9%
13.0%
0.7%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.



Spratt Creek (Elevation: 6,200 feet)
Estimated Total Available Runoff by Time Period (Inches)
15
10
5
0
-5
11.2
3.7
-1.1
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.


Spratt Creek (Elevation: 6,200 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
15
10
5
0
-5
8.8
-2.4
11.2
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion


Spratt Creek (Elevation: 6,200 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
250%
200%
150%
100%
50%
0%
0%
155%
155%
161%
100%
169%
6%
222%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

Appendix E

Walker River Basin

NRCS SNOTEL Sites

Virginia Lakes Ridge
Leavitt Lake
Lobdell Lake
Sonora Pass [2]
Leavitt Meadows

Tables

4A. Precipitation Summary

4B. Comparisons of Changes in Precipitation and Snowpack Water Content

Part I—12/16/96–12/23/96

Part II—12/30/96–01/06/97

Part III—12/16/96–01/06/97

Graphs

Snowpack Water Content and Total Precipitation (Inches)

Ratio of Snowpack Water Content and Total Precipitation (Percent)

Estimated Total Available Runoff by Time Period (Inches)

Composition of Total Available Runoff (Inches)—12/30/96–01/06/97

Percent of Normal—Snowpack Water Content/Total Precipitation (Percent)

4A--Walker River Basin--Precipitation Summary

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97 [1]

NRCS SNOTEL Sites	SNOTEL Site Elevation (feet MSL) [2]	Change in Precipitation (Inches)	Change in Snowpack Water Content (Inches)	Precipitation/ Snowpack Difference (Inches) [3]
Virginia Lakes Ridge:	9,200			
December 16-23, 1996........................		4.9	5.6	**-0.7**
December 30, 1996-January 6, 1997..		6.4	1.0	**5.4**
Leavitt Lake:	9,400			
December 16-23, 1996........................		4.6	9.2	**-4.6**
December 30, 1996-January 6, 1997..		15.4	6.5	**8.9**
Lobdell Lake:	9,200			
December 16-23, 1996........................		4.3	4.4	**-0.1**
December 30, 1996-January 6, 1997..		3.6	2.4	**1.2**
Sonora Pass [2]:	8,800			
December 16-23, 1996........................		4.2	-1.9	**6.1**
December 30, 1996-January 6, 1997..		10.8	4.7	**6.1**
Leavitt Meadows:	7,200			
December 16-23, 1996........................		3.5	2.8	**0.7**
December 30, 1996-January 6, 1997..		9.7	-4.1	**13.8**

[1] December 16, 1996--December 23, 1996 was a heavy snowfall event with significant additions to snowpack water content; December 30, 1996--January 6, 1997 was a heavy, warm rainfall event with significant runoff and snowpack depletion.

[2] MSL = Above mean sea level.

[3] Positive values for column entries under "Precipitation/Snowpack Difference" reflect available runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

Table Interpretation: Entries under "Change in Precipitation" and "Change in Snowpack Water Content" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time can the change in snowpack water content accumulated between dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content, are not realistic and along with values close to zero (0) should be interpreted only in the sense that the snowpack is absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle event) the effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

4B--WALKER RIVER BASIN

For the Comparative Periods: 12/16/96--12/23/96 and 12/30/96--01/06/97

Site		Precipitation			Snowpack Water Content			
Part I--12/16/96-12/23/96	**Elevation (feet MSL)**	**12/16/96**	**12/23/96**	**Change (inches of water)**	**12/16/96**	**12/23/96**	**Change (inches of water)**	**Precipitation/ Snowpack Difference [1]**
Virginia Lakes Ridge.........	9,200	13.7	18.6	4.9	12.1	17.7	5.6	**-0.7**
Percent of Normal		163%	200%		247%	311%		
Leavitt Lake.....................	9,400	28.1	32.7	4.6	31.1	40.3	9.2	**-4.6**
Percent of Normal		--	--		--	--		
Lobdell Lake....................	9,200	10.7	15.0	4.3	12.0	16.4	4.4	**-0.1**
Percent of Normal		155%	197%		267%	315%		
Sonora Pass [2]...............	8,800	17.3	21.5	4.2	14.2	12.3	(1.9)	**6.1**
Percent of Normal		152%	172%		200%	146%		
Leavitt Meadows..............	7,200	16.9	20.4	3.5	4.8	7.6	2.8	**0.7**
Percent of Normal		163%	181%		141%	185%		
Part II--12/30/96-01/06/97	**Elevation (feet MSL)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**12/30/96**	**01/06/97**	**Change (inches of water)**	**Precipitation/ Snowpack Difference [1]**
Virginia Lakes Ridge.........	9,200	19.6	26.0	6.4	19.8	20.8	1.0	**5.4**
Percent of Normal		192%	228%		305%	281%		
Leavitt Lake.....................	9,400	36.2	51.6	15.4	50.9	57.4	6.5	**8.9**
Percent of Normal		--	--		--	--		
Lobdell Lake....................	9,200	16.0	19.6	3.6	17.8	20.2	2.4	**1.2**
Percent of Normal		195%	211%		307%	297%		
Sonora Pass....................	8,800	24.0	34.8	10.8	20.1	24.8	4.7	**6.1**
Percent of Normal		175%	230%		209%	223%		
Leavitt Meadows..............	7,200	23.3	33.0	9.7	9.0	4.9	(4.1)	**13.8**
Percent of Normal		191%	248%		188%	96%		

4B--WALKER RIVER BASIN

For the Entire Period: 12/16/96--01/06/97

Site		Precipitation			Snowpack Water Content			
Part III--12/16/96-01/06/97	Elevation (feet MSL)	12/16/96	01/06/97	Change (inches of water)	12/16/96	01/06/97	Change (inches of water)	Precipitation/ Snowpack Difference [1]
Virginia Lakes Ridge.........	9,200	13.7	26.0	12.3	12.1	20.8	8.7	**3.6**
Percent of Normal		163%	228%		247%	281%		
Leavitt Lake.....................	9,400	28.1	51.6	23.5	31.1	57.4	26.3	**-2.8**
Percent of Normal		--	--		--	--		
Lobdell Lake....................	9,200	10.7	19.6	8.9	12.0	20.2	8.2	**0.7**
Percent of Normal		155%	211%		267%	297%		
Sonora Pass.....................	8,800	17.3	34.8	17.5	14.2	24.8	10.6	**6.9**
Percent of Normal		152%	230%		200%	223%		
Leavitt Meadows..............	7,200	16.9	33.0	16.1	4.8	4.9	0.1	**16.0**
Percent of Normal		163%	248%		141%	96%		

[1] Positive values for column entries under "Precipitation/Snowpack Difference" reflect direct runoff; negative values are not realistic, but do provide an indication that the snowpack was effectively absorbing a high proportion of total precipitation.

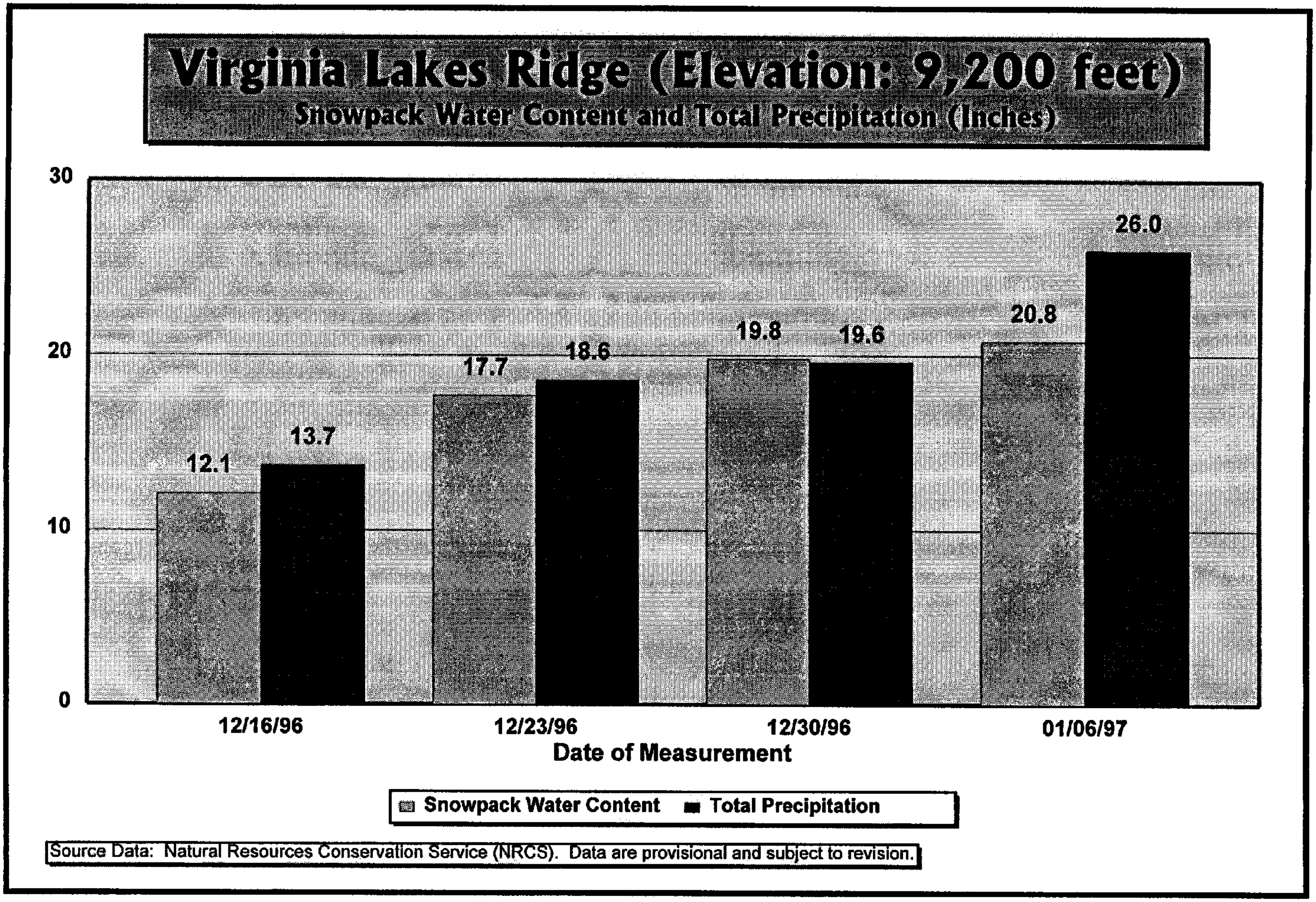
[2] Sonora Pass measuring equipment showed a malfunction for the 12/23/96 time period.

MSL = Above mean sea level.

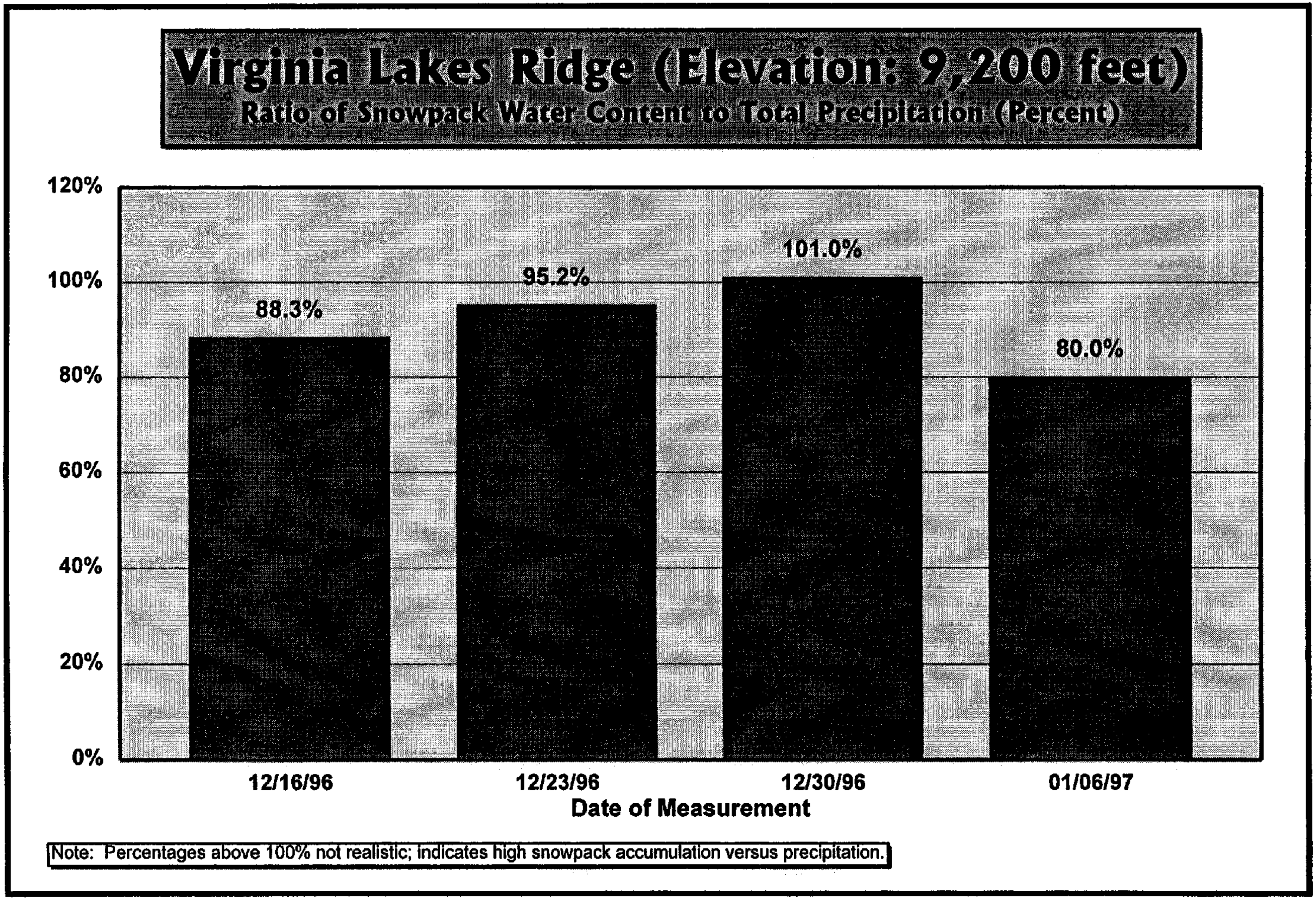
NOTE: Entries showing a "--" indicate no comparable "Percent of Normal" has been established.

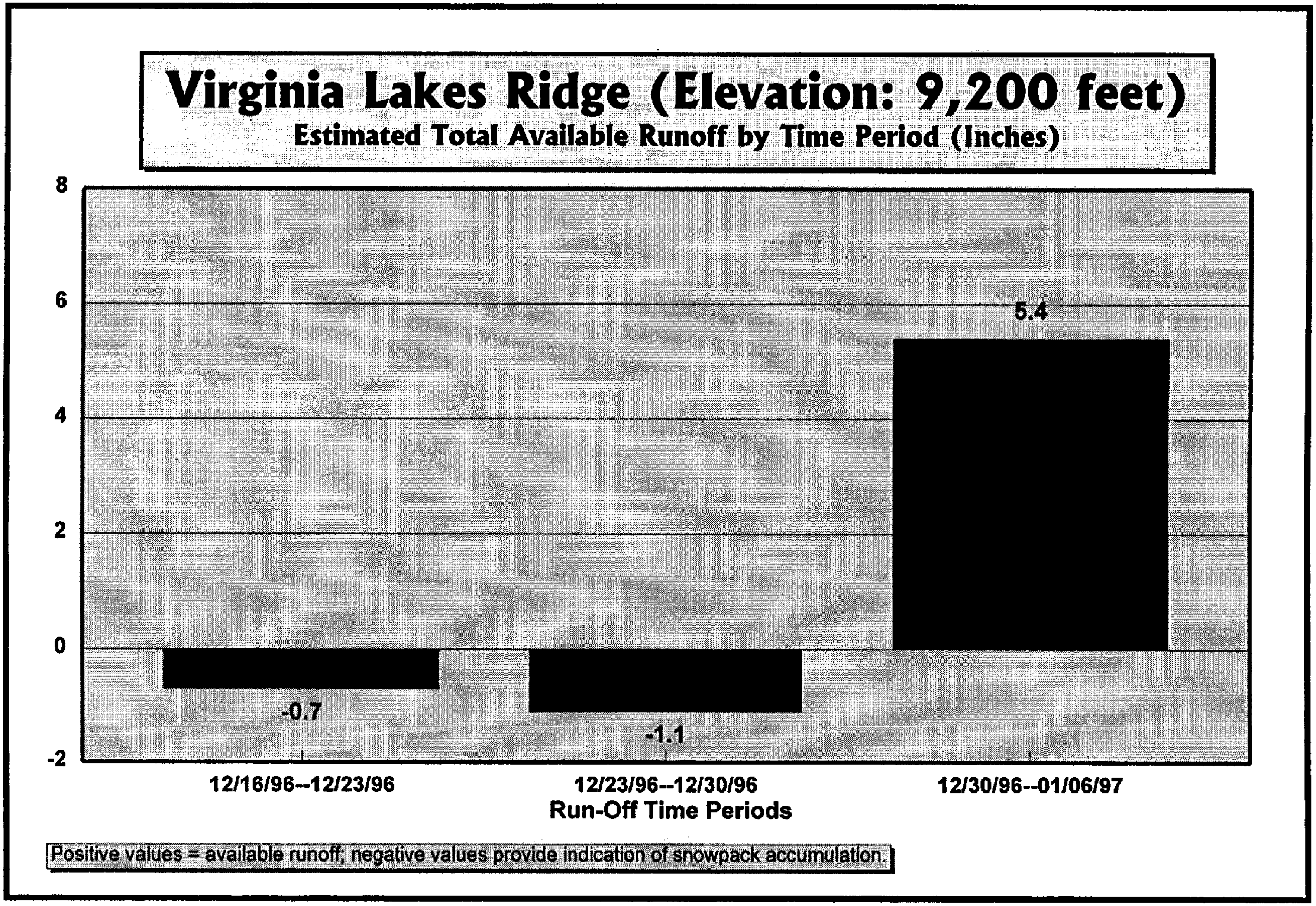
Table Interpretation: Entries under "Precipitation Change" and "Snowpack Water Content Change" provide estimates of the approximate amount of precipitation absorbed by the snowpack and the corresponding change in direct precipitation on the snowpack. Theoretically, at no time should the accumulated snowpack water content exceed the accumulated precipitation for a given date of record. Similarly, at no time should the change in snowpack water content accumulated between two dates exceed the change in precipitation between those same two dates. If such events do occur, as shown here, they may be typically attributable to the nature of the site and instances of blowing and/or drifting snow affecting snowpack readings and particularly precipitation readings. Negative values under the column "Precipitation/Snowpack Difference," which indicate that period's change in precipitation minus the change in snowpack water content are therefore not realistic and should be interpreted only in the sense that the snowpack appears to be absorbing a significant portion of the period precipitation. Large positive numbers under this column, however, are far more significant and indicate the total amount of possible, i.e., available, runoff by measuring the net effects of: (1) change in precipitation between two periods; (2) period additions/losses to snowpack water content; (3) evaporation; and (4) soil absorption. Under saturated soil conditions and normal rates of evaporation, it must be assumed that the majority of these net effects results in runoff. NRCS studies have shown that on saturated soils (wet mantle) effective runoff equals up to 80 percent of available runoff.

Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

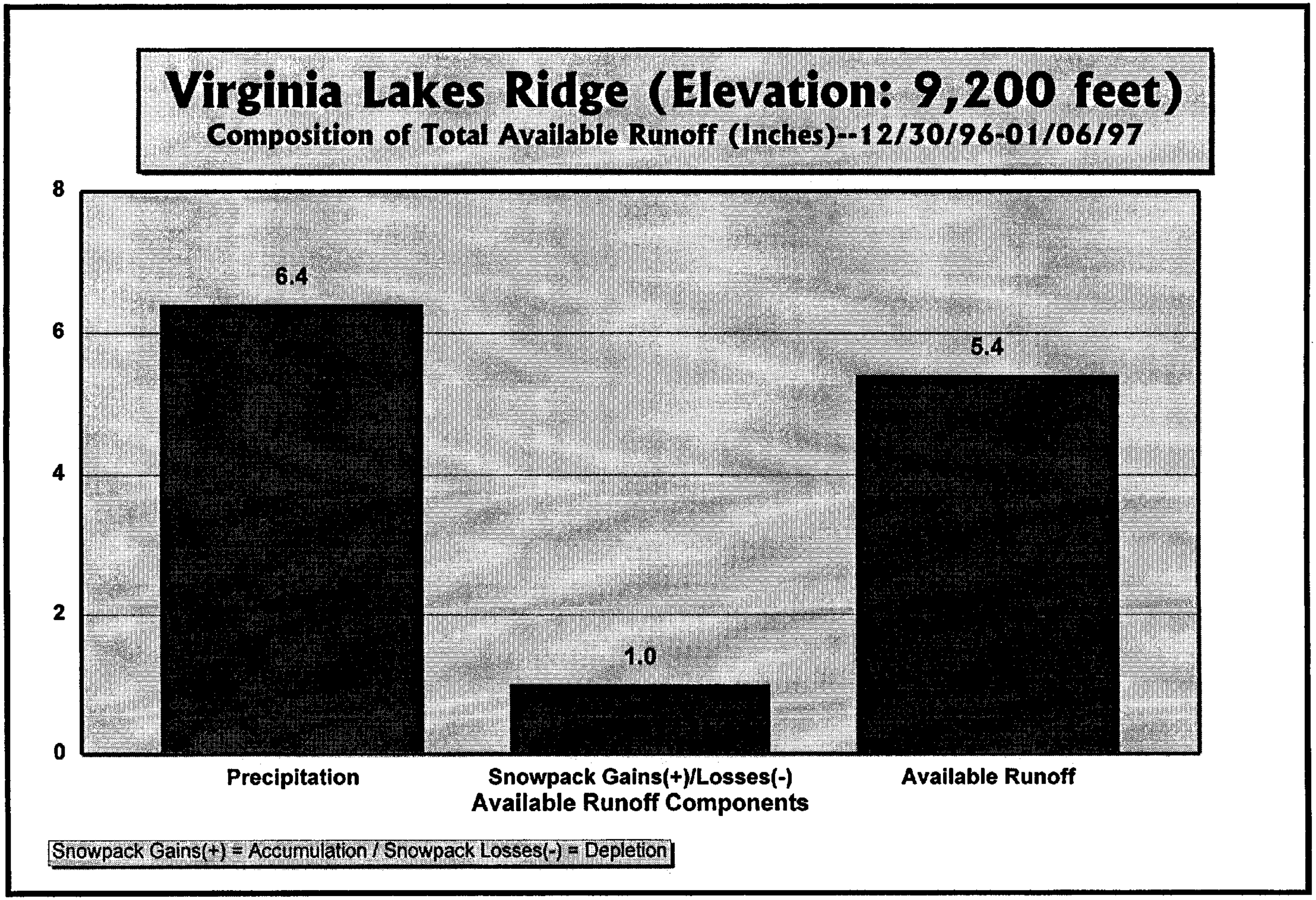


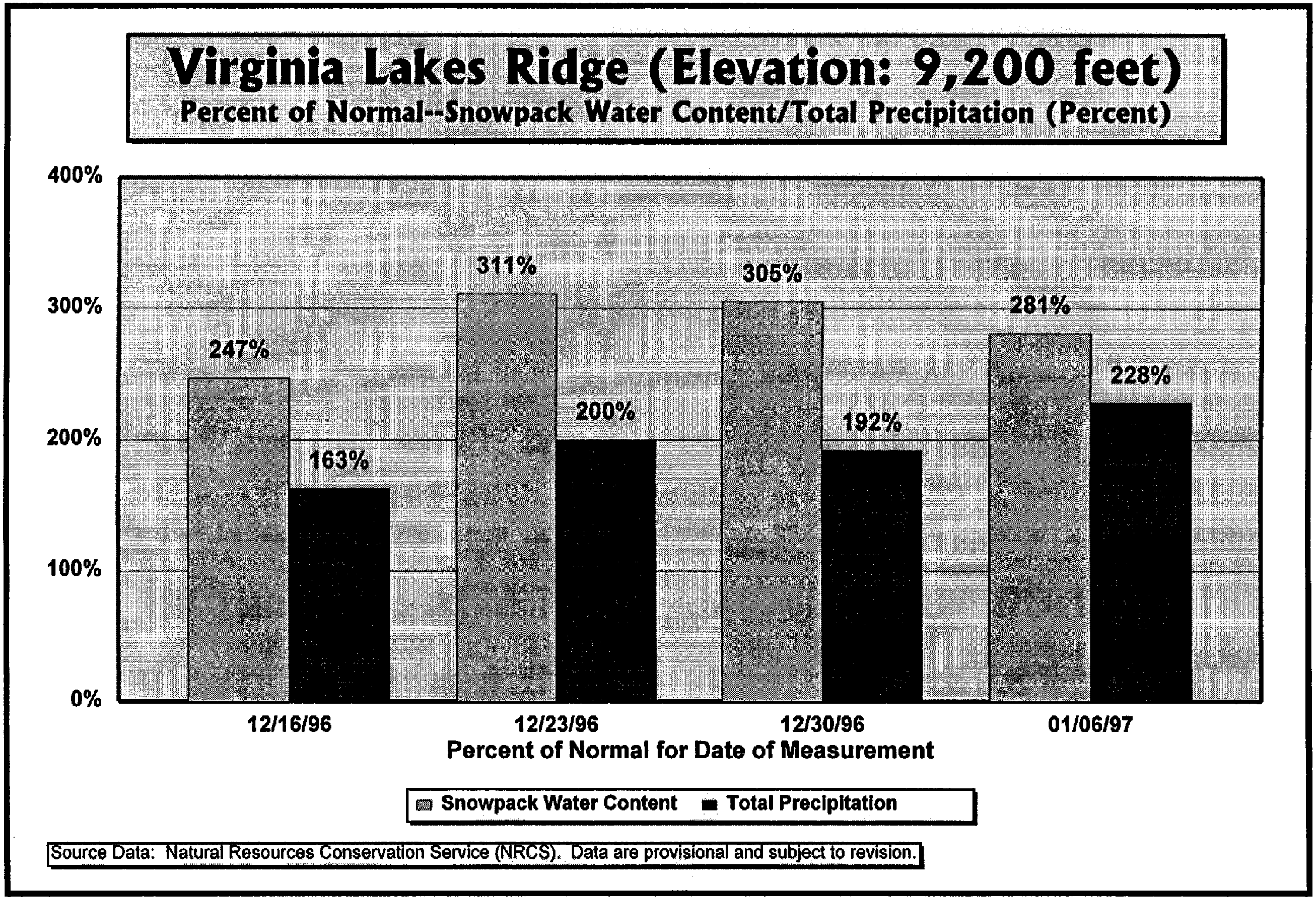
Virginia Lakes Ridge (Elevation: 9,200 feet)
Snowpack Water Content and Total Precipitation (Inches)
30
20
10
0
12.1
13.7
17.7
18.6
19.8
19.6
20.8
26.0
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

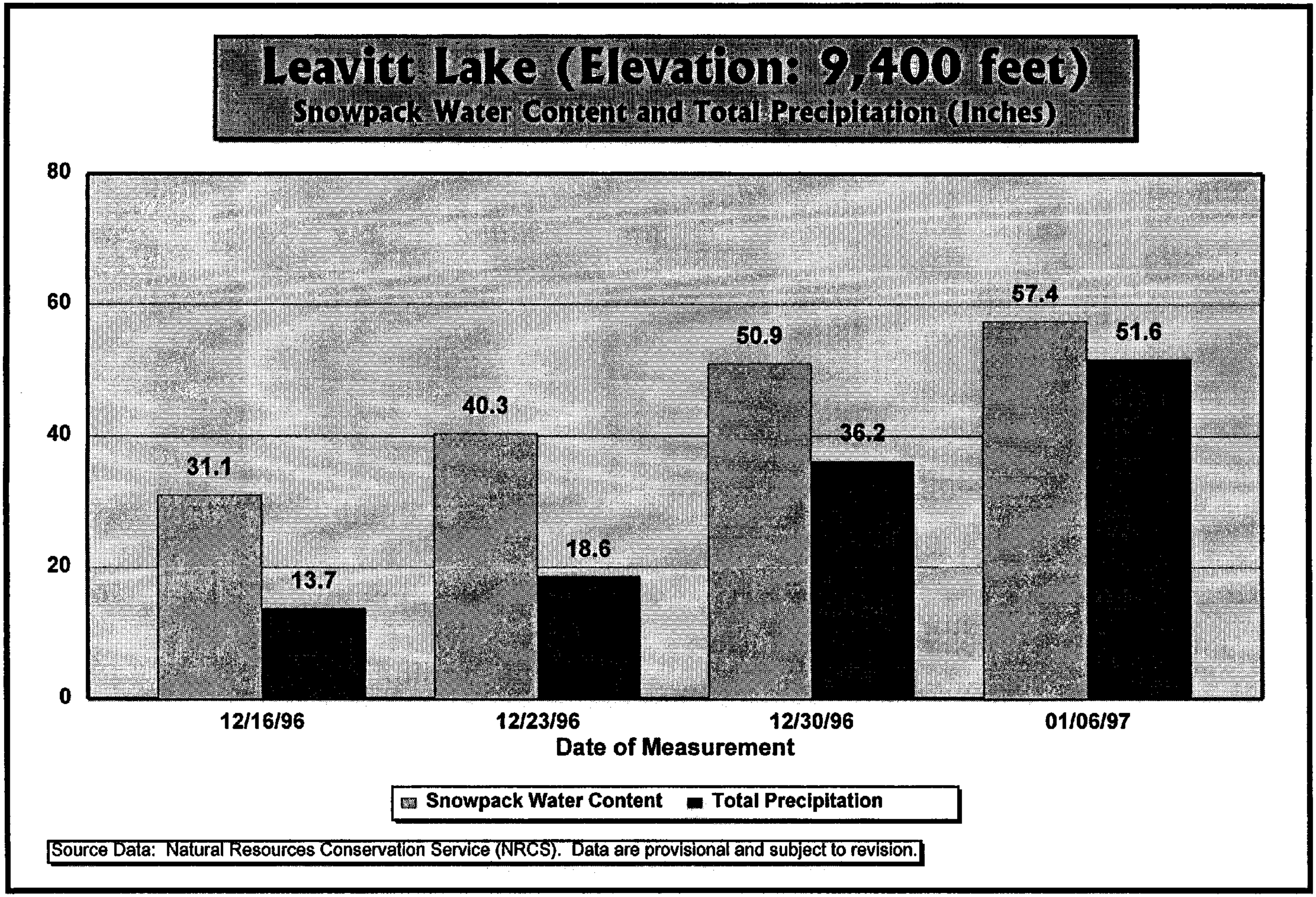

Virginia Lakes Ridge (Elevation: 9,200 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
120%
100%
80%
60%
40%
20%
0%
88.3%
95.2%
101.0%
80.0%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

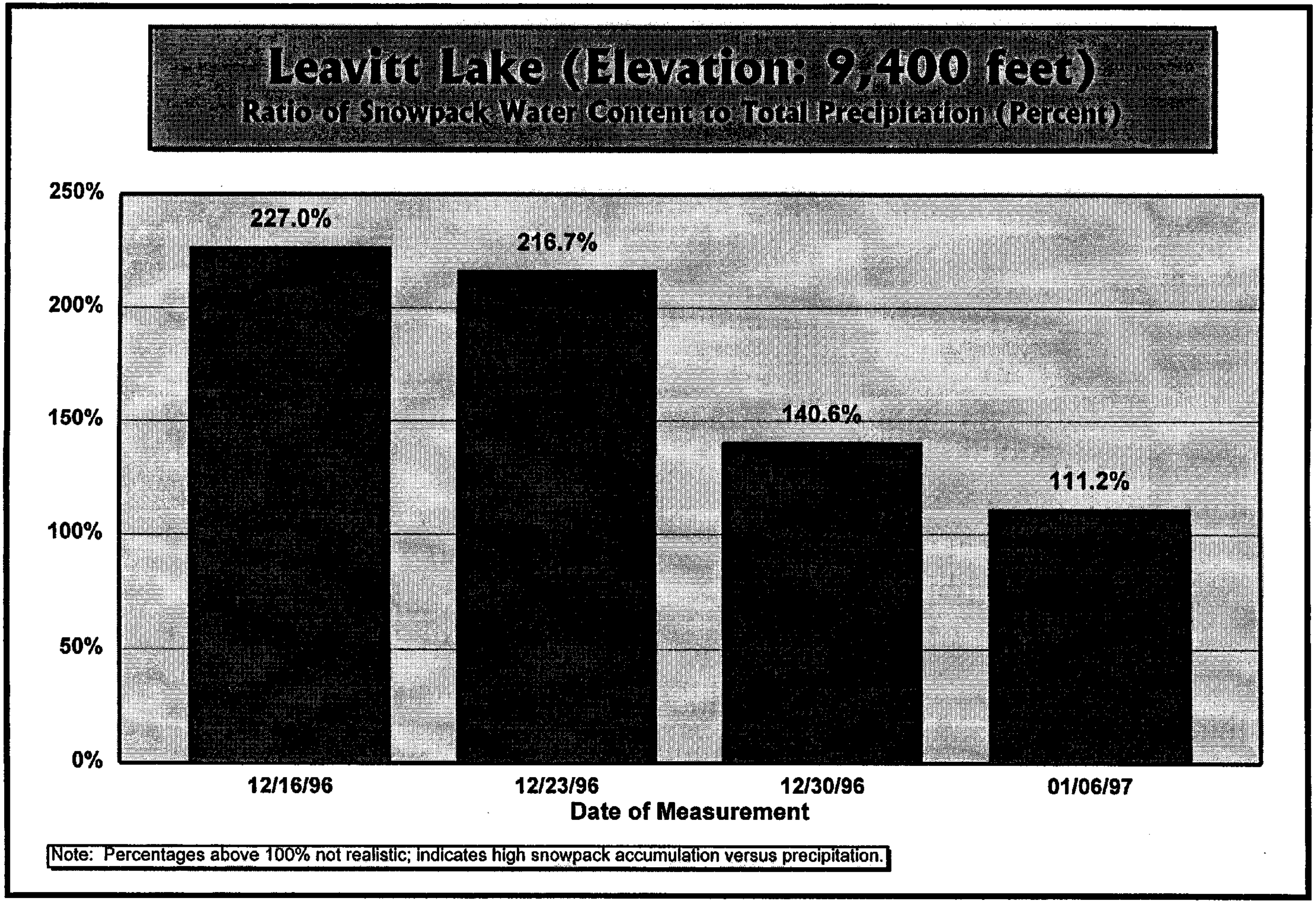


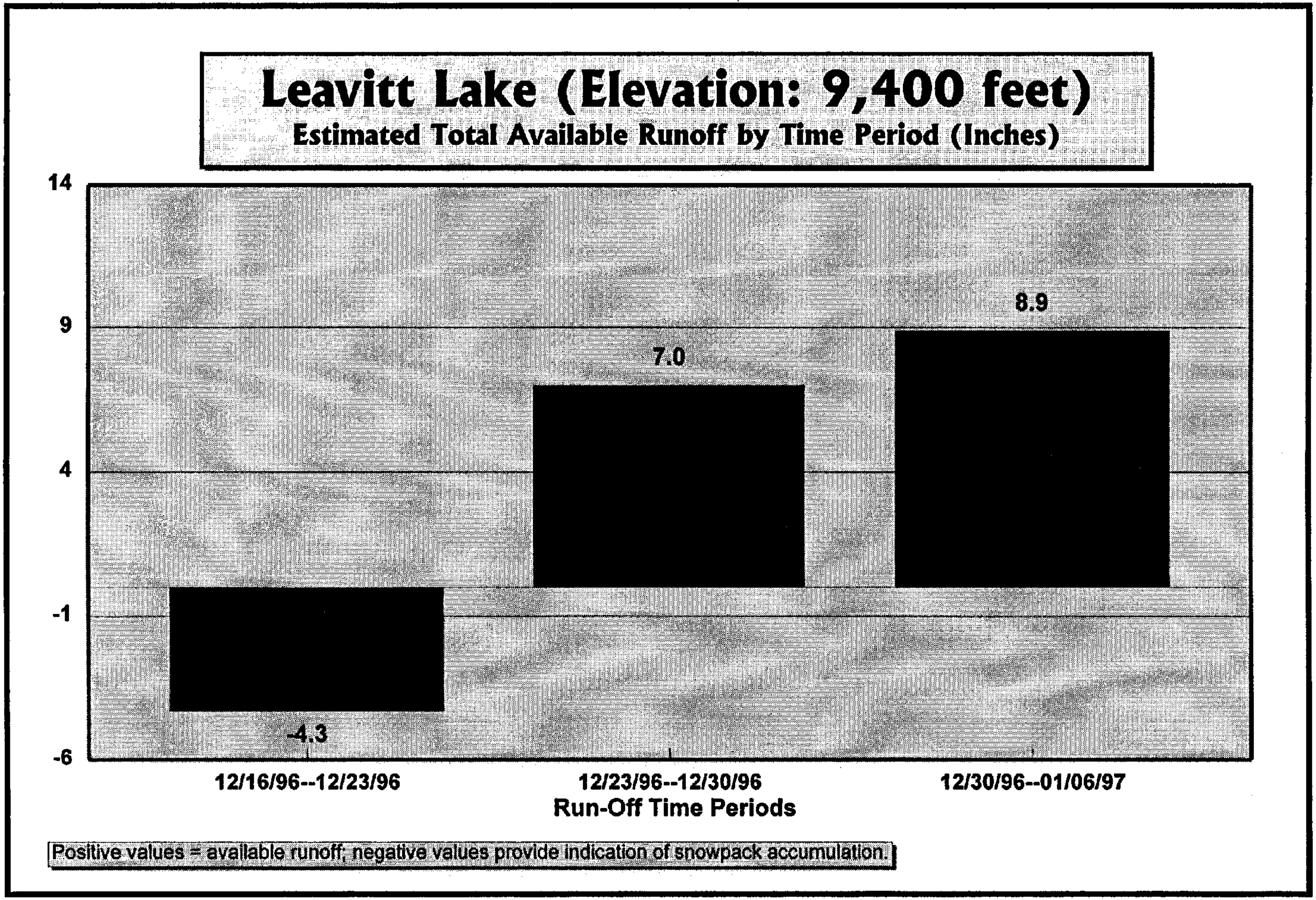
Virginia Lakes Ridge (Elevation: 9,200 feet)
Estimated Total Available Runoff by Time Period (Inches)
8
6
4
2
0
-2
5.4
-0.7
-1.1
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff, negative values provide indication of snowpack accumulation.

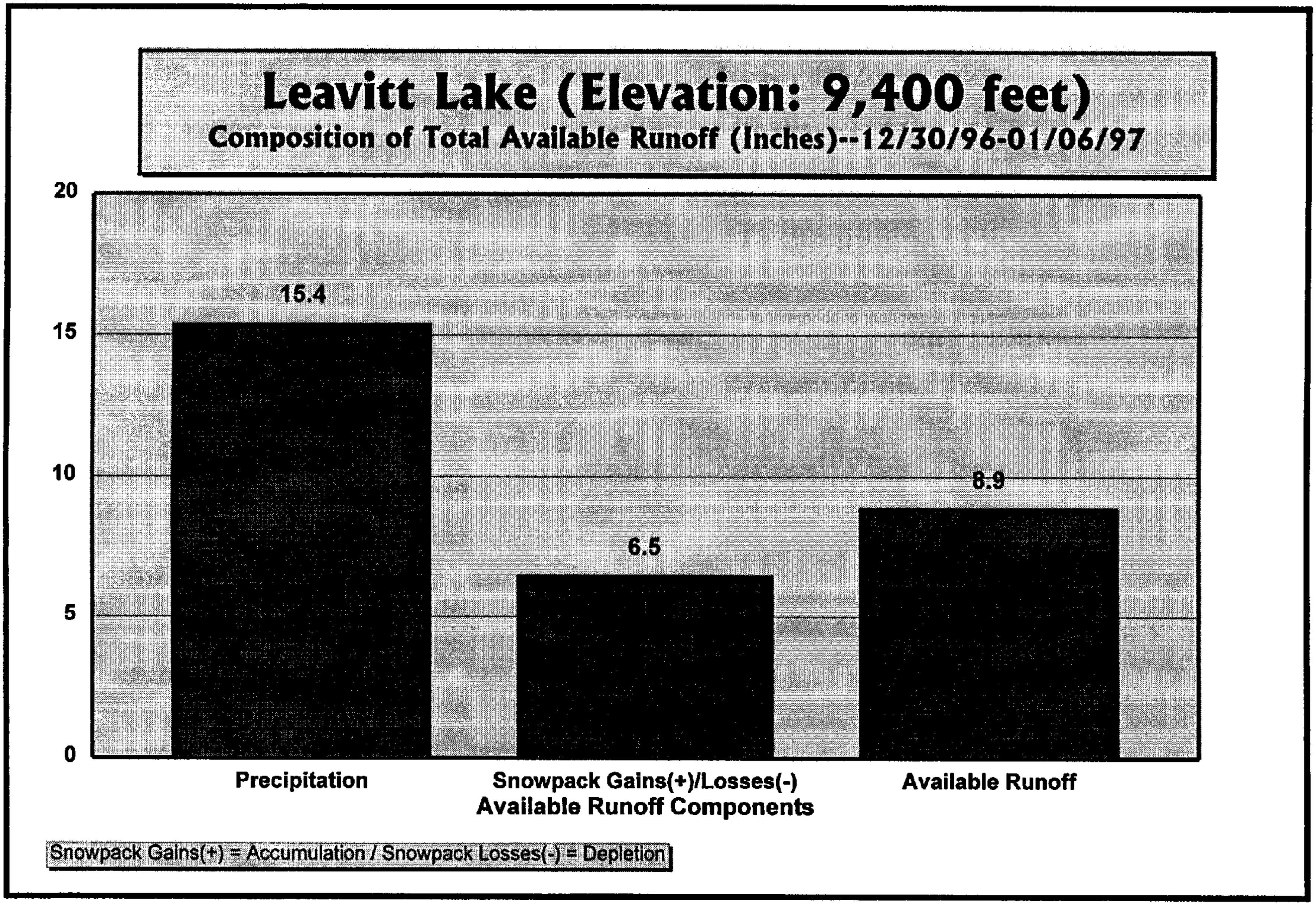

Virginia Lakes Ridge (Elevation: 9,200 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
8
6
4
2
0
6.4
1.0
5.4
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

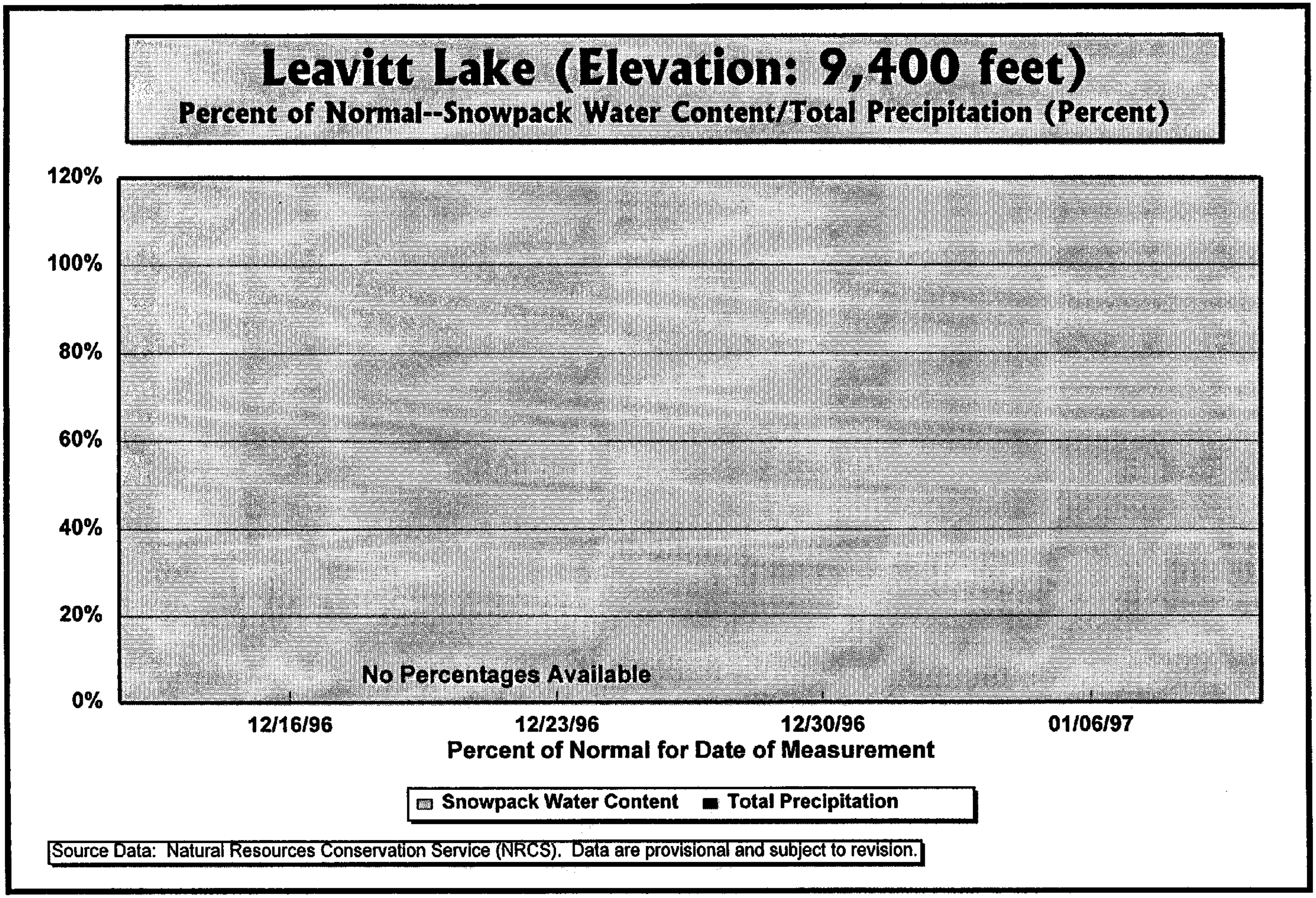

Virginia Lakes Ridge (Elevation: 9,200 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
400%
300%
200%
100%
0%
247%
163%
311%
200%
305%
192%
281%
228%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

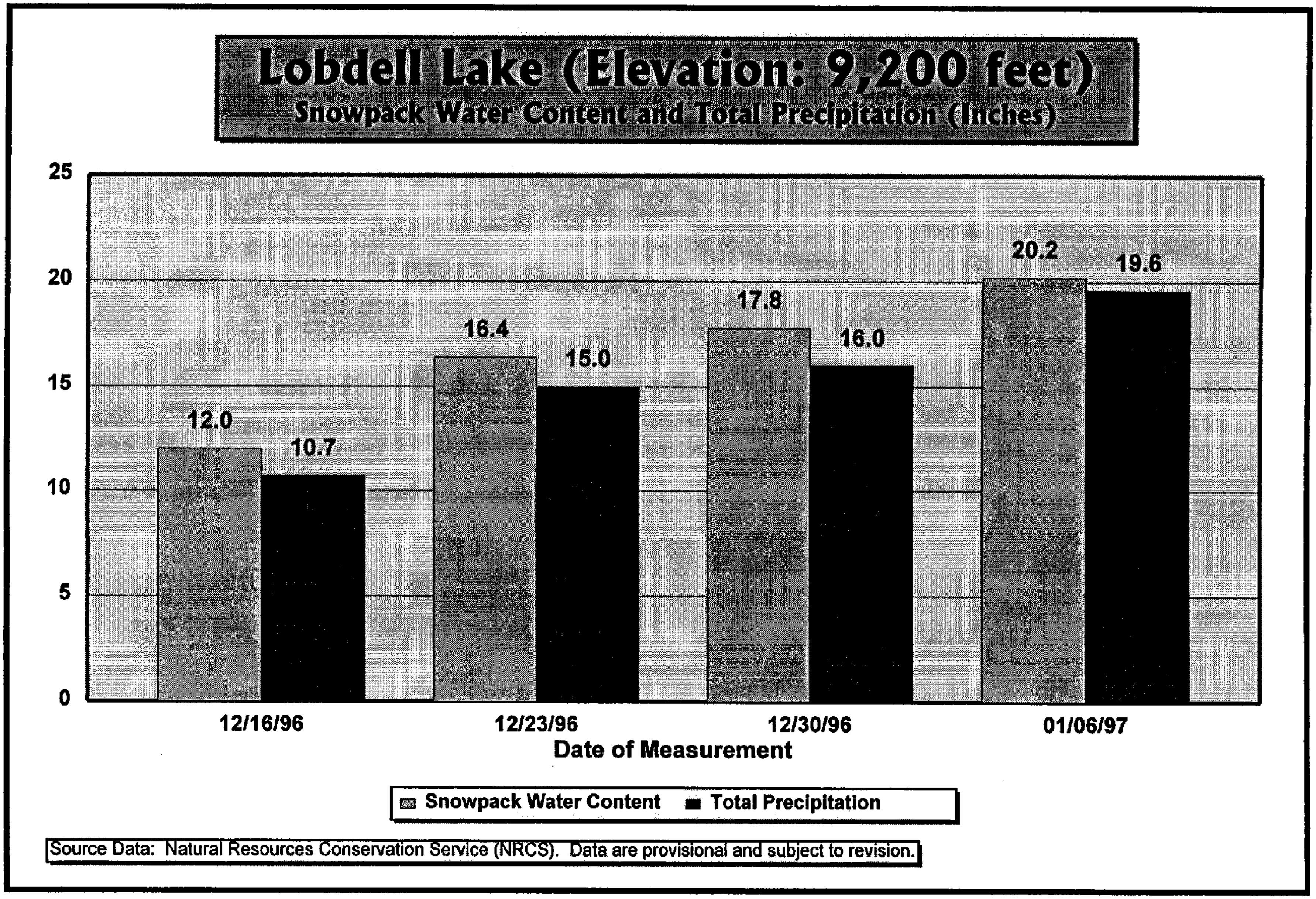

Leavitt Lake (Elevation: 9,400 feet)
Snowpack Water Content and Total Precipitation (Inches)
80
60
40
20
0
31.1
13.7
40.3
18.6
50.9
36.2
57.4
51.6
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Leavitt Lake (Elevation: 9,400 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
250%
200%
150%
100%
50%
0%
227.0%
216.7%
140.6%
111.2%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

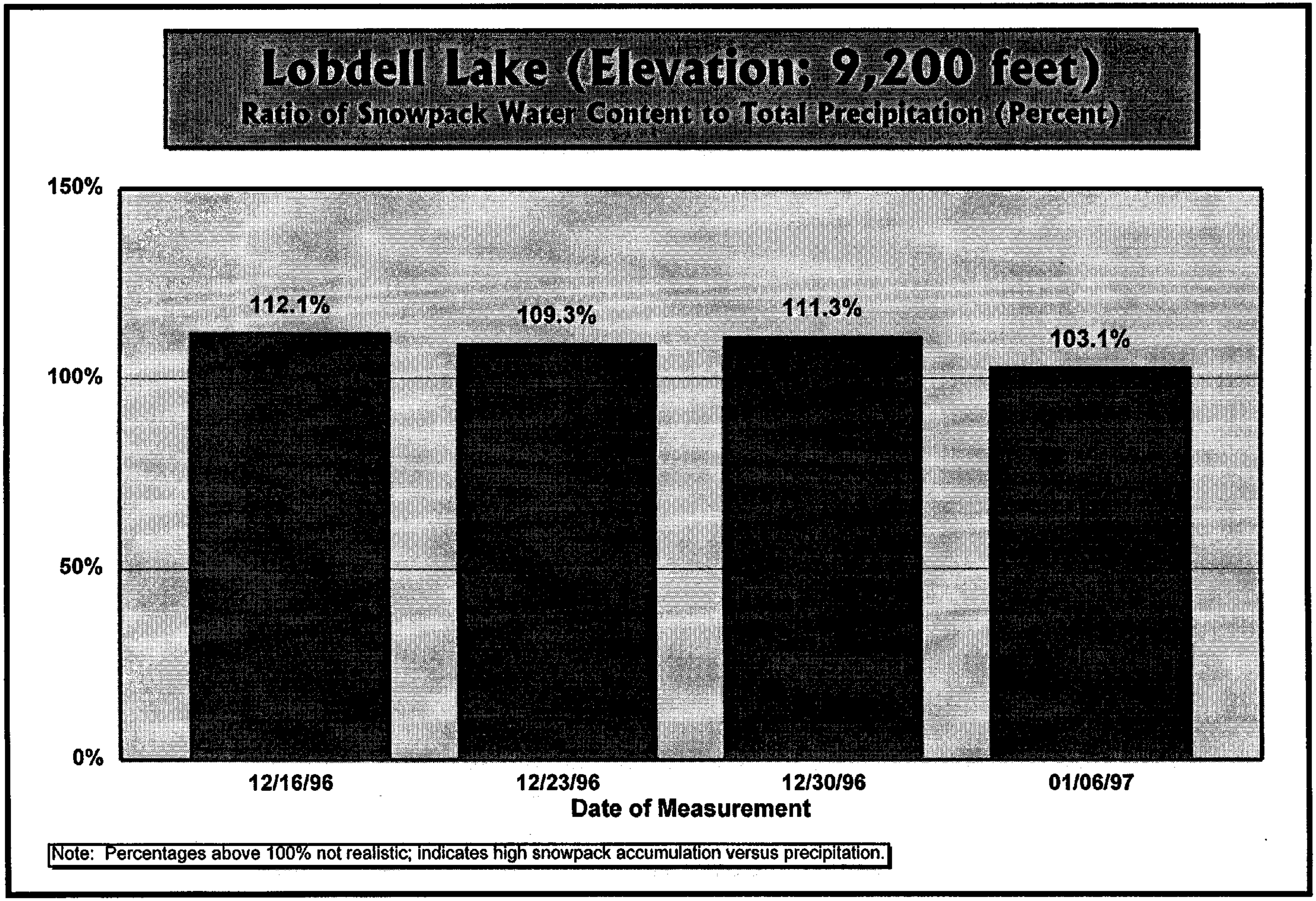

Leavitt Lake (Elevation: 9,400 feet)
Estimated Total Available Runoff by Time Period (Inches)
14
9
4
-1
-6
8.9
7.0
-4.3
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

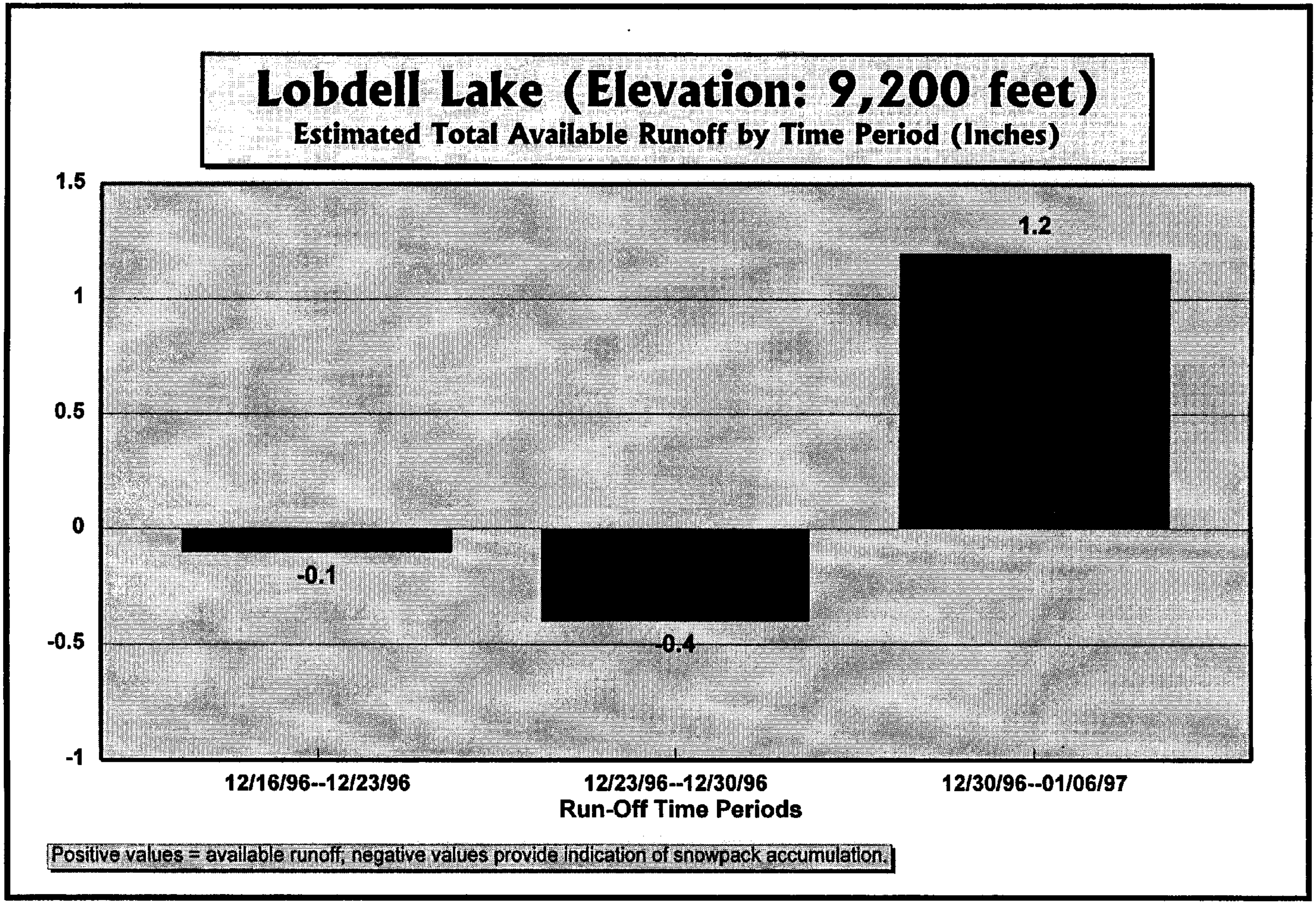

Leavitt Lake (Elevation: 9,400 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
15
10
5
0
15.4
6.5
8.9
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

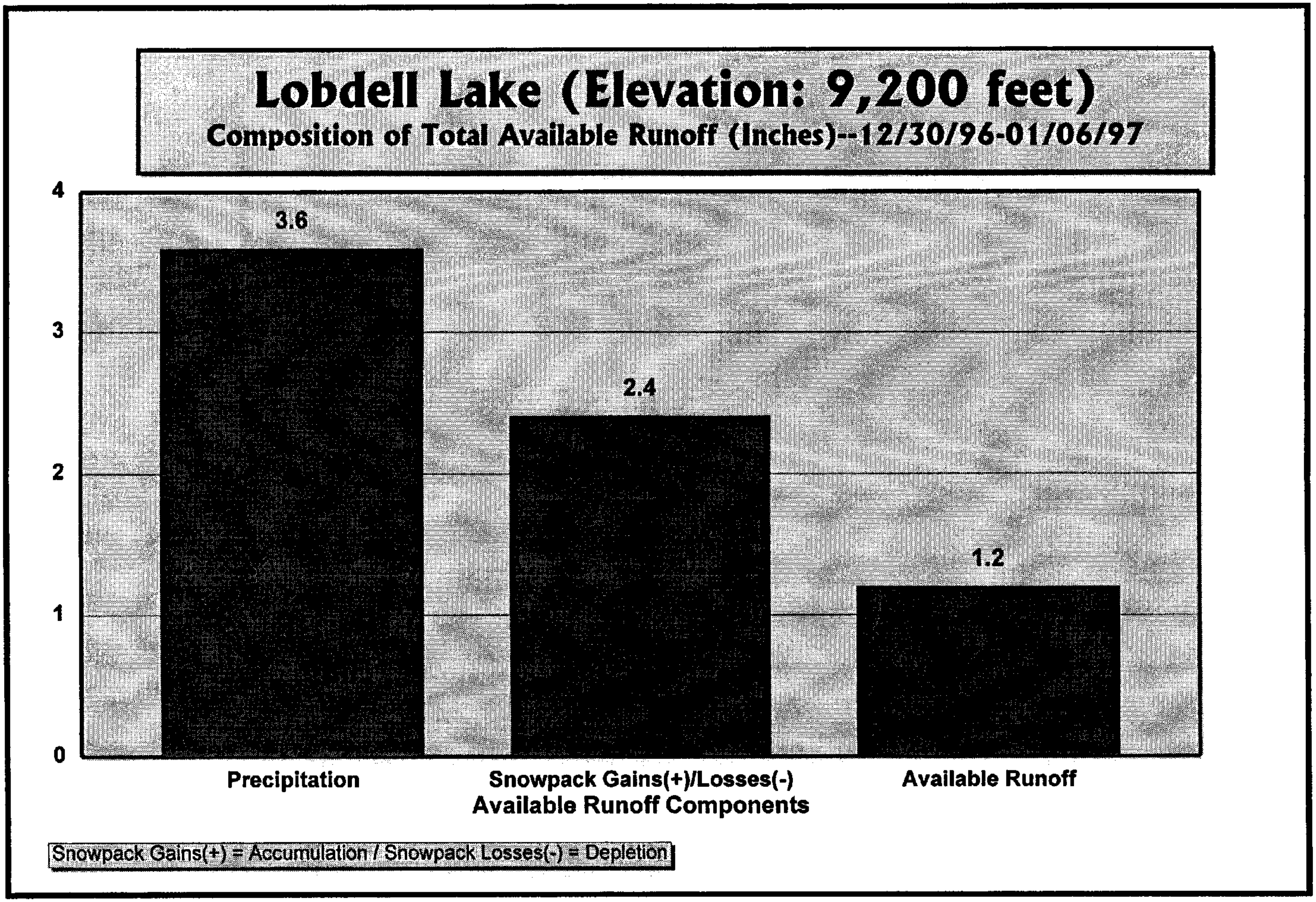

Leavitt Lake (Elevation: 9,400 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
120%
100%
80%
60%
40%
20%
0%
No Percentages Available
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

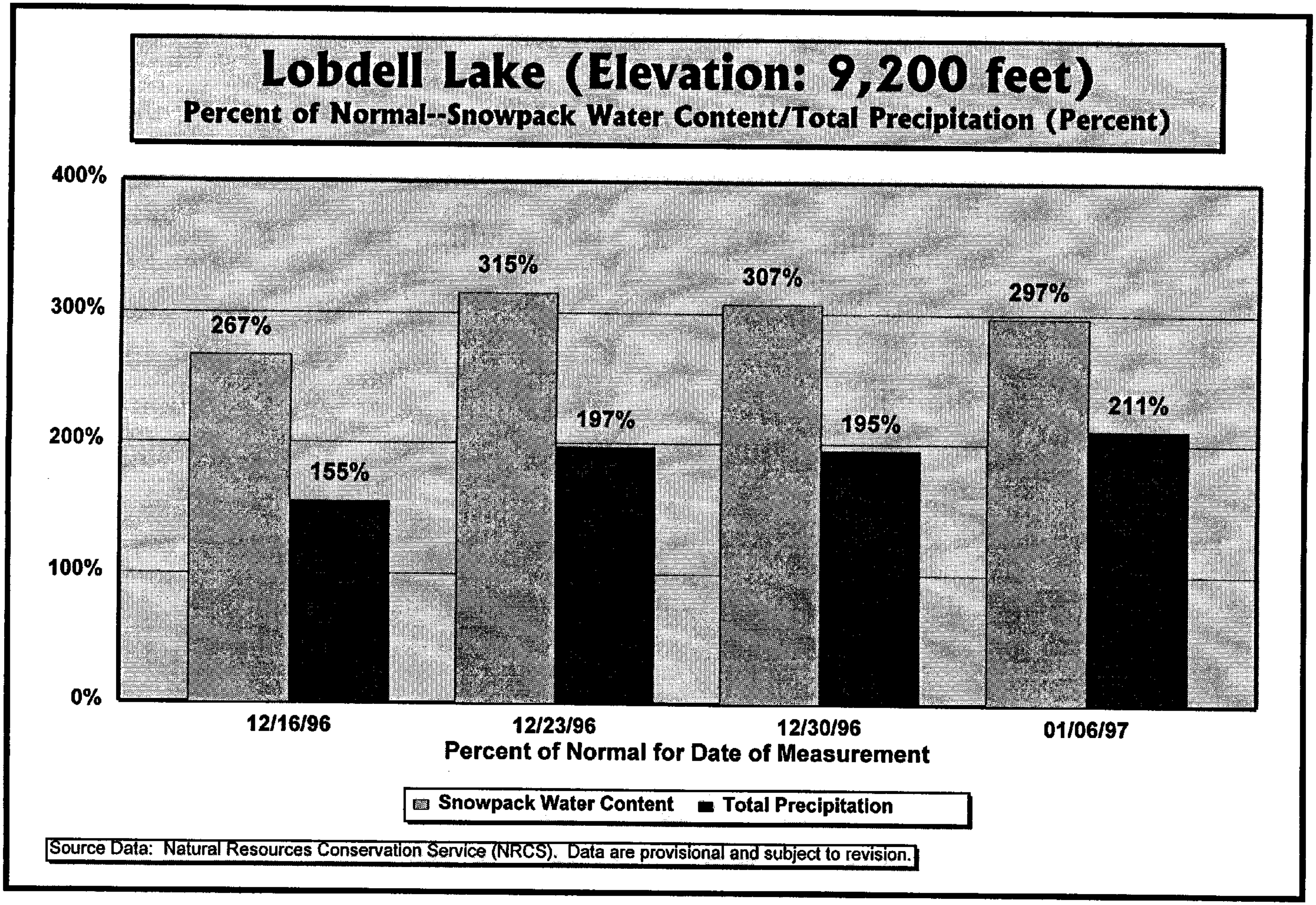


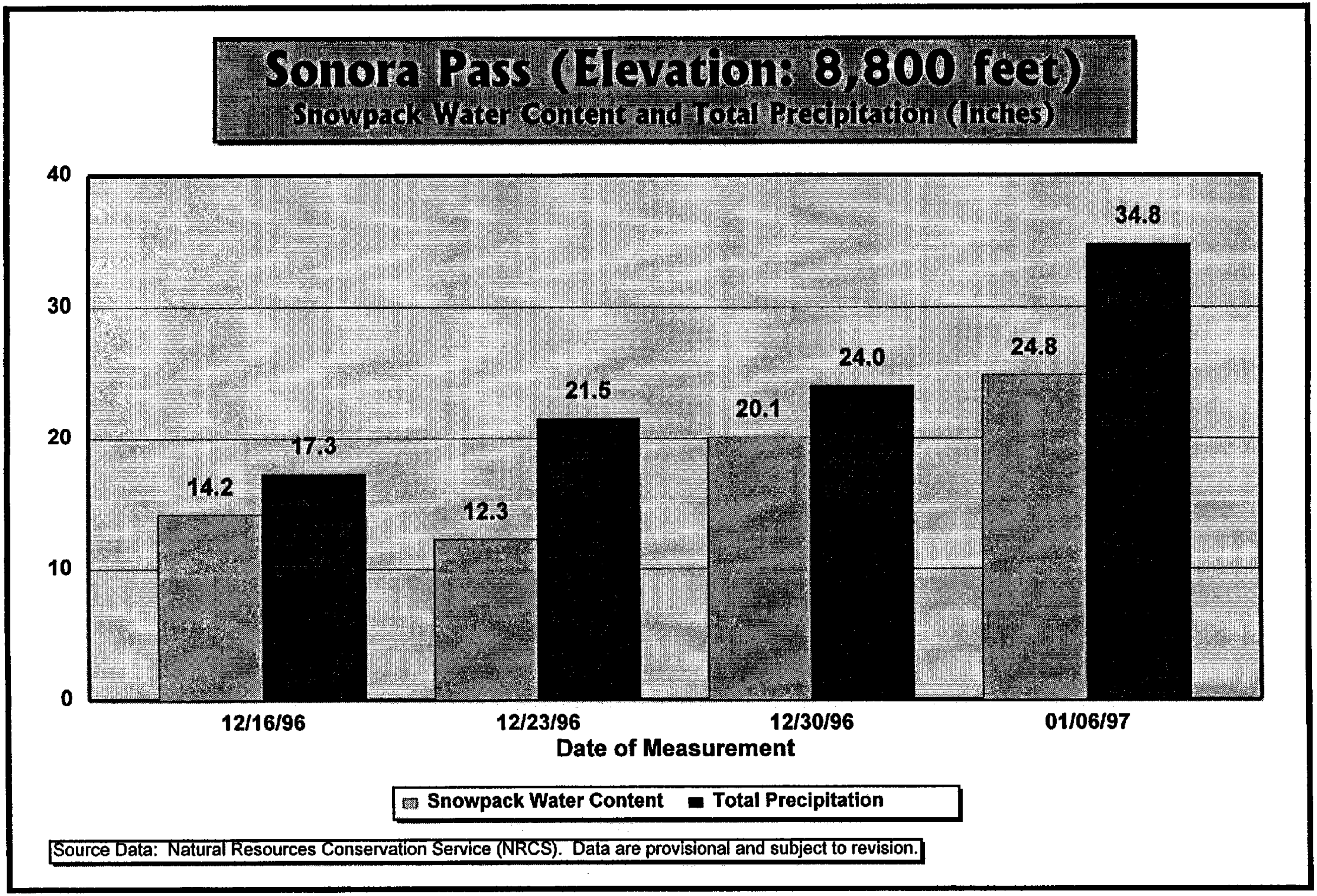
Lobdell Lake (Elevation: 9,200 feet)
Snowpack Water Content and Total Precipitation (Inches)
25
20
15
10
5
0
12.0
10.7
16.4
15.0
17.8
16.0
20.2
19.6
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Lobdell Lake (Elevation: 9,200 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
150%
100%
50%
0%
112.1%
109.3%
111.3%
103.1%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

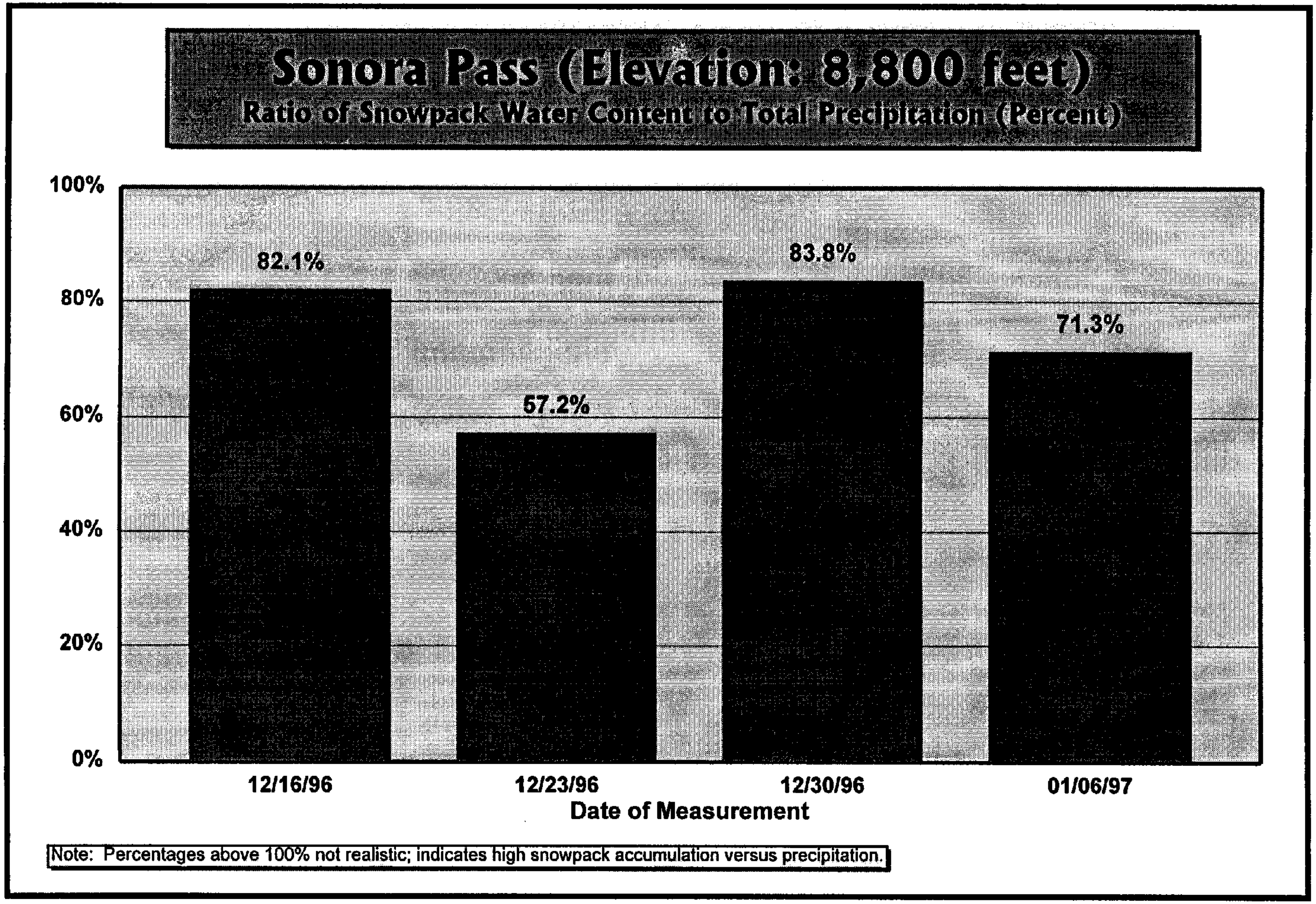

Lobdell Lake (Elevation: 9,200 feet)
Estimated Total Available Runoff by Time Period (Inches)
1.5
1
0.5
0
-0.5
-1
1.2
-0.1
-0.4
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff, negative values provide indication of snowpack accumulation.

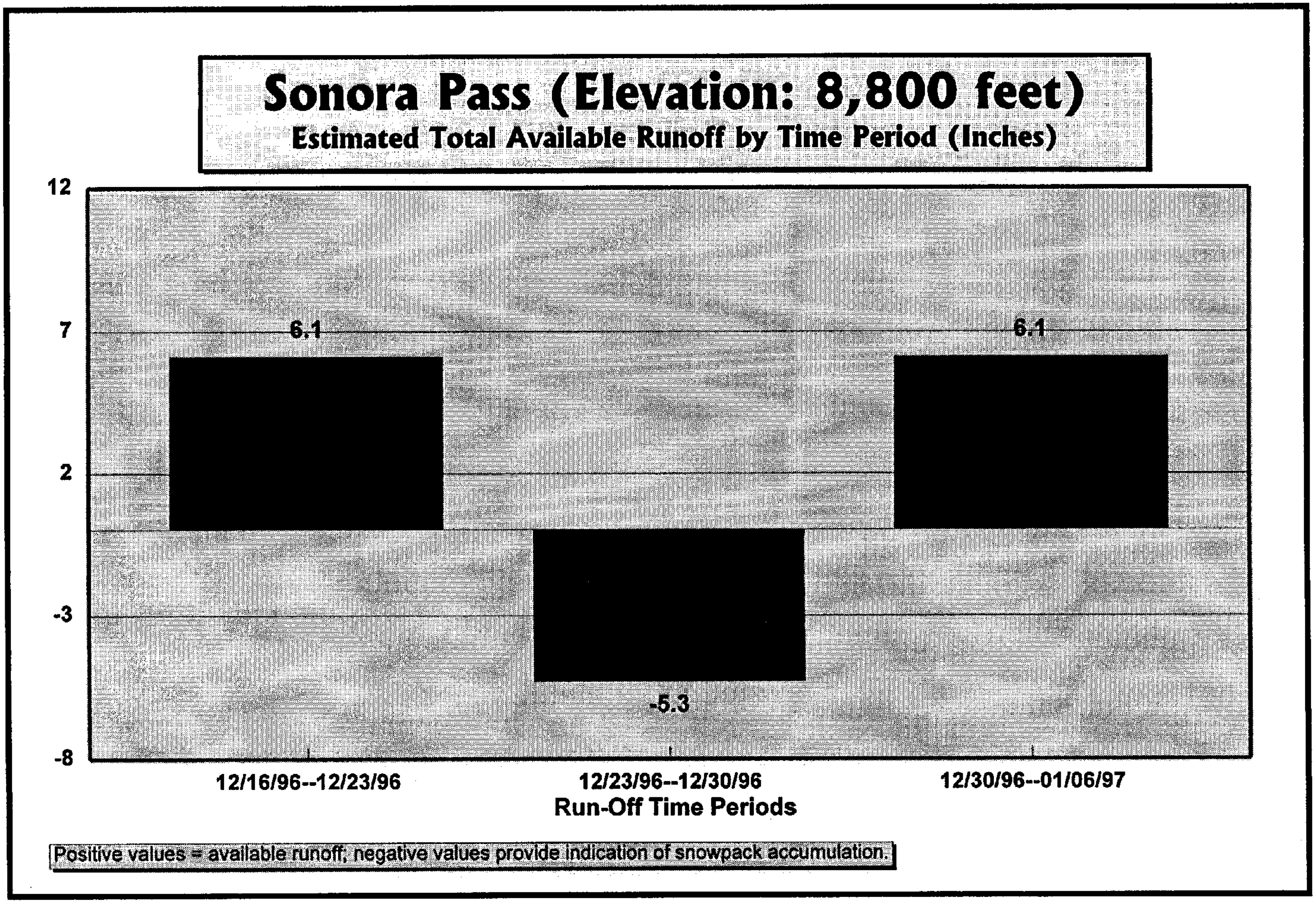

Lobdell Lake (Elevation: 9,200 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
4
3
2
1
0
3.6
2.4
1.2
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion


Lobdell Lake (Elevation: 9,200 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
400%
300%
200%
100%
0%
267%
155%
315%
197%
307%
195%
297%
211%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

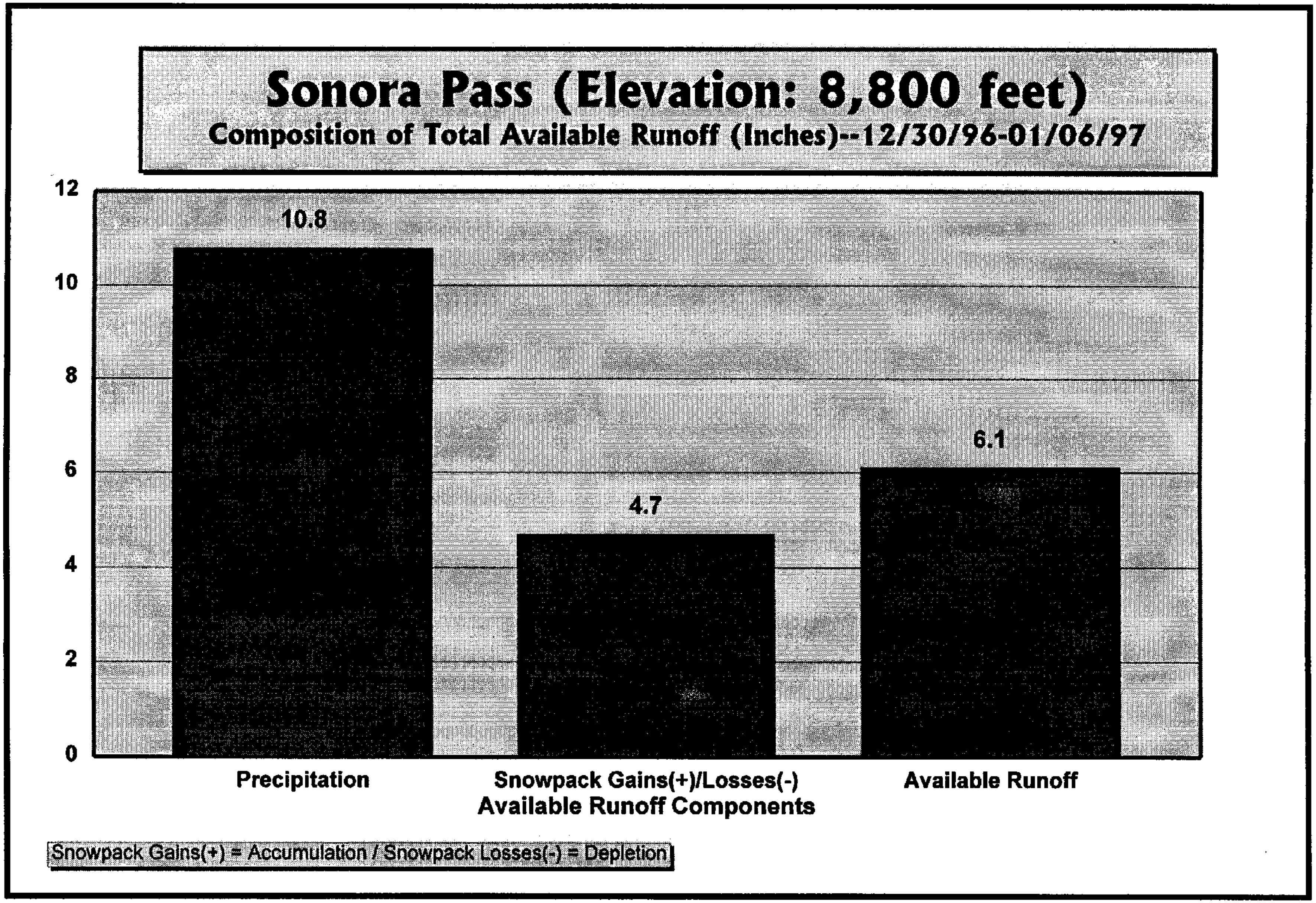


Sonora Pass (Elevation: 8,800 feet)
Snowpack Water Content and Total Precipitation (Inches)
40
30
20
10
0
14.2
17.3
12.3
21.5
20.1
24.0
24.8
34.8
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

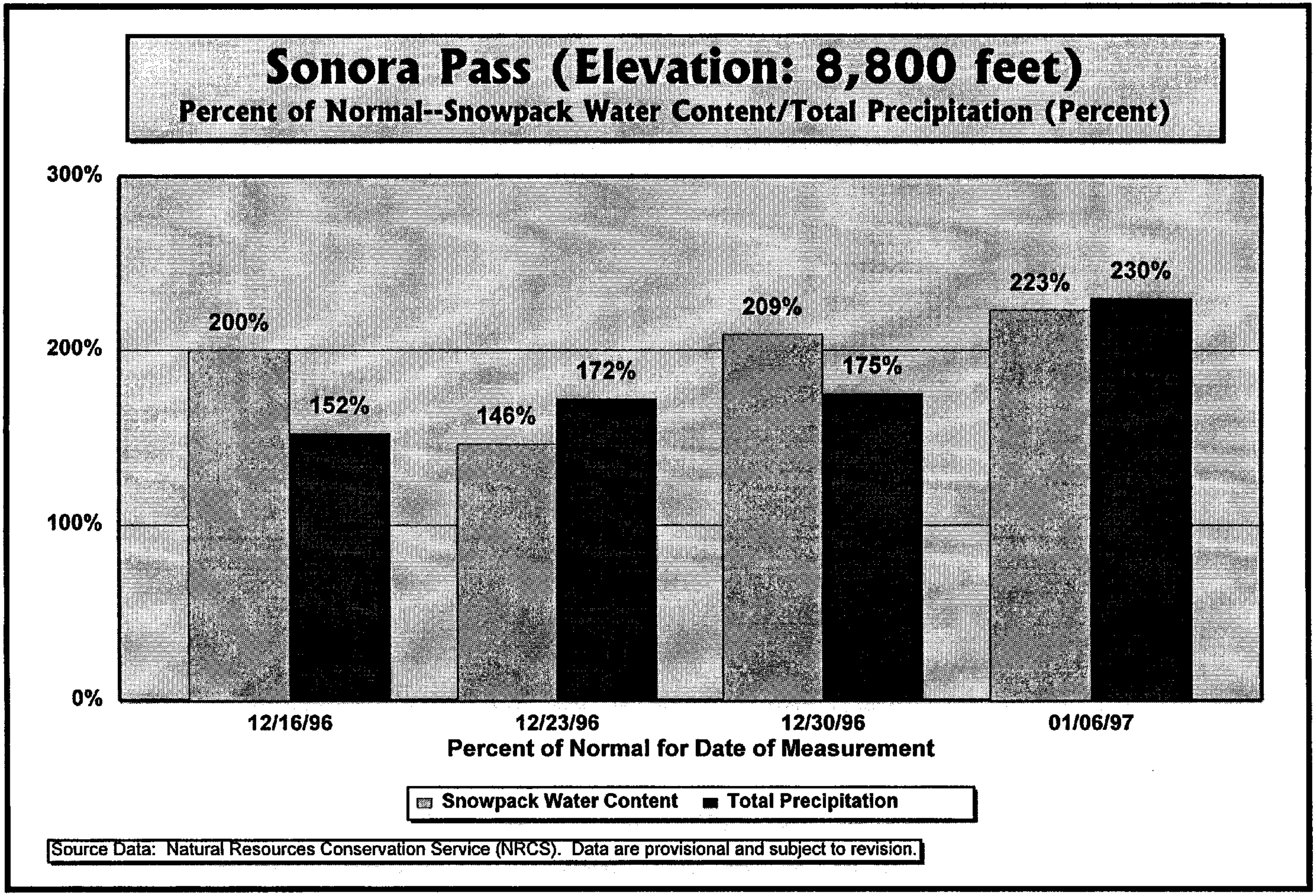

Sonora Pass (Elevation: 8,800 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
100%
80%
60%
40%
20%
0%
82.1%
57.2%
83.8%
71.3%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.

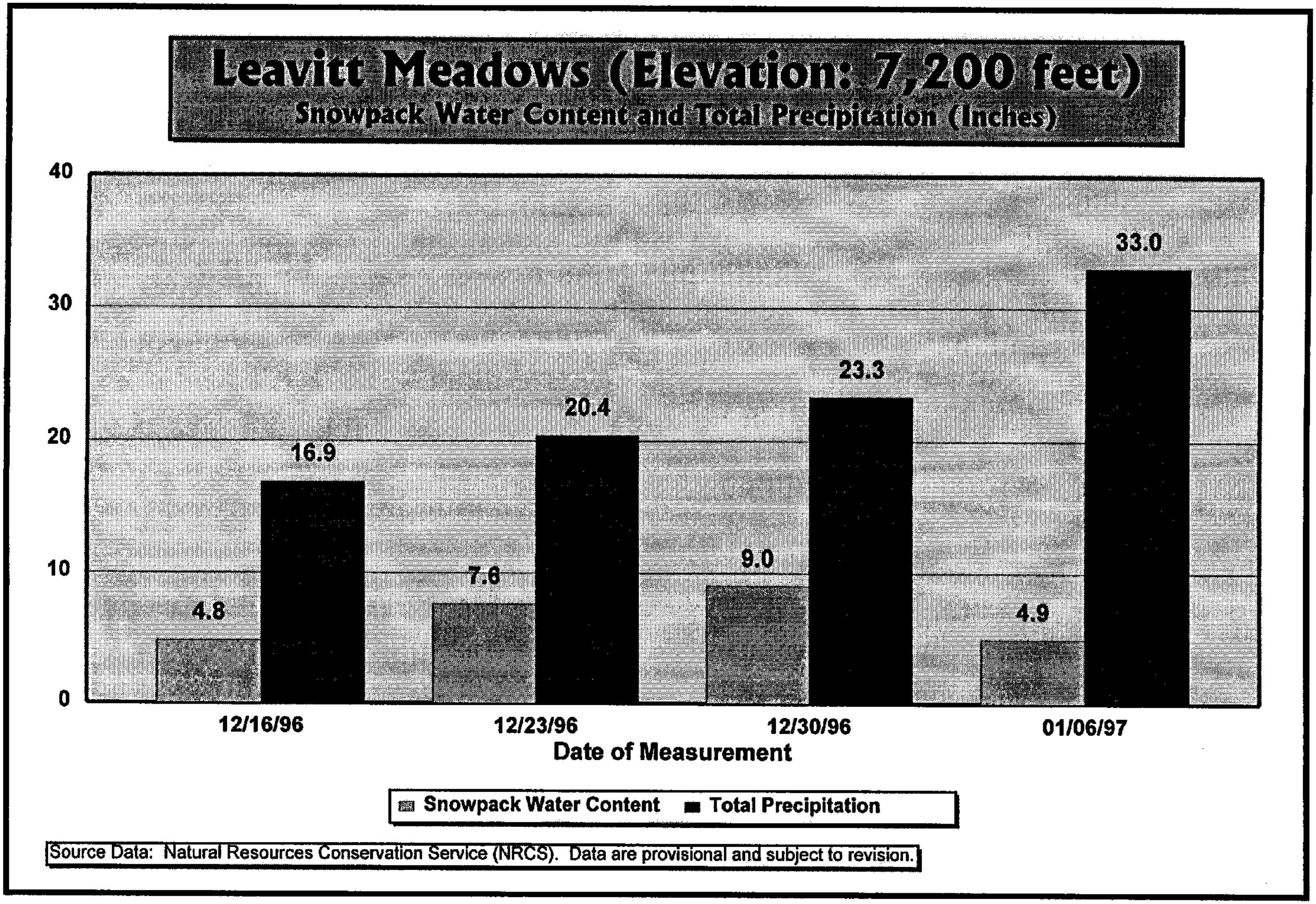


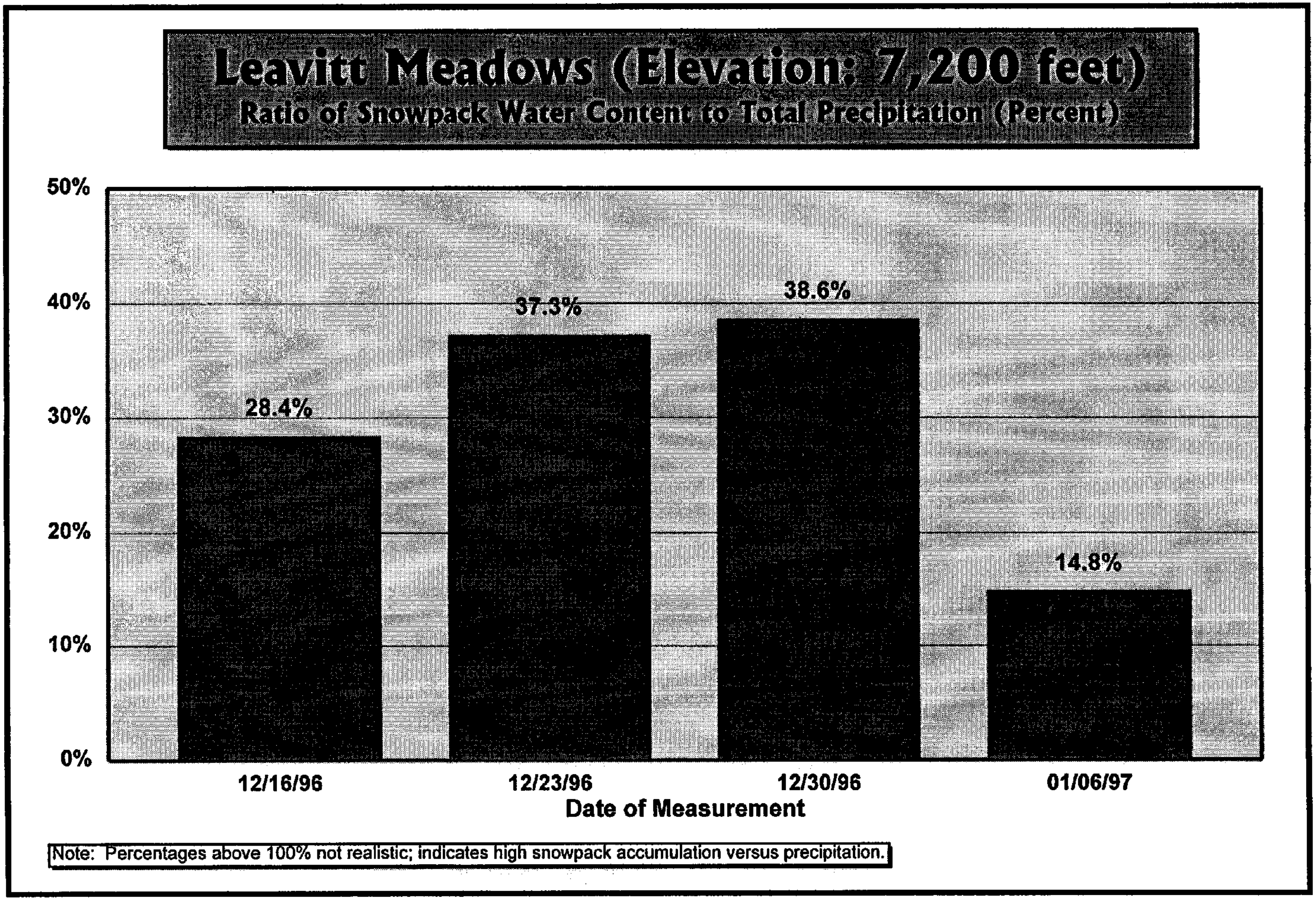
Sonora Pass (Elevation: 8,800 feet)
Estimated Total Available Runoff by Time Period (Inches)
12
7
2
-3
-8
6.1
-5.3
6.1
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.

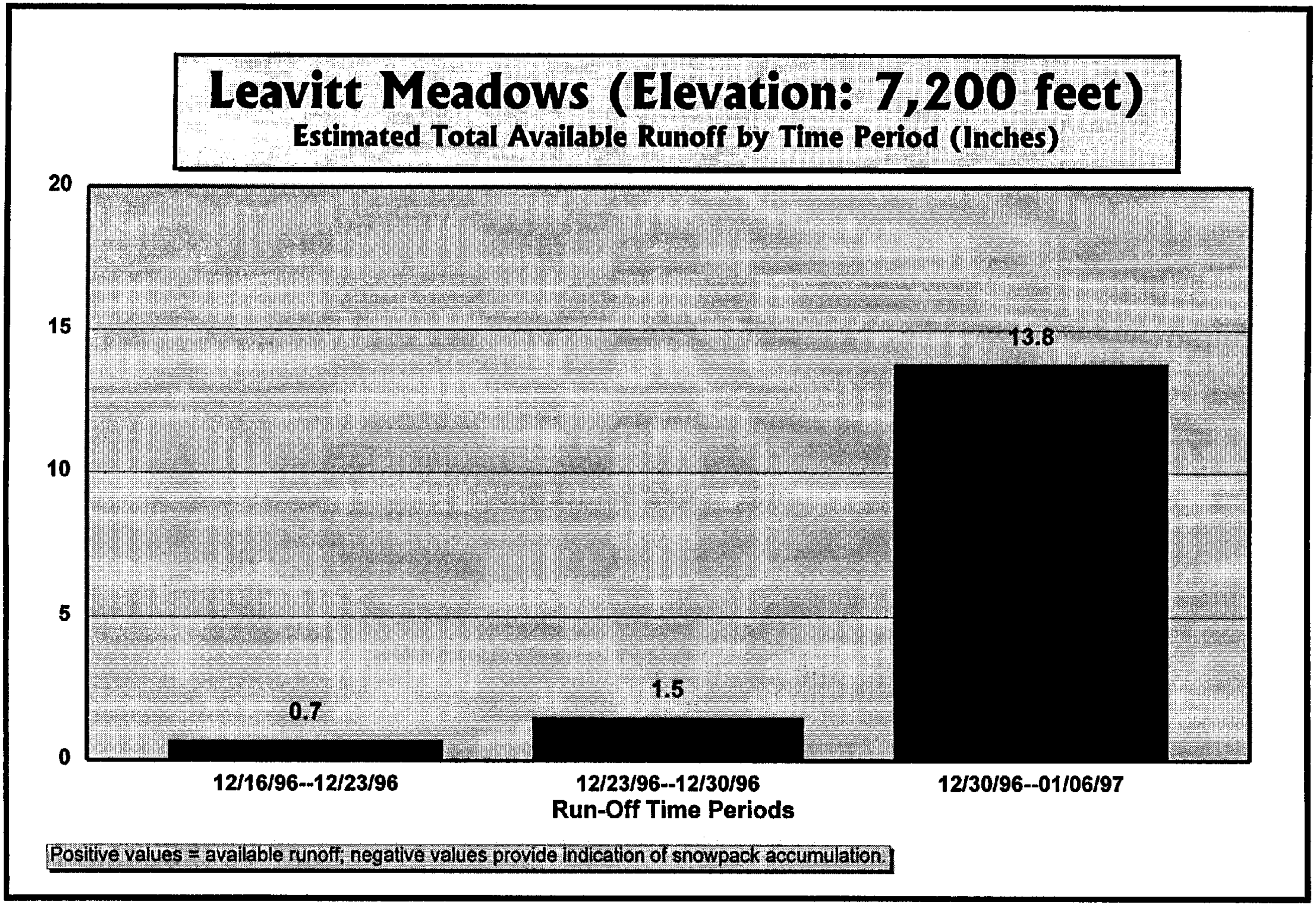


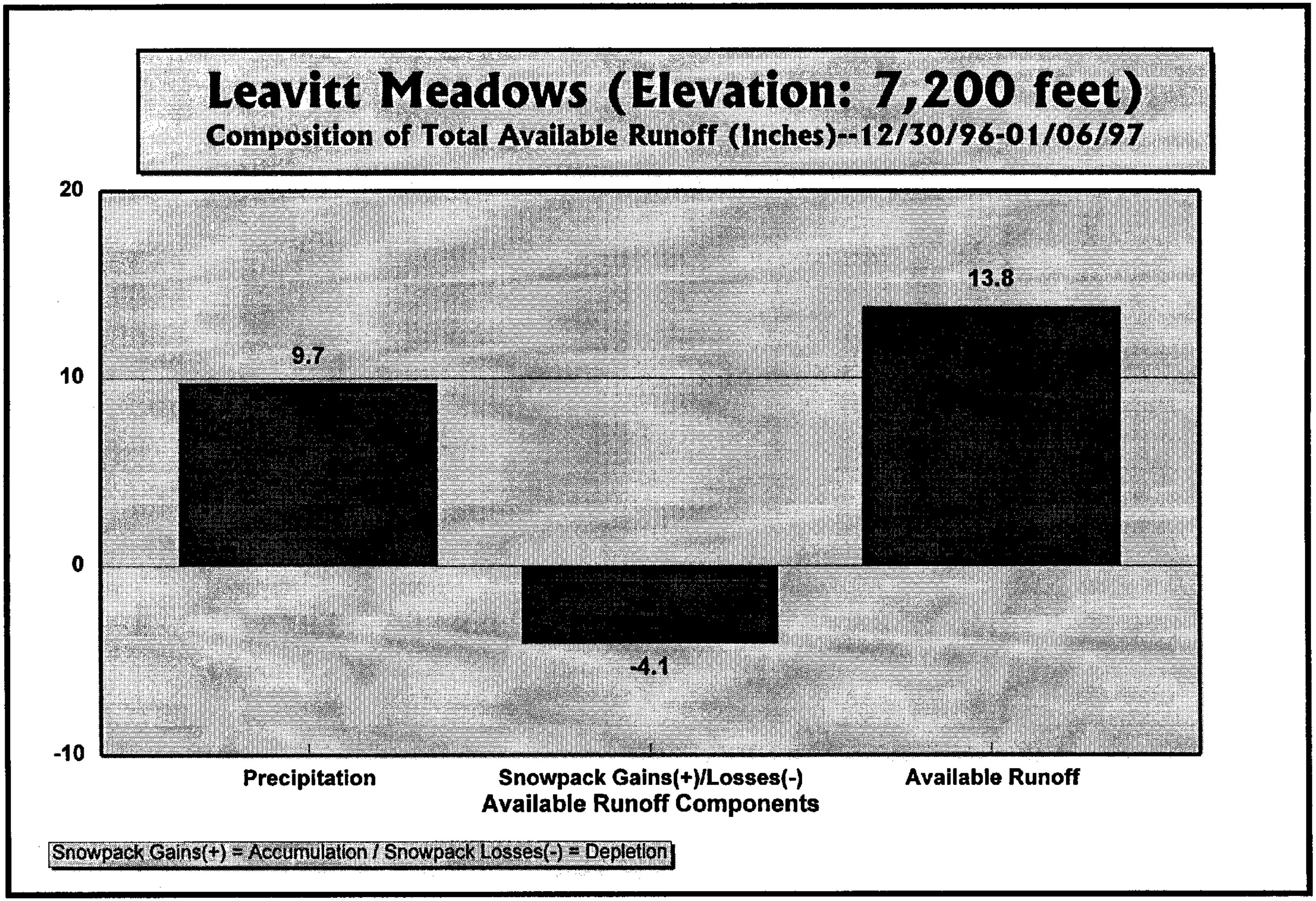
Sonora Pass (Elevation: 8,800 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
12
10
8
6
4
2
0
10.8
4.7
6.1
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion

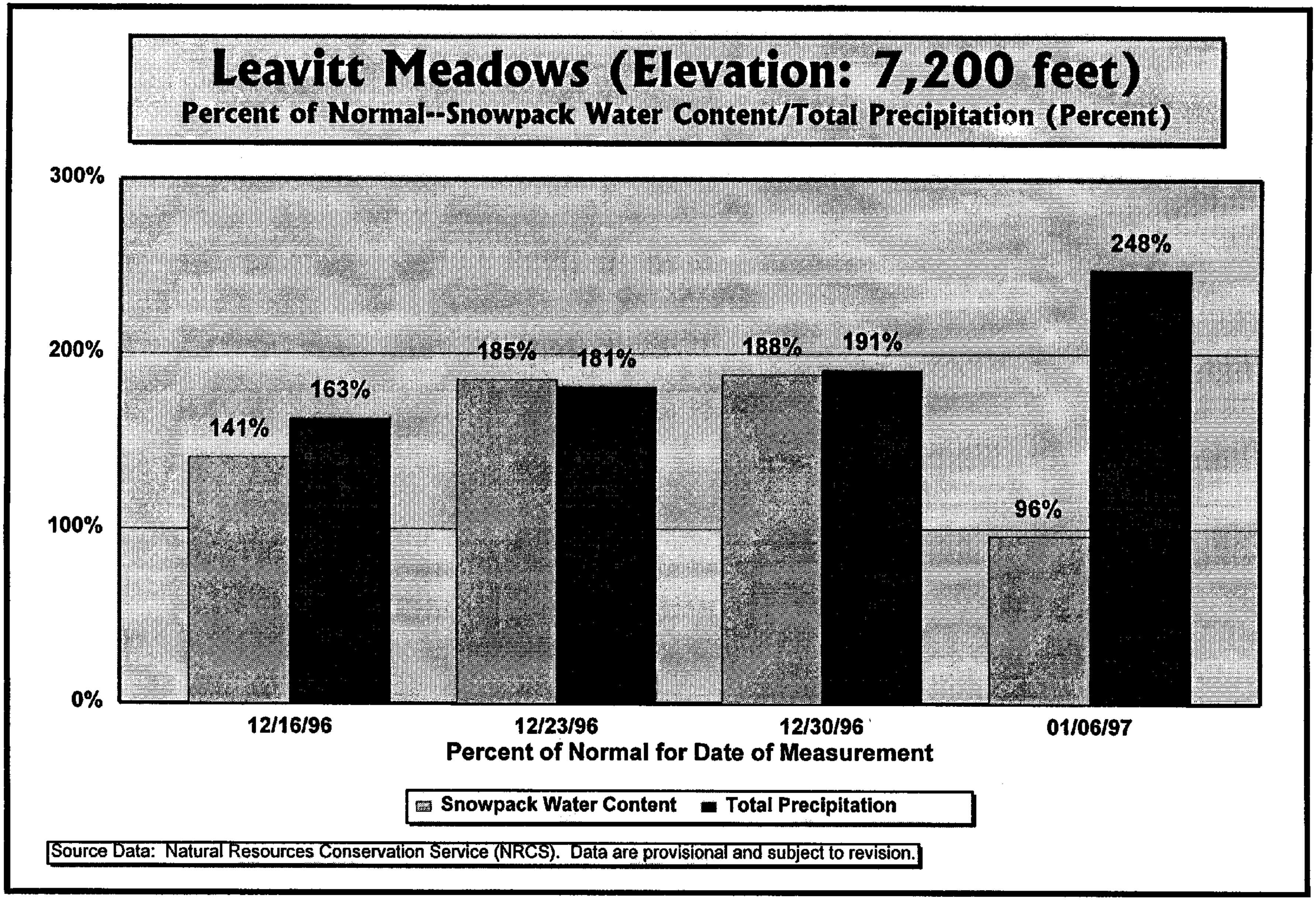

Sonora Pass (Elevation: 8,800 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
200%
152%
146%
172%
209%
175%
223%
230%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Leavitt Meadows (Elevation: 7,200 feet)
Snowpack Water Content and Total Precipitation (Inches)
40
30
20
10
0
4.8
16.9
7.6
20.4
9.0
23.3
4.9
33.0
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.


Leavitt Meadows (Elevation: 7,200 feet)
Ratio of Snowpack Water Content to Total Precipitation (Percent)
50%
40%
30%
20%
10%
0%
28.4%
37.3%
38.6%
14.8%
12/16/96
12/23/96
12/30/96
01/06/97
Date of Measurement
Note: Percentages above 100% not realistic; indicates high snowpack accumulation versus precipitation.


Leavitt Meadows (Elevation: 7,200 feet)
Estimated Total Available Runoff by Time Period (Inches)
20
15
10
5
0
13.8
1.5
0.7
12/16/96--12/23/96
12/23/96--12/30/96
12/30/96--01/06/97
Run-Off Time Periods
Positive values = available runoff; negative values provide indication of snowpack accumulation.


Leavitt Meadows (Elevation: 7,200 feet)
Composition of Total Available Runoff (Inches)--12/30/96-01/06/97
20
10
0
-10
9.7
-4.1
13.8
Precipitation
Snowpack Gains(+)/Losses(-)
Available Runoff
Available Runoff Components
Snowpack Gains(+) = Accumulation / Snowpack Losses(-) = Depletion



Leavitt Meadows (Elevation: 7,200 feet)
Percent of Normal--Snowpack Water Content/Total Precipitation (Percent)
300%
200%
100%
0%
141%
163%
185%
181%
188%
191%
96%
248%
12/16/96
12/23/96
12/30/96
01/06/97
Percent of Normal for Date of Measurement
Snowpack Water Content
Total Precipitation
Source Data: Natural Resources Conservation Service (NRCS). Data are provisional and subject to revision.

Appendix F

Precipitation Table and Graphs

Table

Daily and Accumulated Precipitation at Selected Sites

12/20/96–01/06/97

Lake Tahoe Basin

Truckee River Basin

Carson River Basin

Walker River Basin

Graphs

Daily and Accumulated Precipitation at Selected Sites

12/20/96–01/06/97

NORTHERN NEVADA WATERBASIN PRECIPITATION LEVELS

Daily and Accumulated Precipitation Levels at Specific Sites--Part 1

December 20, 1996--January 6, 1997

Basins/Dates	12/20	12/21	12/22	12/23	12/24	12/25	12/26	12/27	12/28	12/29	12/30	12/31	01/01	01/02	01/03	01/04	01/05	01/06
Lake Tahoe Basin																		
Tahoe City	0.00	2.17	1.77	1.24	0.00	0.00	0.08	1.76	0.14	0.05	1.72	1.22	2.43	4.65	1.58	0.00	0.01	T
Accumulated	0.00	2.17	3.94	5.18	5.18	5.18	5.26	7.02	7.16	7.21	8.93	10.15	12.58	17.23	18.81	18.81	18.82	18.82
Truckee River Basin																		
Truckee	0.00	1.90	1.40	0.88	0.00	0.00	0.40	1.85	0.40	0.11	1.35	1.03	1.70	4.60	1.30	0.20	0.10	0.00
Accumulated	0.00	1.90	3.30	4.18	4.18	4.18	4.58	6.43	6.83	6.94	8.29	9.32	11.02	15.62	16.92	17.12	17.22	17.22
Boca	0.00	2.38	1.95	1.15	0.00	0.00	0.02	1.64	0.13	0.00	1.55	0.86	1.26	2.36	1.10	0.00	0.03	0.00
Accumulated	0.00	2.38	4.33	5.48	5.48	5.48	5.50	7.14	7.27	7.27	8.82	9.68	10.94	13.30	14.40	14.40	14.43	14.43
Reno	0.06	0.93	0.23	0.00	0.00	T	0.18	0.07	0.00	0.69	T	T	0.36	0.85	T	T	0.03	0.00
Accumulated	0.06	0.99	1.22	1.22	1.22	1.22	1.40	1.47	1.47	2.16	2.16	2.16	2.52	3.37	3.37	3.37	3.40	3.40
Sparks	0.00	0.31	0.88	0.16	0.00	0.00	0.00	0.38	0.00	0.00	0.39	0.00	0.00	0.35	0.53	0.00	T	0.00
Accumulated	0.00	0.31	1.19	1.35	1.35	1.35	1.35	1.73	1.73	1.73	2.12	2.12	2.12	2.47	3.00	3.00	3.00	3.00
Stead	0.00	0.40	0.77	0.10	0.00	0.00	0.00	1.20	0.00	0.00	1.57	0.00	0.19	1.22	0.50	0.00	T	0.00
Accumulated	0.00	0.40	1.17	1.27	1.27	1.27	1.27	2.47	2.47	2.47	4.04	4.04	4.23	5.45	5.95	5.95	5.95	5.95
Carson River Basin																		
Markleeville	0.00	0.83	1.38	0.31	0.00	0.00	0.03	0.85	0.00	T	1.21	0.21	1.40	2.90	1.53	0.00	0.14	0.08
Accumulated	0.00	0.83	2.21	2.52	2.52	2.52	2.55	3.40	3.40	3.40	4.61	4.82	6.22	9.12	10.65	10.65	10.79	10.87
Minden	0.77	1.01	0.13	0.00	0.00	0.00	0.20	0.00	0.00	0.67	0.00	0.33	1.35	1.14	0.00	0.05	0.03	0.00
Accumulated	0.77	1.78	1.91	1.91	1.91	1.91	2.11	2.11	2.11	2.78	2.78	3.11	4.46	5.60	5.60	5.65	5.68	5.68
Carson City	0.00	0.40	0.03	0.67	0.00	0.00	0.10	0.47	0.00	0.33	0.13	T	0.86	1.73	0.65	0.00	0.03	0.00
Accumulated	0.00	0.40	0.43	1.10	1.10	1.10	1.20	1.67	1.67	2.00	2.13	2.13	2.99	4.72	5.37	5.37	5.40	5.40
Virginia City	0.75	1.67	0.80	0.00	0.00	0.00	0.68	T	0.00	0.36	T	T	T	0.98	0.76	T	T	T
Accumulated	0.75	2.42	3.22	3.22	3.22	3.22	3.90	3.90	3.90	4.26	4.26	4.26	4.26	5.24	6.00	6.00	6.00	6.00

See notes at end of table.

NORTHERN NEVADA WATERBASIN PRECIPITATION LEVELS

Daily and Accumulated Precipitation Levels at Specific Sites--Part 2

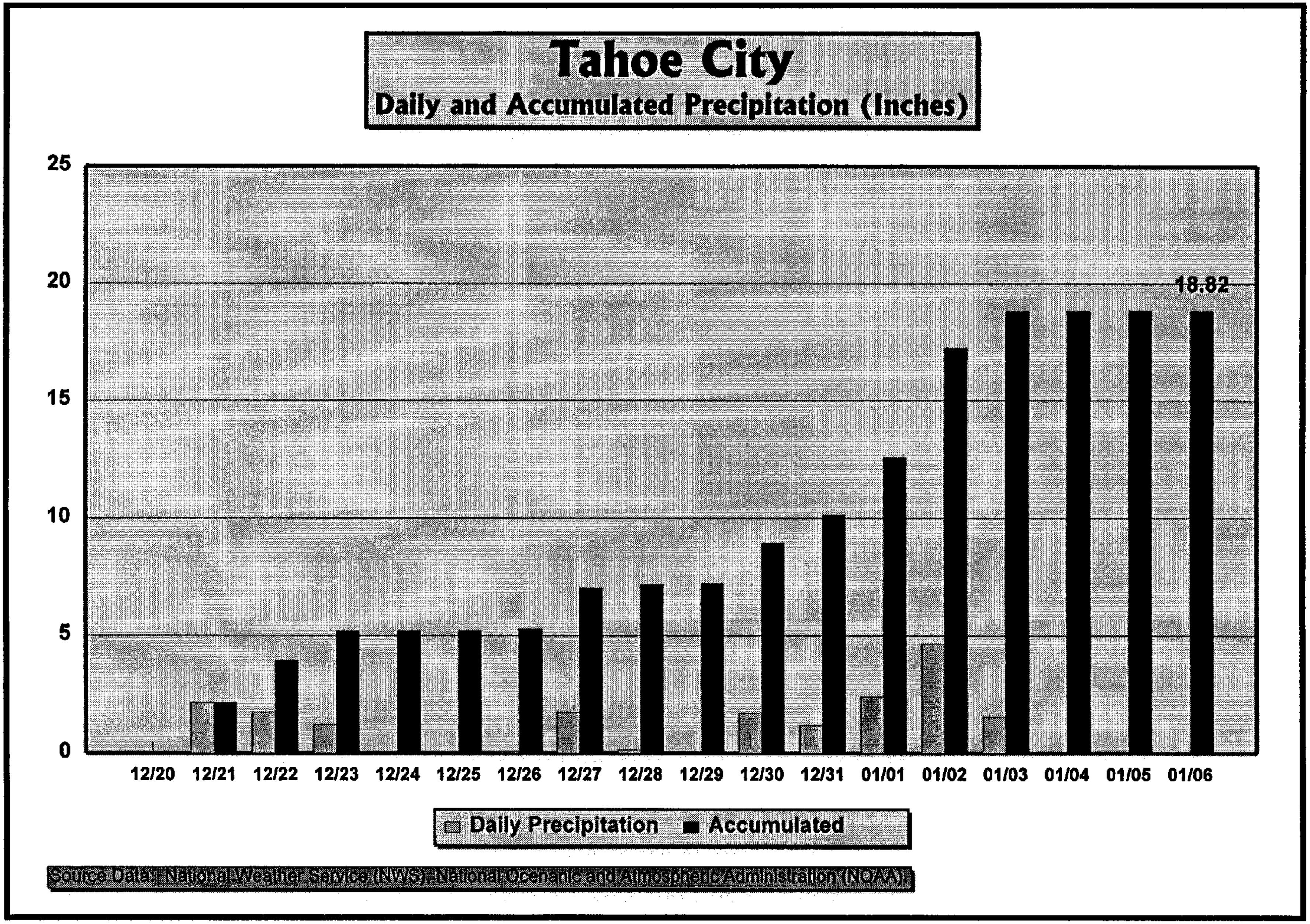
December 20, 1996--January 6, 1997

Basins/Dates	12/20	12/21	12/22	12/23	12/24	12/25	12/26	12/27	12/28	12/29	12/30	12/31	01/01	01/02	01/03	01/04	01/05	01/06
Walker River Basin																		
Bridgeport	0.00	0.58	2.00	0.35	0.00	0.00	T	0.10	0.00	T	0.37	0.00	0.03	0.26	1.40	0.00	0.10	0.20
Accumulated	0.00	0.58	2.58	2.93	2.93	2.93	2.93	3.03	3.03	3.03	3.40	3.40	3.43	3.69	5.09	5.09	5.19	5.39
Topaz Lake	0.59	0.64	0.28	0.00	0.00	0.00	0.16	0.00	0.00	0.41	0.00	0.00	0.72	1.26	0.00	0.10	T	0.00
Accumulated	0.59	1.23	1.51	1.51	1.51	1.51	1.67	1.67	1.67	2.08	2.08	2.08	2.80	4.06	4.06	4.16	4.16	4.16
Smith	0.00	0.57	0.08	0.00	0.00	0.00	0.05	0.00	0.00	0.25	0.00	0.00	0.11	0.78	0.00	0.07	0.03	0.00
Accumulated	0.00	0.57	0.65	0.65	0.65	0.65	0.70	0.70	0.70	0.95	0.95	0.95	1.06	1.84	1.84	1.91	1.94	1.94
Yerington	T	0.37	0.03	0.00	0.00	T	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.79	0.00	0.02	0.00	0.00
Accumulated	T	0.37	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.43	0.43	0.43	0.44	1.23	1.23	1.25	1.25	1.25
Wabuska	0.00	0.10	0.30	0.00	0.00	0.00	0.00	0.04	0.00	0.00	T	0.00	0.00	0.30	0.65	0.00	0.00	0.00
Accumulated	0.00	0.10	0.40	0.40	0.40	0.40	0.40	0.44	0.44	0.44	0.44	0.44	0.44	0.74	1.39	1.39	1.39	1.39

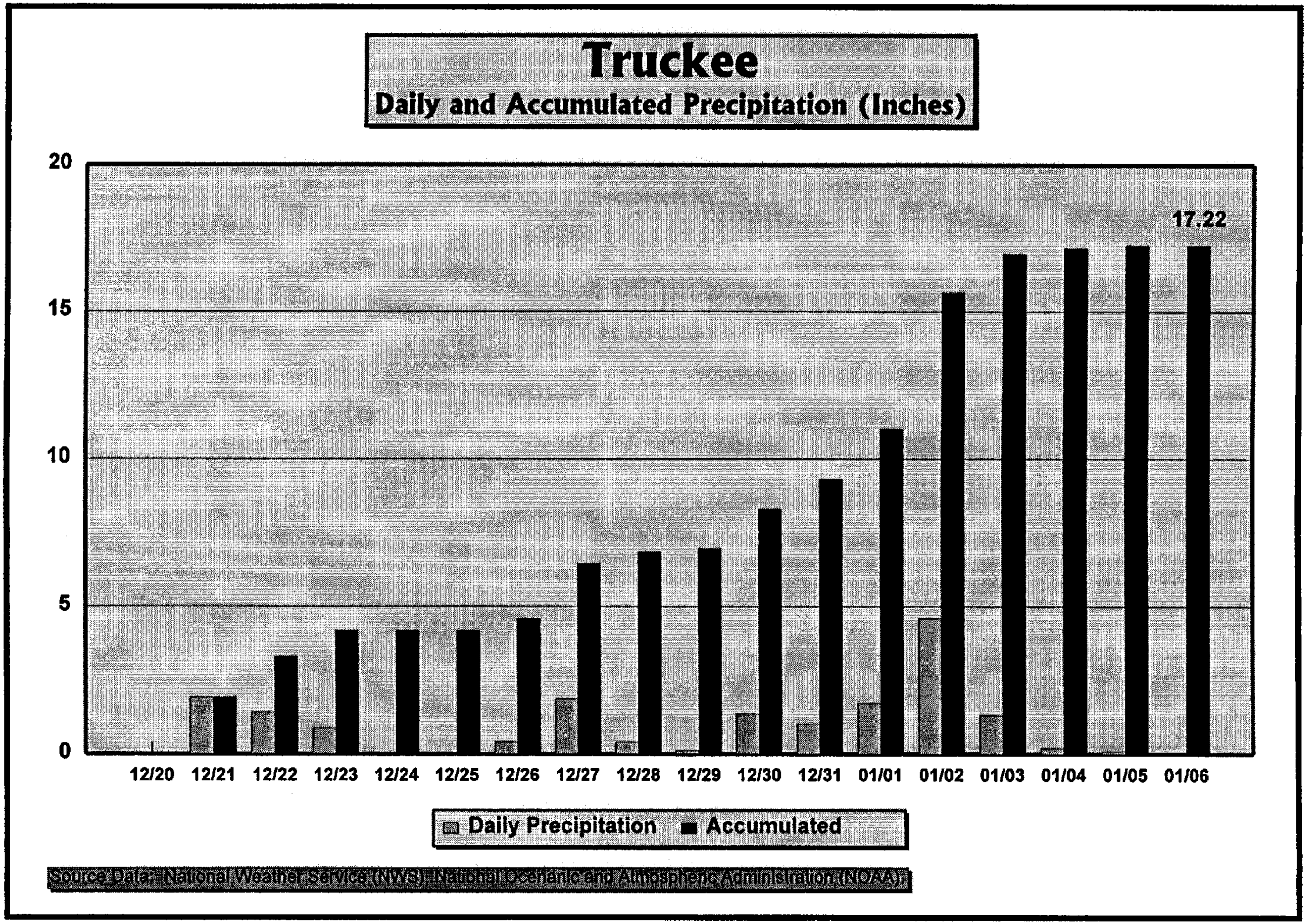
Note: Measurement recording times vary for each gaging station--Tahoe City (0800); Truckee (0800); Boca (0800); Reno Air Port (Midnight); Sparks (1600); Stead (0700); Markleeville (0700); Minden (0800); Carson City (1700); Virginia City (0700); Bridgeport (1600); Topaz Lake (0700); Smith (1800); Yerington (0800); Wabuska (0800). All times based on 24-hour clock, e.g., 0800 = 8:00 a.m.; 1600 = 4:00 p.m.

T = Trace precipitation

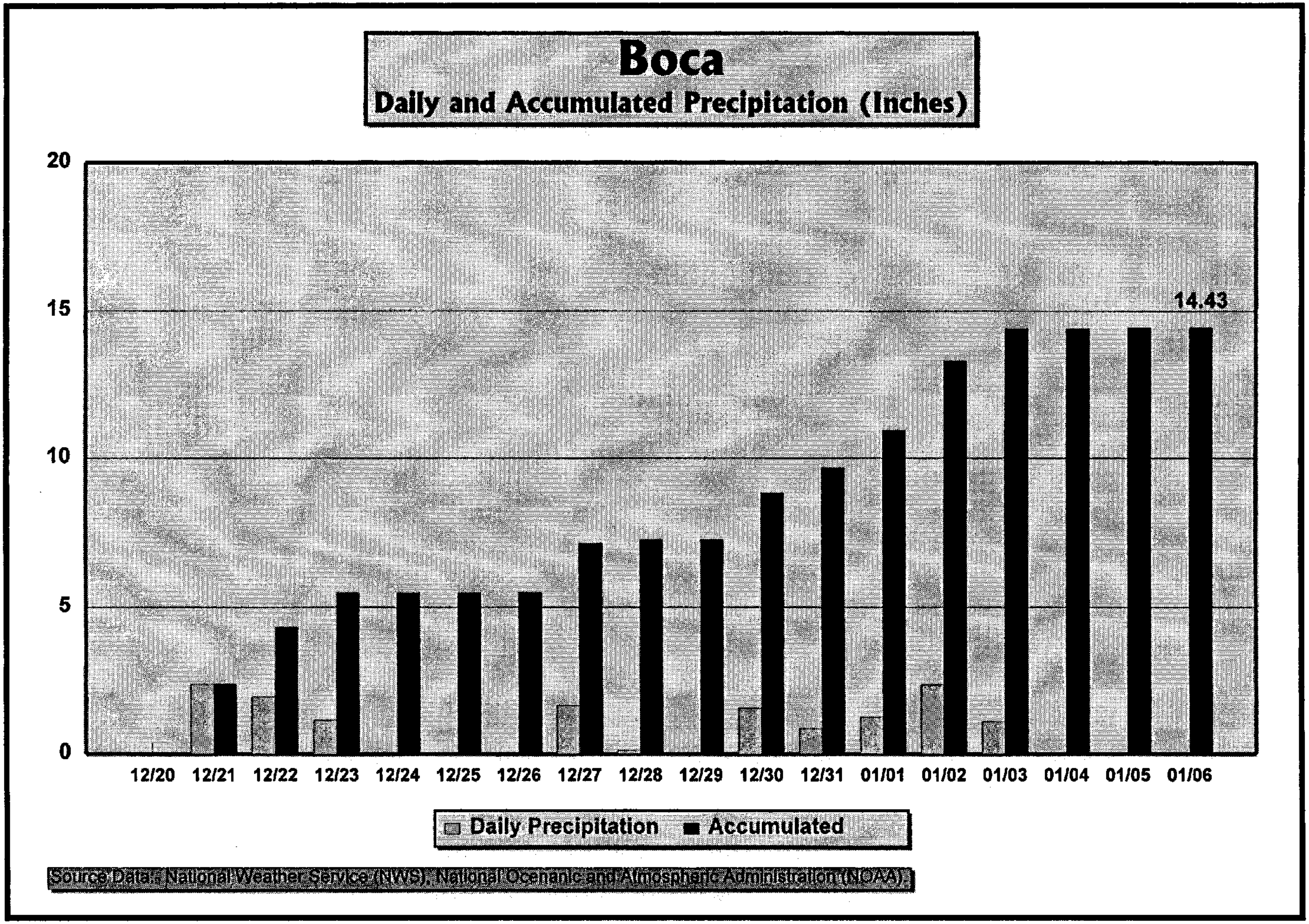
Source Data: National Weather Service (NWS), National Ocenanic and Atmospheric Administration (NOAA).

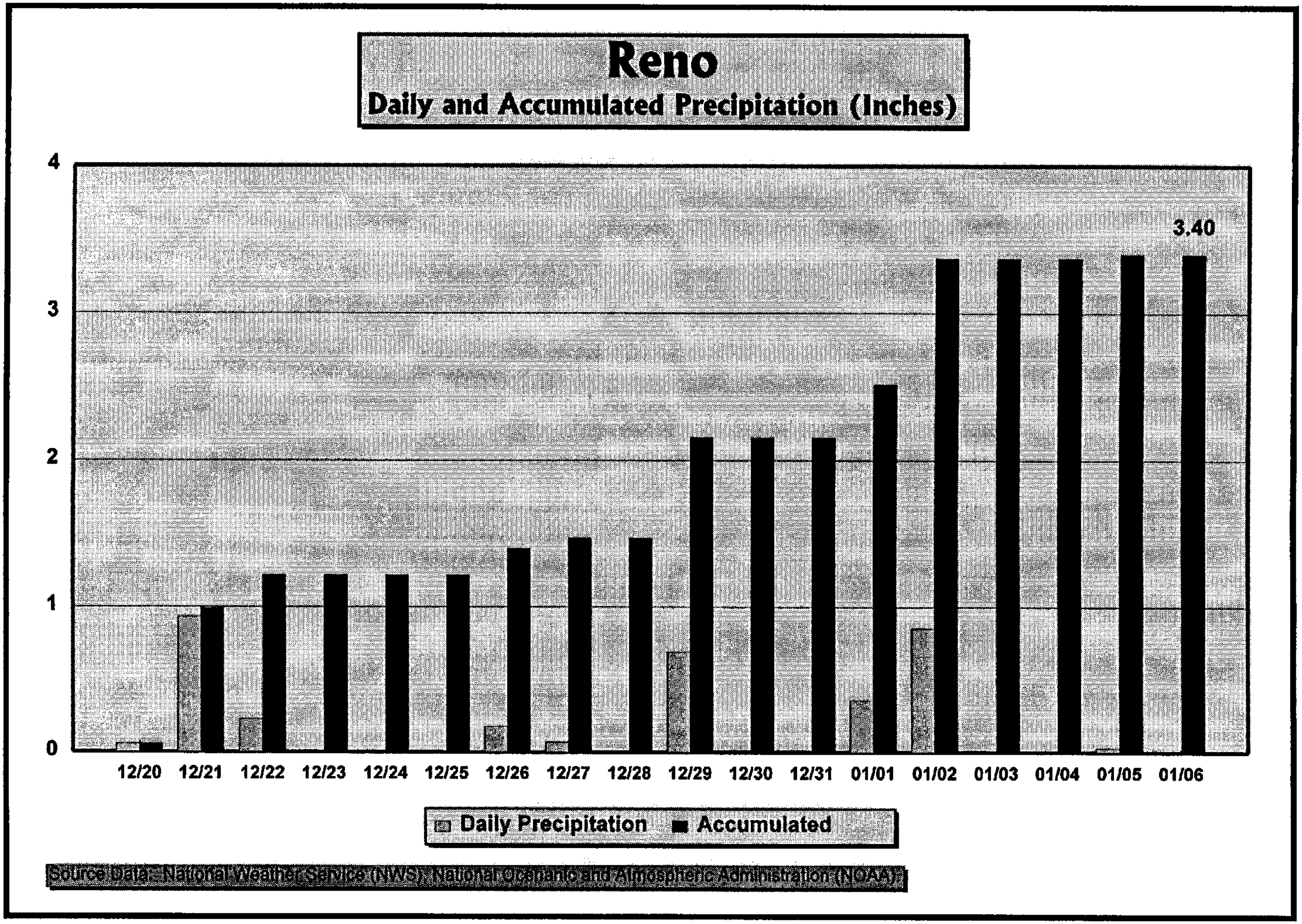


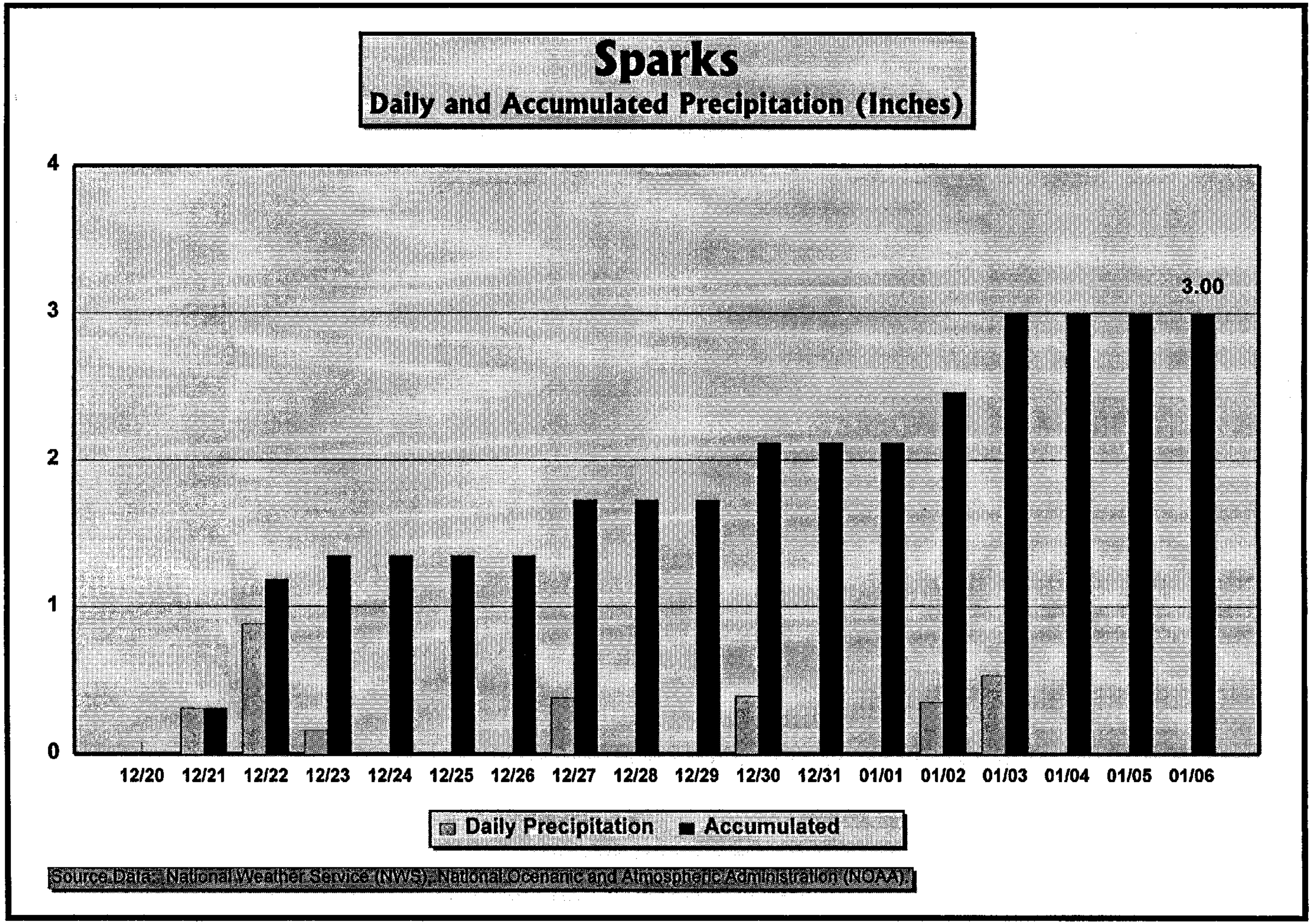
Tahoe City
Daily and Accumulated Precipitation (Inches)
25
20
15
10
5
0
18.82
12/20 12/21 12/22 12/23 12/24 12/25 12/26 12/27 12/28 12/29 12/30 12/31 01/01 01/02 01/03 01/04 01/05 01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA)



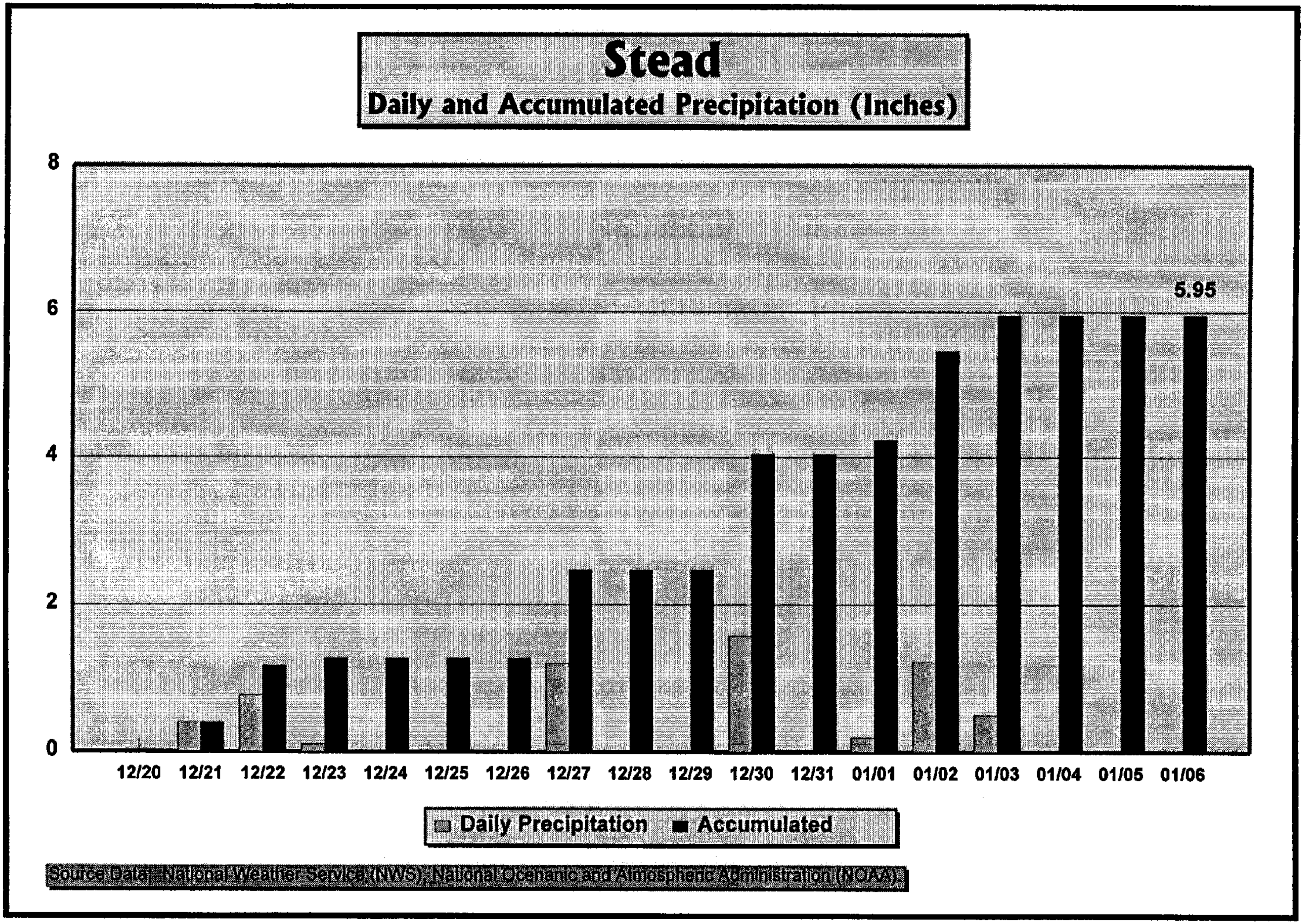
Truckee
Daily and Accumulated Precipitation (Inches)
20
15
10
5
0
17.22
12/20 12/21 12/22 12/23 12/24 12/25 12/26 12/27 12/28 12/29 12/30 12/31 01/01 01/02 01/03 01/04 01/05 01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA)


Boca
Daily and Accumulated Precipitation (Inches)
20
15
10
5
0
14.43
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).

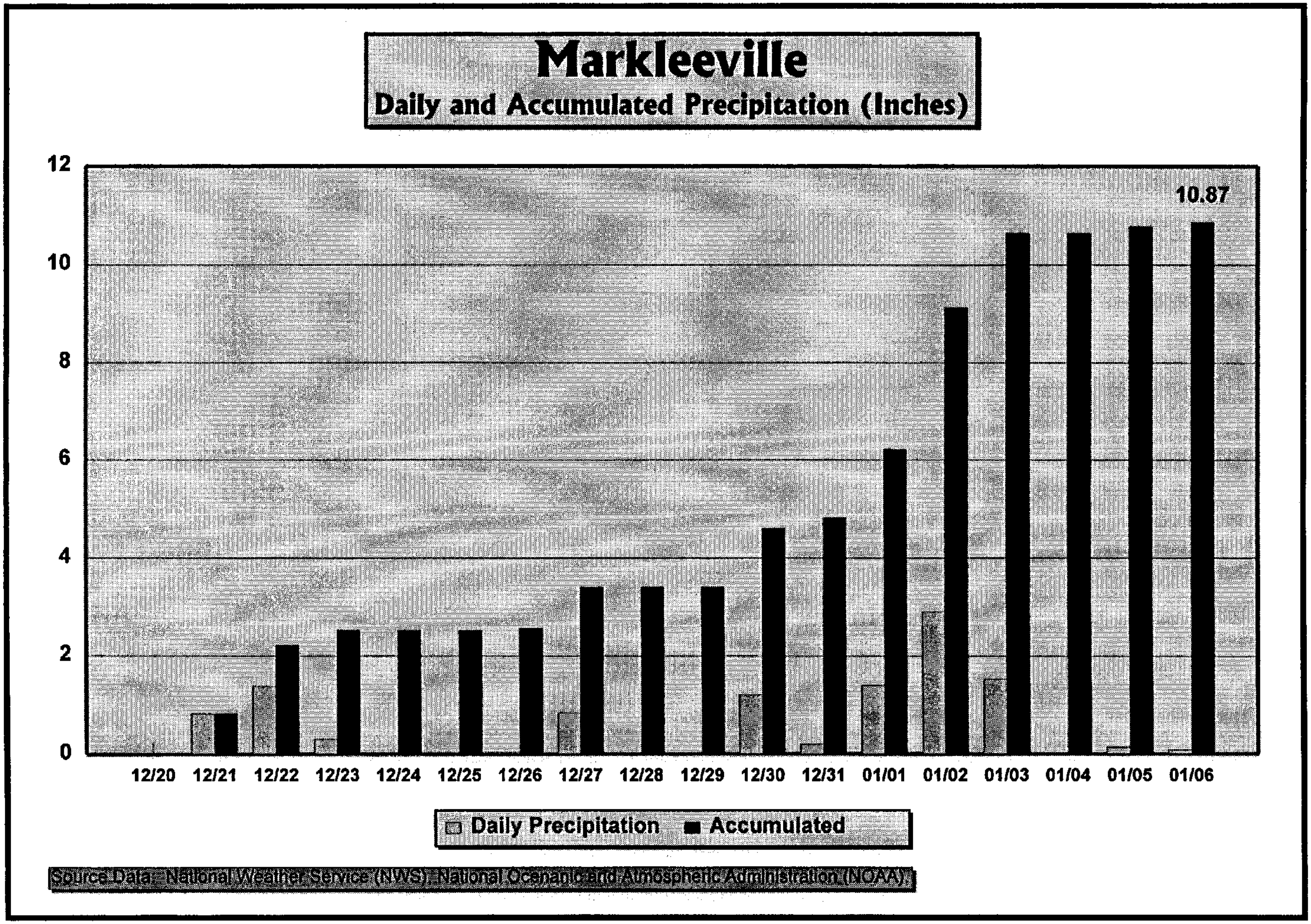

Reno
Daily and Accumulated Precipitation (Inches)
4
3
2
1
0
3.40
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA)



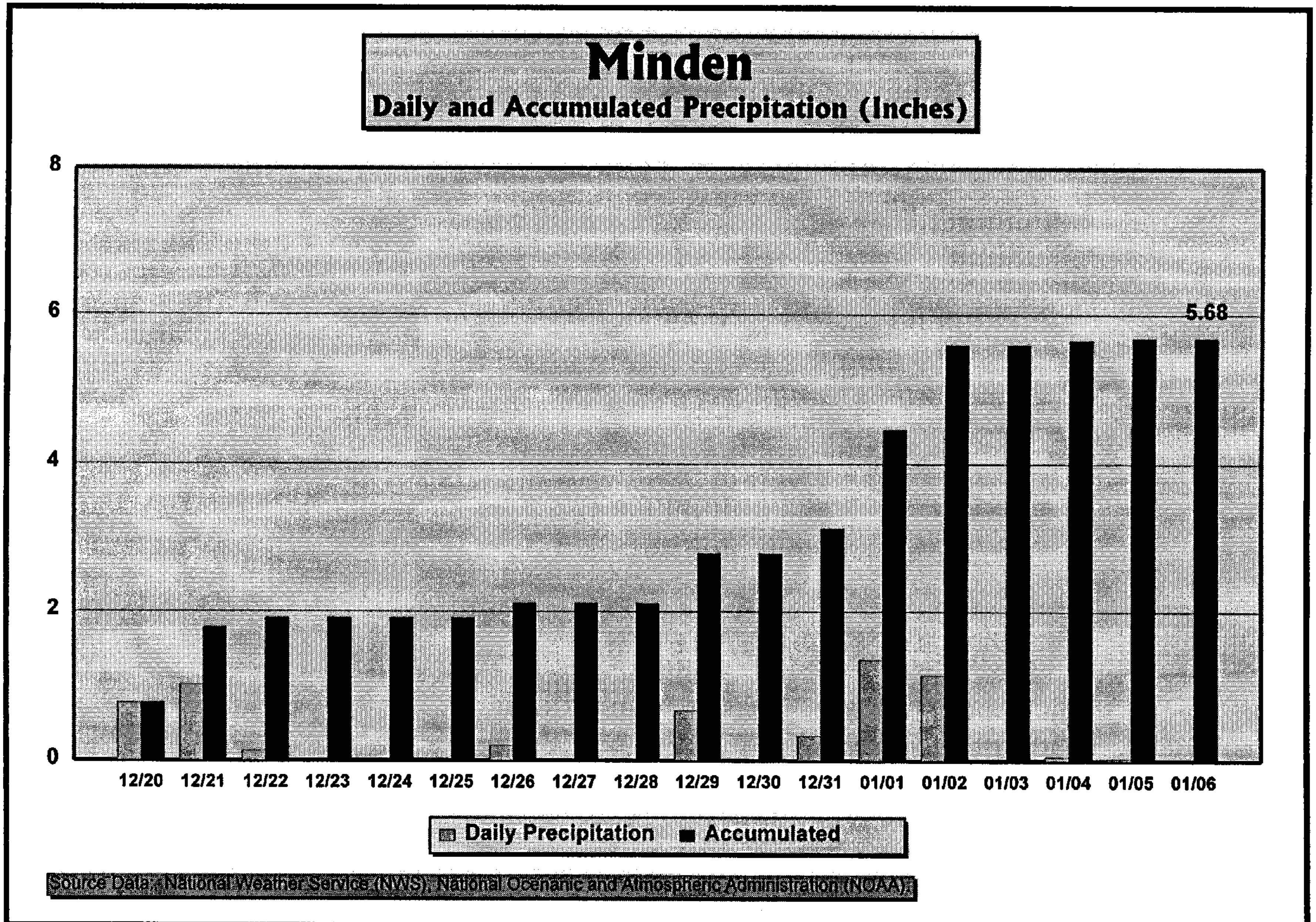
Sparks
Daily and Accumulated Precipitation (Inches)
4
3
2
1
0
3.00
12/20 12/21 12/22 12/23 12/24 12/25 12/26 12/27 12/28 12/29 12/30 12/31 01/01 01/02 01/03 01/04 01/05 01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).



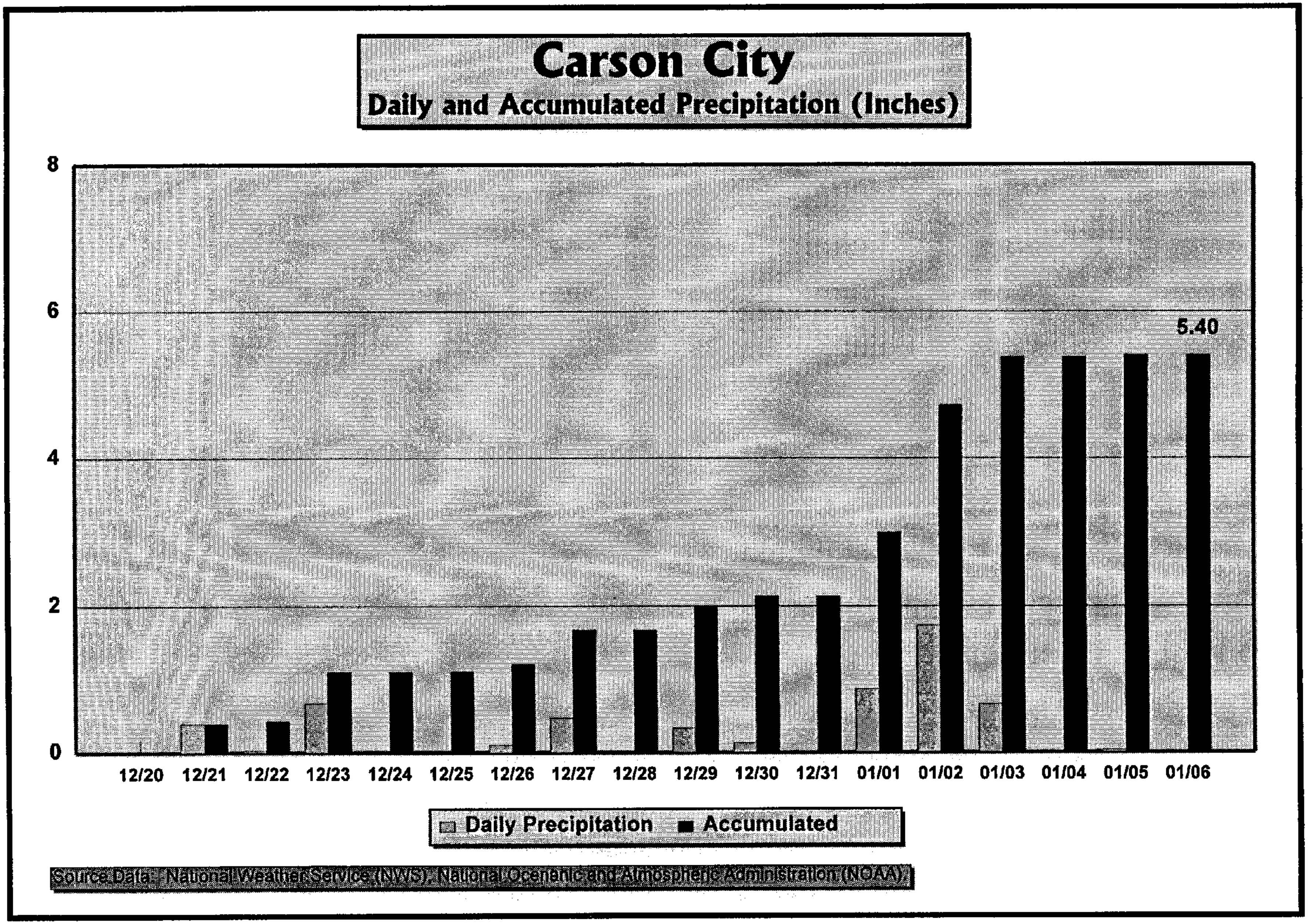
Stead
Daily and Accumulated Precipitation (Inches)
8
6
4
2
0
5.95
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).



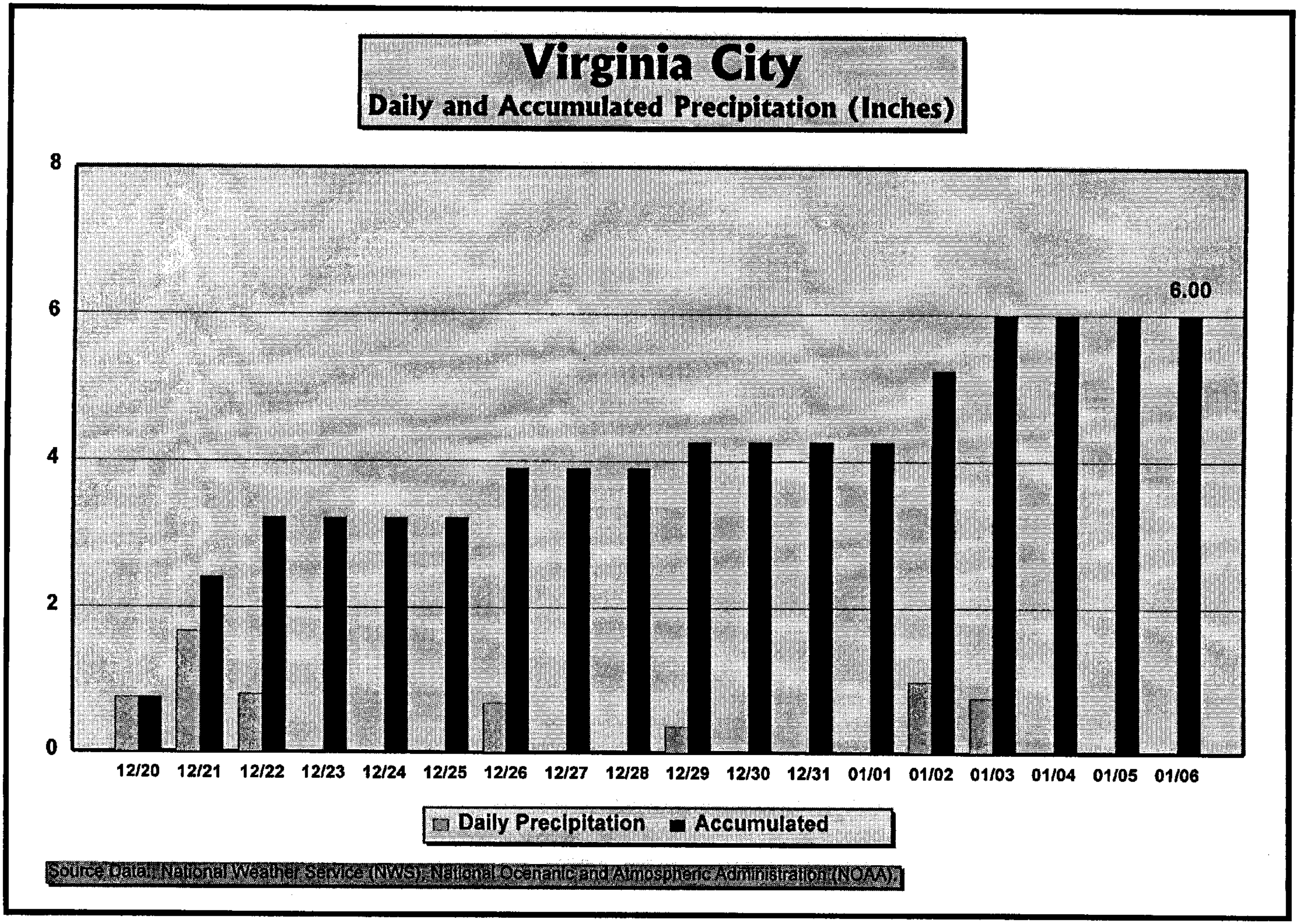
Markleeville
Daily and Accumulated Precipitation (Inches)
12
10
8
6
4
2
0
10.87
12/20 12/21 12/22 12/23 12/24 12/25 12/26 12/27 12/28 12/29 12/30 12/31 01/01 01/02 01/03 01/04 01/05 01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).



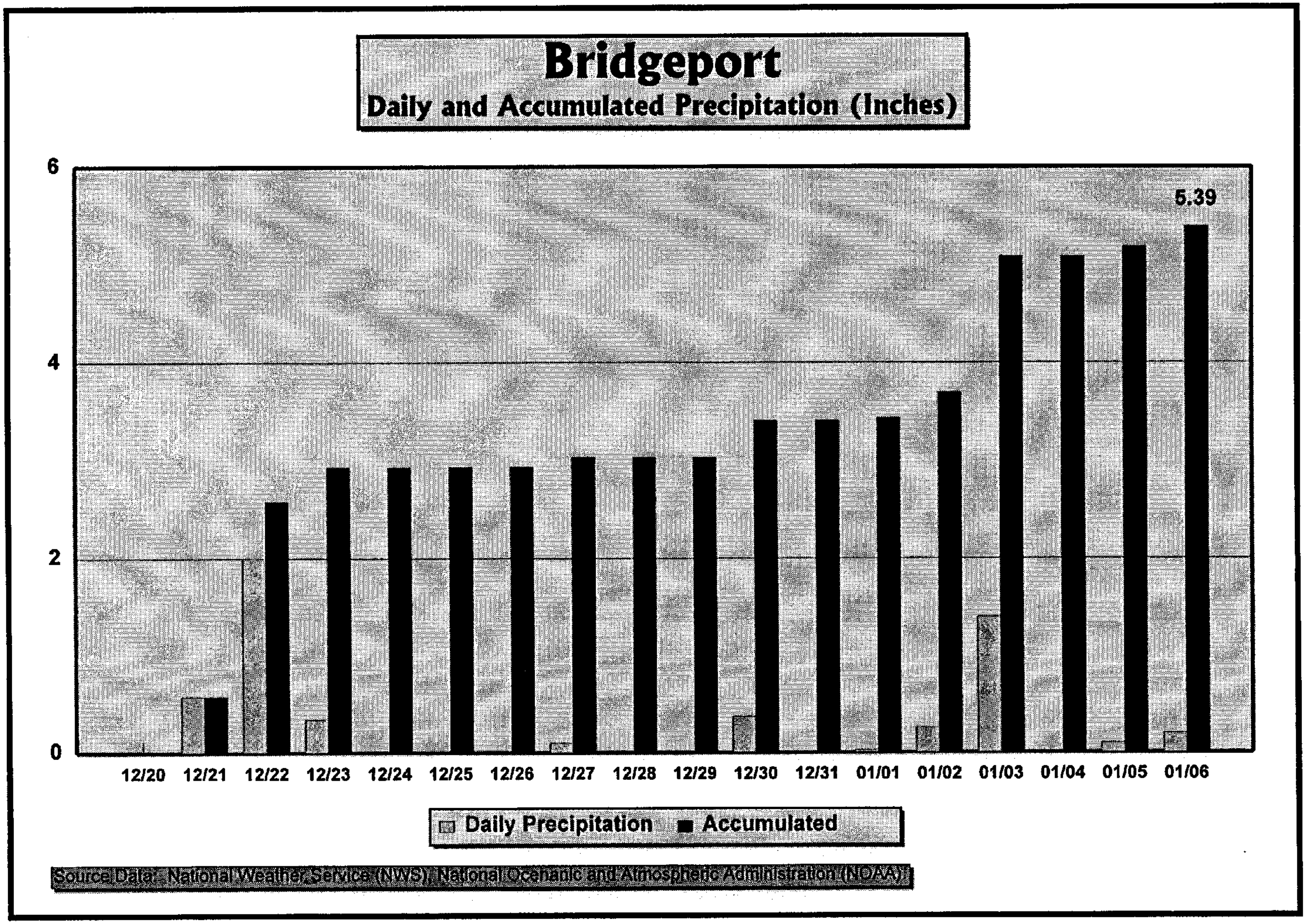
Minden
Daily and Accumulated Precipitation (Inches)
8
6
4
2
0
5.68
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).



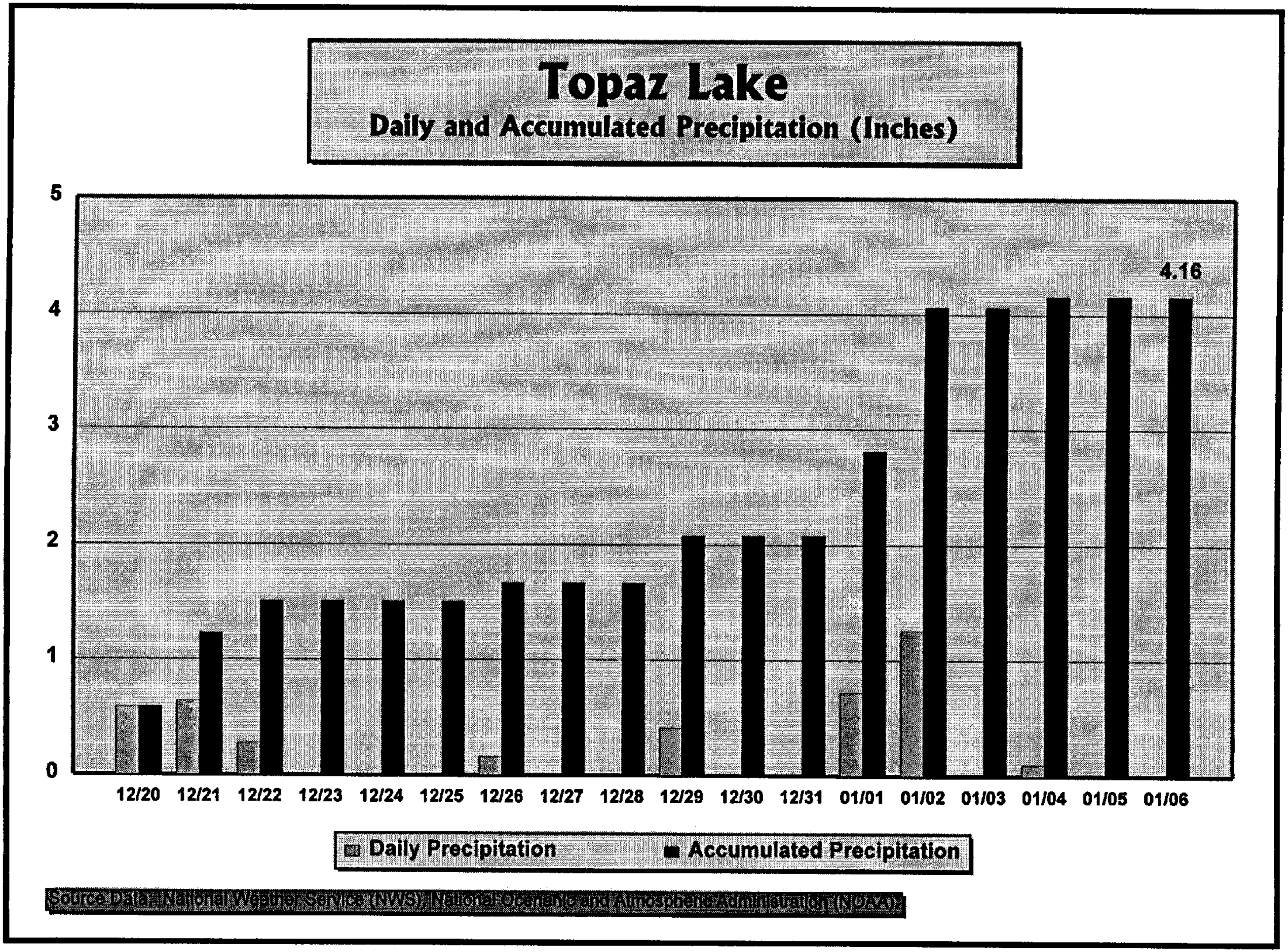
Carson City
Daily and Accumulated Precipitation (Inches)
8
6
4
2
0
5.40
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).

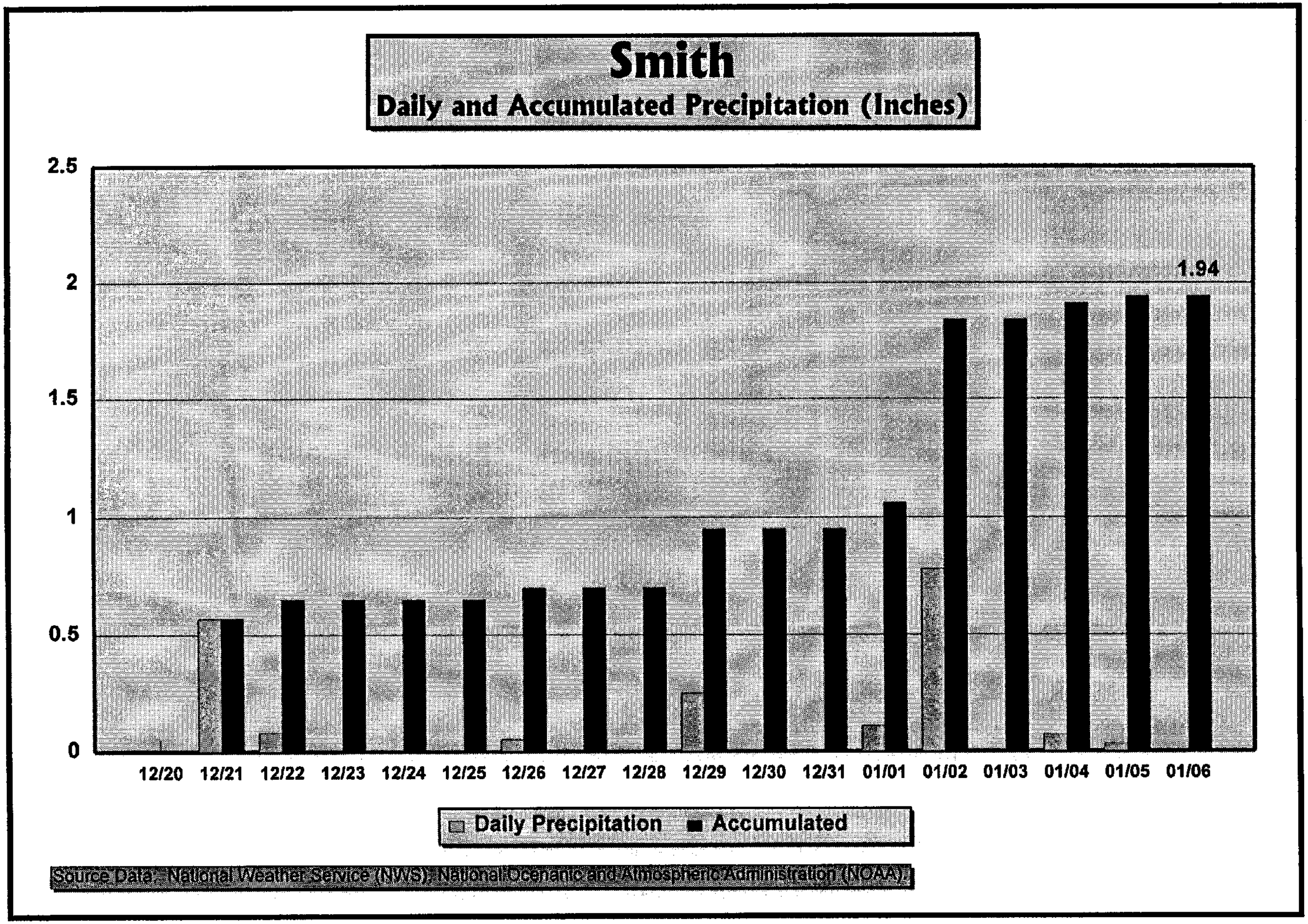


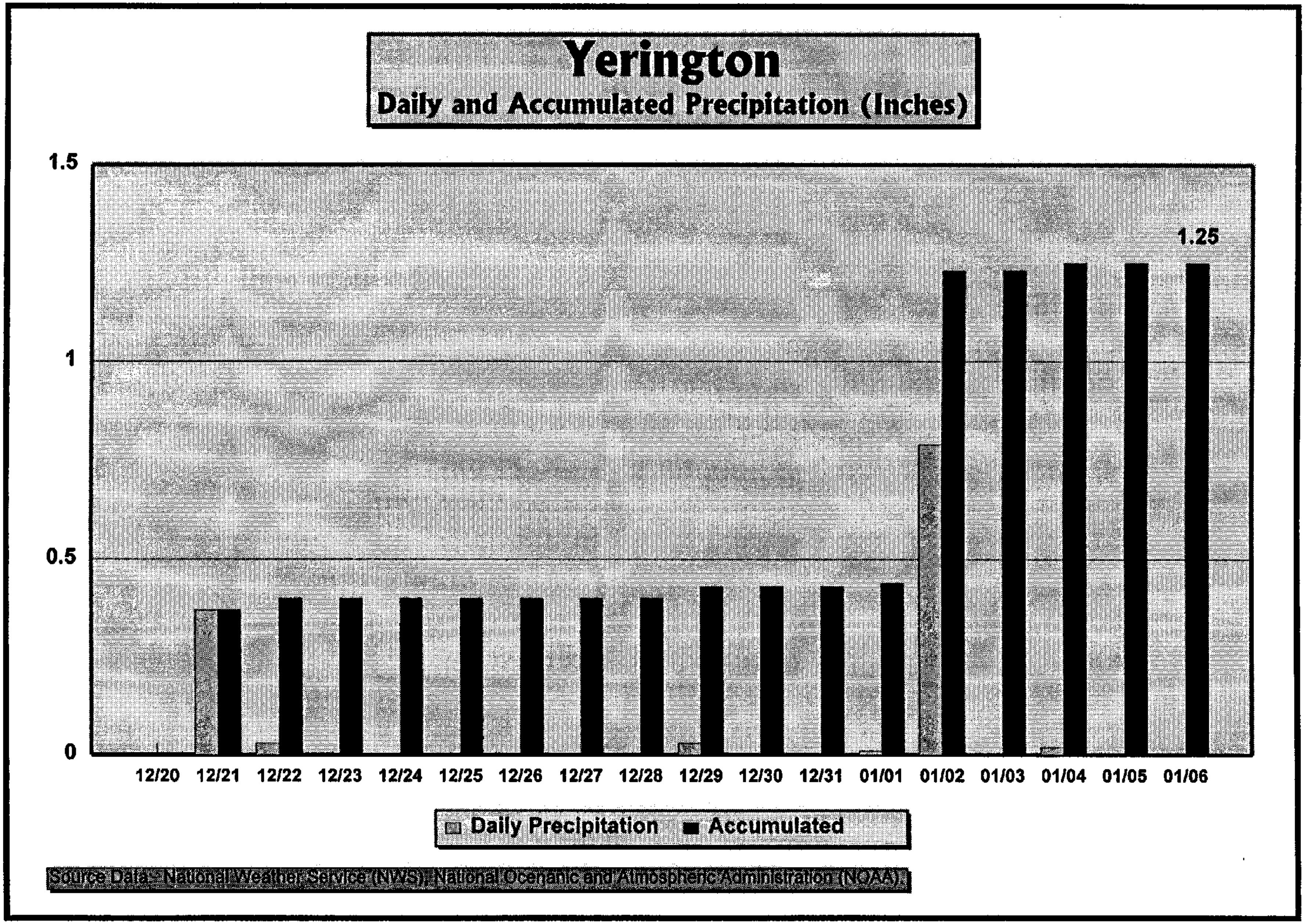
Virginia City
Daily and Accumulated Precipitation (Inches)
8
6
4
2
0
6.00
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).

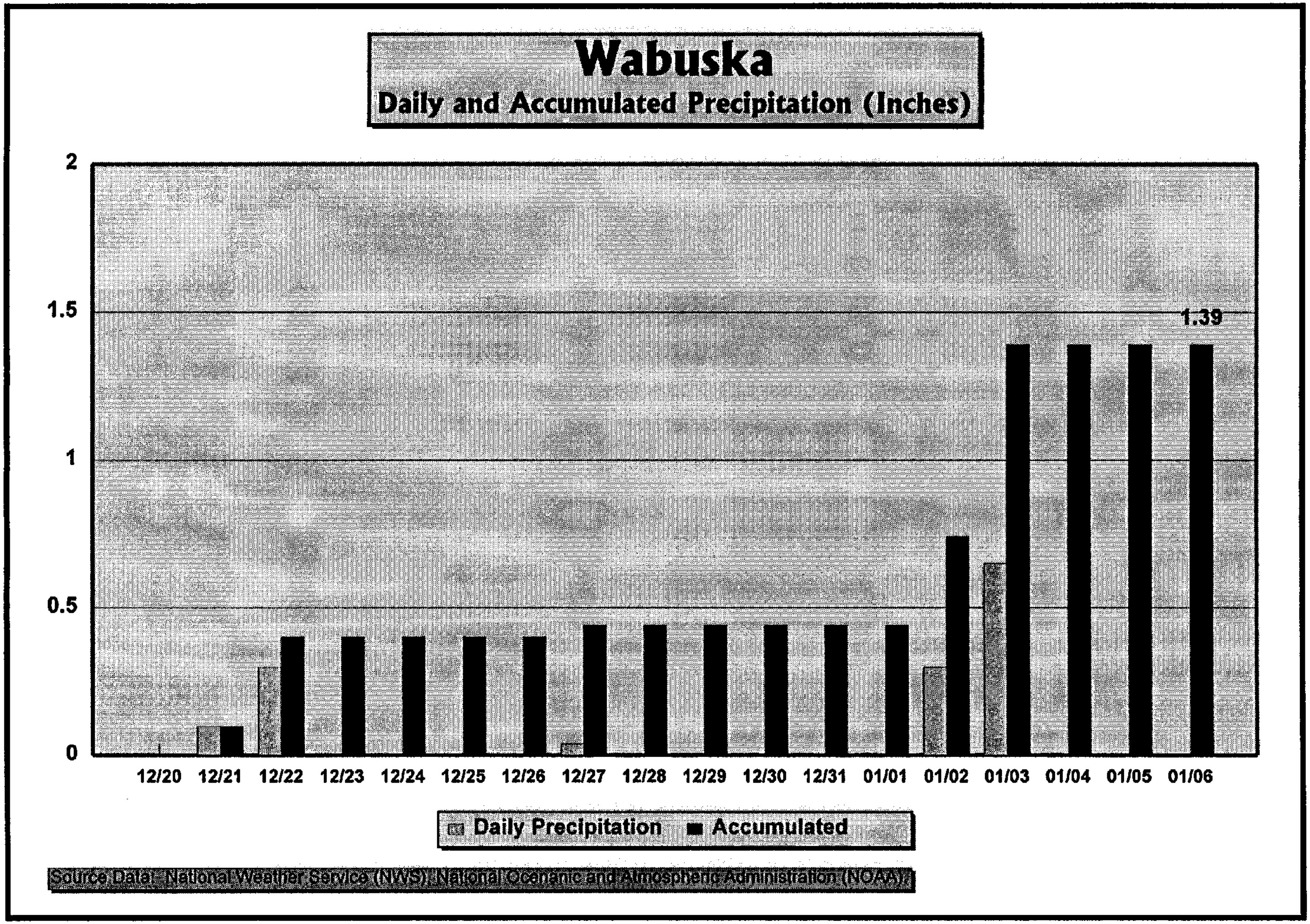


Bridgeport
Daily and Accumulated Precipitation (Inches)
6
4
2
0
5.39
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA)


Topaz Lake
Daily and Accumulated Precipitation (Inches)
5
4
3
2
1
0
4.16
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated Precipitation
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA)


Smith
Daily and Accumulated Precipitation (Inches)
2.5
2
1.5
1
0.5
0
1.94
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).


Yerington
Daily and Accumulated Precipitation (Inches)
1.5
1
0.5
0
1.25
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data - National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA).



Wabuska
Daily and Accumulated Precipitation (Inches)
2
1.5
1
0.5
0
1.39
12/20
12/21
12/22
12/23
12/24
12/25
12/26
12/27
12/28
12/29
12/30
12/31
01/01
01/02
01/03
01/04
01/05
01/06
Daily Precipitation
Accumulated
Source Data: National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA)

Notes

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