

NRBIB: MDE-1073
7/14/95

NRBib 86899

THE OCCURRENCE OF SPRINGS AND SEEPS
IN MESA VERDE NATIONAL PARK

ER 542

Hydrogeology

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November 28, 1989

INTRODUCTION

Purpose and Scope

One hundred and twenty water sources in Mesa Verde National Park (MEVE) in southwestern Colorado have been identified as springs and seeps. In 1989, the National Park Service (NPS) developed a computer database of the water sources in Mesa Verde National Park which includes these springs and seeps. The database contains information on the geologic formations and the elevations at which these springs and seeps occur as well as flow measurements for some of the springs and seeps. Estimates of the vegetative area supported by different springs and seeps have also been made and used to calculate evapotranspiration (ET) which is used as an indicator of the spring or seep's discharge. Some information on the chemical characteristics of water samples collected at various springs and seeps in MEVE is also available. The purpose of this report is to discuss the occurrence of the springs and seeps in MEVE within a hydrogeologic framework based on the available information. The attached map shows the location of springs and seeps in MEVE and the geologic formations they are associated with.

GEOGRAPHY

Topography and Drainage

MEVE is part of a highly dissected tableland which rises

nearly 2,000 feet above the surrounding plain known as the Dolores Plateau. The surface of the Mesa Verde gradually slopes to the south and ranges in elevation from about 7,000 to 8,500 feet above mean sea level (MSL) within the boundaries of MEVE. In some instances, the streams which drain the Mesa Verde to the south have eroded headward until they have reached its north rim. For the most part, these streams drain into the Mancos River which forms part of the eastern boundary of the park.

Climate

The Mesa Verde area has a semiarid climate. At the climatological station operated at MEVE since 1922, the average annual precipitation for 1922-1987 was 18 inches, with most of the precipitation occurring in the form of snow or summer thundershowers. The mean average January and July temperatures for the same period of record are 29.3 and 72.2 degrees Fahrenheit, respectively (Colorado Climate Center, 1989).

GEOLOGY

The principal geologic formations within the boundaries of MEVE include the following sedimentary rocks of the Cretaceous period: Dakota sandstone, Mancos shale, Point Lookout sandstone, Menefee formation, and Cliff House sandstone. Some Tertiary igneous rocks in dikes are also visible on the surface within the park boundaries. In addition, Quaternary surficial deposits of

alluvium, colluvium, and high level terrace and pediment gravels occur in localized areas. The brief descriptions of the geologic formations which follow are taken primarily from Wanek (1954 and 1959).

Dakota Sandstone

The Dakota sandstone is the oldest exposed sedimentary formation in MEVE and the base of the formation is not exposed in the park. The Dakota sandstone is a grayish to yellowish-orange crossbedded sandstone interspersed with lenses of carbonaceous shale and lenticular coal. This formation only outcrops on the downside of the Mesa Verde to the north and near the Mancos River. The Dakota sandstone is overlain in a few areas by colluvium and alluvial deposits of soil, sand and gravel.

Mancos Shale

The 2000-foot thick Mancos shale formation lies on top of Dakota sandstone and consists primarily of a soft dark-gray to black marine shale. It contains thin lenses and concretions of sandy yellowish-orange limestone, and at the top of the formation, it intertongues with the Point Lookout sandstone.

Point Lookout Sandstone

This pale to yellowish-orange crossbedded marine sandstone includes an upper massive sandstone member about 235 feet thick and an alternating sandstone and shale member at the base ranging

in thickness from approximately 60 to 140 feet. The Point Lookout sandstone unit intertongues with the Mancos shale formation at its base and the Menefee formation along its upper surface.

Menefee Formation

The Menefee formation ranges in thickness from approximately 340 to 800 feet and includes layers of gray to grayish-orange lenticular crossbedded sandstone and dark-colored carbonaceous shale and coal beds. An upper coal member, a middle barren member, and a lower coal member occur within this formation locally. Along its top and bottom, this formation intertongues with the Cliff House and Point Lookout sandstones, respectively.

Cliff House Sandstone

The Cliff House sandstone is a pale to dark yellowish-orange crossbedded marine sandstone approximately 400 feet thick which contains thick beds of yellowish gray fossiliferous shale. At its base, it intertongues with the Menefee formation.

Igneous Rocks

Small bodies of igneous rocks, in the form of dikes, are intruded into the sedimentary layers in the Mancos Canyon area as well as at the southern end of the park. As indicated on the geologic map, all of the dikes within the park show northeasterly trends.

THE OCCURRENCE OF SPRINGS AND SEEPS AT MEVE

Background

Davis and DeWeist (1966) define a spring as any natural surface water discharge large enough to flow in a small rivulet. Any surface discharge less than this can be called a seep.

The discharge of springs and seeps is primarily determined by: (1) aquifer permeability, (2) the area contributing recharge to the aquifer, and (3) the quantity of recharge. Vertical or horizontal variations in permeability are the most common causes of springs and seeps (Davis and DeWeist), however changes in permeability resulting from faults and dikes can also cause springs and seeps to appear. The intersection of the watertable with the side of a surface depression such as a stream channel may also result in the occurrence of a spring or seep.

Springs and seeps may be classified based on numerous factors including: relation to geologic structure, magnitude, discharge, direction of water migration, relation to topography, chemical characteristics of the water, and water temperature. Based on the information available and the relative importance, the only factors which will be discussed regarding the occurrence of springs and seeps in MEVE are the relation to geologic structure, the discharge, and very briefly, the chemical characteristics of the water.

Relation to Geologic Structure

Although some of the springs and seeps in MEVE may be related to igneous dikes, on the database developed by the NPS, all of the springs and seeps have been identified by the sedimentary formation they are thought to be associated with.

These formations and the number of springs and seeps associated with the various formations are given below:

Cliff House sandstone - 36 water sources

Menefee formation - 59 water sources

Mancos shale - 17 water sources

Point Lookout sandstone - 6 water sources

The springs and seeps at MEVE can also be divided into three broad categories based on their apparent causes: (1) springs and seeps resulting from a stratigraphic control such as a shale layer underlying a sandstone layer, (2) springs and seeps associated with dikes, and (3) springs and seeps appearing in drainage channels, often where the alluvium is thinner.

The springs and seeps in Cliff House sandstone occur almost exclusively in the southern half of the park and almost all appear to result from a stratigraphic control. A few of the springs and seeps within this formation may appear in drainage channels. The elevations at which springs and seeps outcrop in the Cliff House sandstone range from 6540 to 7400 feet above MSL, with the higher elevations generally associated with the springs

and seeps which are further north. Thus, the differences in elevations are probably related to the slope of the formation.

Within the Menefee formation, the springs and seeps occur in places all over the park, mostly in drainage bottoms or at what appear to be contact points between different layers. At the southern end of the park, about five or six of the springs and seeps may be related to the presence of an igneous dike. Although none of the other water sources appear to be related to the presence of faults or dikes based on the faults and dikes shown on the geologic map, MEVE park staff are of the opinion that many other springs and seeps in MEVE, particularly those occurring in the north half of the park, may be related to faults and dikes (pers. comm.). Given that the springs and seeps in the northern part of the park are limited in their recharge area, it may very well be the case that these water sources are associated with, as yet unmapped, faults and dikes. The springs and seeps within the Menefee formation outcrop at elevations ranging from 6050 to 8400 feet above MSL, again with the higher elevations relating to the springs and seeps further to the north.

Springs and seeps within the Mancos shale are limited in their occurrence to the northern end of the park and along the Mancos River. Most appear to occur in the drainage channels. The approximate elevations at which these springs and seeps outcrop range from 6350 to 8050 feet above MSL. The springs and seeps at the lower elevations being those along the Mancos River.

The only places springs and seeps seem to occur within the

Point Lookout formation are in the drainage channels or at contact points between different layers along Prater and Morefield Canyons. Within the Point Lookout formation, the springs and seeps outcrop at elevations ranging from 7300 to 7950 feet above MSL. The springs and seeps occurring at the higher elevations, again, are further north.

It should be noted that for some of the springs and seeps, the formation listed on the database and shown on the geologic map do not coincide. Thus, additional field work may be necessary to verify the formations related to some of the water sources. For this report, it was assumed that the formations given on the NPS database are correct.

Discharge

Flow measurements have not been made for all of the springs and seeps at MEVE. For springs and seeps within the Cliff House sandstone, estimates of the flow have been made at eight of the water sources. These estimates range from 0.0125 to 3 gpm. Flows recorded for twenty of the springs and seeps within the Menefee formation range from 0.125 to 900 gpm. For springs and seeps within the Mancos shale, flow estimates have been made for 12 water sources and range from 0.125 gpm to 112 gpm. No flow measurements have been taken at any of the springs and seeps within the Point Lookout formation.

In addition to the recorded flows, calculations of the ET associated with the vegetation supported by the springs and seeps

in MEVE have been made. To estimate ET, the water sources were divided into four categories based on the amount of vegetation thought to be associated with different springs and seeps. The four divisions include: (1) springs and seeps within the Cliff House sandstone primarily resulting from stratigraphic controls, (2) springs and seeps within the Menefee formation which occur on slopes or at contact points between different layers, (3) springs and seeps within the Menefee formation thought to be associated with faults and dikes and the springs and seeps in the Mancos and Point Lookout formations, except those covered under the fourth classification, and (4) springs and seeps occurring in the drainage channels. The ET was estimated using the Blaney-Criddle method with the frost-free period assumed to start on May 14 and continue until October 15 or for 155 days each year. Based on the calculations made, the average ET associated with a type (1) spring or seep would be equivalent to continuous flow of approximately 0.1 gpm during the frost-free period. The average ET associated with a type (2) spring or seep would be approximately equal to a continuous flow of 0.01 gpm for that same period. The ET values calculated for the type (3) and (4) water sources would be equivalent to a steady flow of approximately 0.05 and 0.87 gpm, respectively during the frost-free period. Based on the amount of vegetation thought to be supported by these different types of water sources and the ET values calculated, the springs and seeps in the drainage channel appear to be the most productive, followed by the

stratigraphically controlled springs and seeps which emerge from the Cliff House sandstone.

Chemical Characteristics of the Water

The chemical characteristics of water samples taken at various springs and seeps will be mentioned briefly since it may support the theory that some of the springs and seeps are related to unmapped dikes and faults. Data from the analysis of water samples collected at MEVE were obtained for the years 1983, 1984, and 1986-1988. During these years, water samples were collected at 19 different springs and seeps in MEVE. One of the water sources sampled was #86, which appears to be associated with the dike at the south end of the park. The water sample analyzed for this source shows the water has higher values of electrical conductivity, sodium and sulfate than many of the other water samples analyzed from springs and seeps in MEVE. Water samples analyzed at springs and seeps in the general vicinity of the mapped dikes and in the northern half of the park also show high values for electrical conductivity, sodium, and sulfate, indicating that these other water sources may be associated with dikes as well. Obviously, a more in-depth study is necessary to determine whether the similarities in the values of some of the chemical constituents result from geologic similarities (the association of the water sources to dikes).

SUMMARY

Springs and seeps at MEVE occur within four different sedimentary formations (Cliff House sandstone, Menefee formation, Mancos shale, and Point Lookout sandstone) and some may also be associated with igneous dikes or faults. The possibility of unmapped igneous dikes and faults may be supported by the lack of recharge area for the springs and seeps in the northern part of the park and the possibility of unmapped dikes may also be supported by the differences in the chemical characteristics of the water from different springs and seeps in the park. Springs and seeps in the drainage channels appear to be the most productive given the calculated ET values which were based on estimates of the amount of vegetation different types of springs and seeps support.

REFERENCES

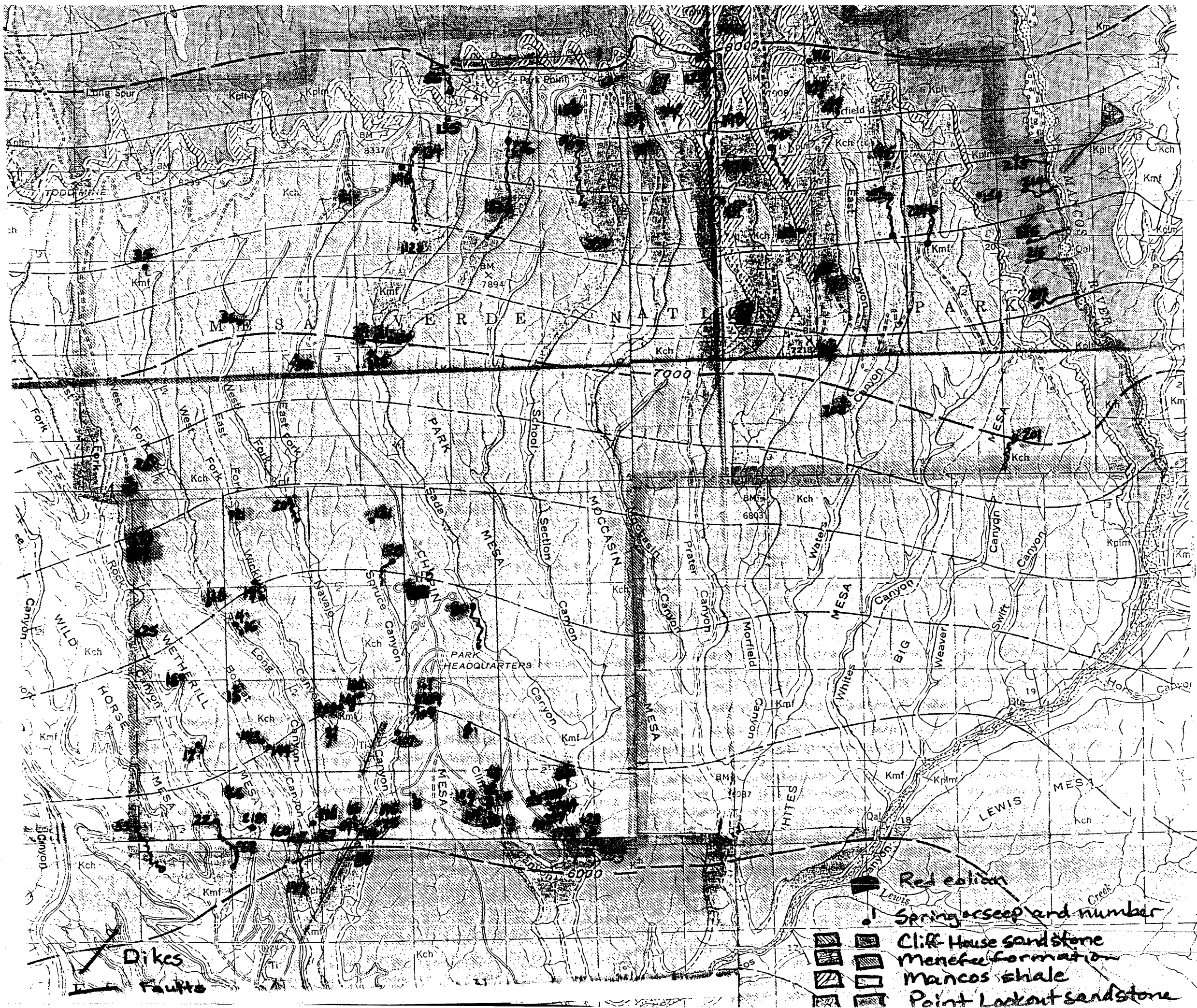
Colorado Climate Center, November, 1989, written communication.

Davis, Stanley N. and DeWeist, Roger J.M., 1966, Hydrogeology, John Wiley & Sons, Inc.

National Park Service staff, 1989, personal communication.

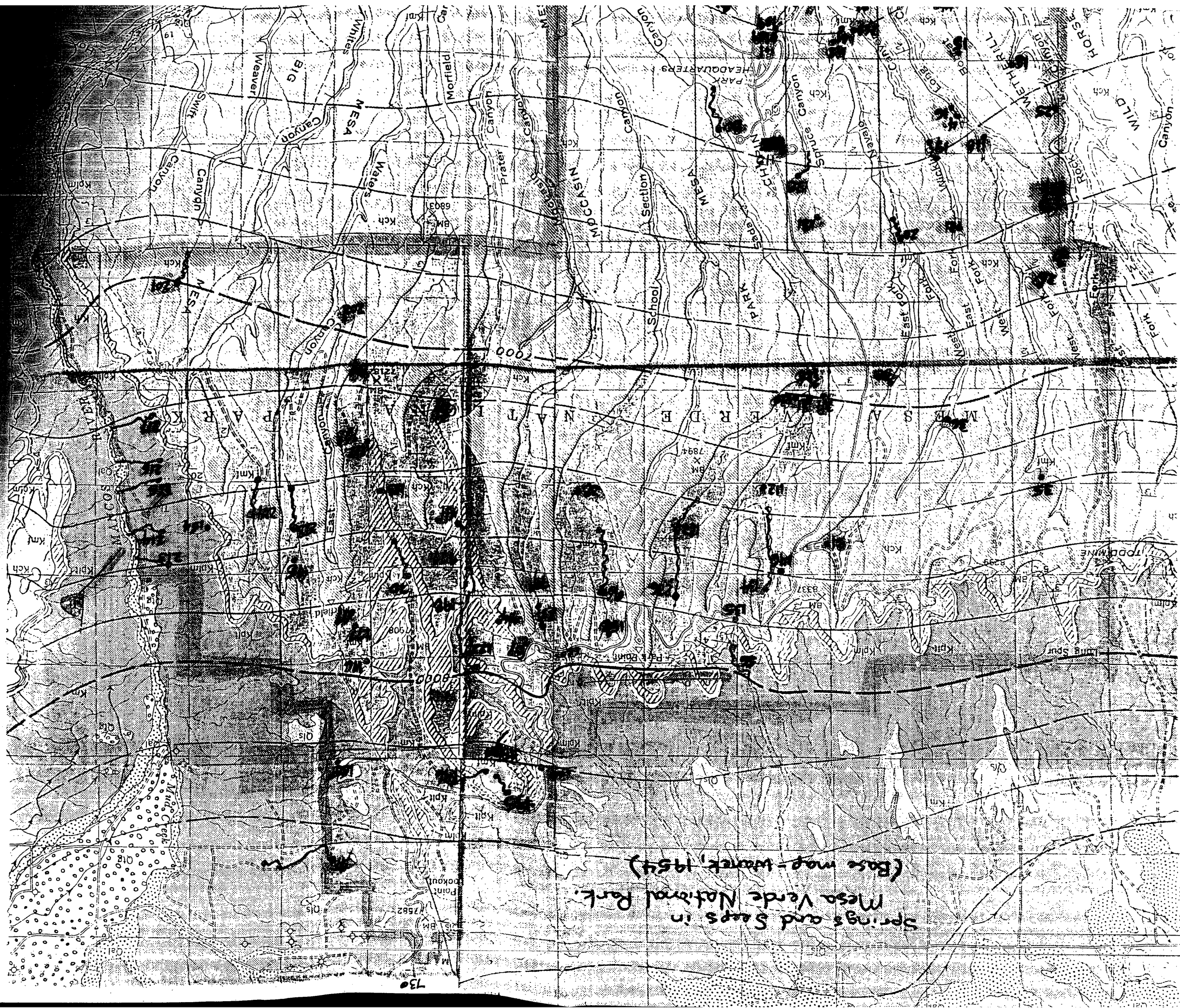
Wanek, A. A., 1954, Geologic map of the Mesa Verde area, Montezuma County, Colorado: U.S. Geological Survey Oil and Gas Investigations Map OM-152.

-----, 1959, Geology and fuel resources of the Mesa Verde area, Montezuma and La Plata Counties, Colorado: U.S. Geological Survey Bulletin 1072-M.



- Red soil
- Spring or seep and number
- Cliff House sandstone
- Menefee formation
- Mancos shale
- Point Lookout sandstone

(Base map - Wozdek, 1954)



Springs and Seeps in
Mesa Verde National Park.
(Base map - Waret, 1954)

