CHAPTER XXII. HYPERSPECTRAL REMOTE SENSING OF WATER QUALITY

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A. INTRODUCTION

Hydrologic assessments of the Little Washita River basin in southwest Oklahoma are a primary focus of Washita-94, a collaborative effort involving scientists from NASA and USDA-ARS and research faculty from several major universities. As a part of Washita-94, water samples from fifty small lakes within the watershed were collected several times during 1994 in an effort to document seasonal limnological characteristics. In addition to with the water sampling, narrow-band reflectance spectra were obtained for several lakes during April and August, 1994. Concurrent with the water quality sampling, radiance flux data were measured for each lake and for a reflectance panel using a Spectron Engineering SE 590 hand-held spectroradiometer. For each lake sampled, the radiance data (lake and panel) were combined to obtain reflectance for 252 narrow wavelength bands across the visible and near infrared. Nineteen lake reflectance spectra were obtained during the two field surveys. The data collected using the close range sensor provide high quality information that can be used to further our understanding of reflectance spectra from natural waters. In addition, the radiance data and reflectance spectra can be used to corroborate the visible and near infrared wavelength remote sensing data obtained from Landsat satellite and aircraft platforms; which were also acquired during Washita-94.

B. SAMPLING METHODS

Narrow-band reflectance spectra were obtained for selected lakes in the Little Washita basin. An attempt was made to select lakes (in April) that would provide a range of water quality characteristics. The specific lakes sampled are the result of: 1) an a priori attempt to determine water bodies that would vary in chemical and optical characteristics and 2) the logistics of scheduling water sampling crews and gaining access to the lakes. The data collection procedure required use of a small boat so that the SE 590 sensor could be positioned about .5 meters above a relatively calm and deep water surface. For all lakes (except Lake Burtschi), this required use of a light-weight boat to get out on the water surface. On some of the cleanest lakes, the use of the boat greatly facilitated the process of finding a location where the lake bottom was not visible. Lake radiance data were obtained by measuring the vertical flux of energy upward from the water surface (primarily solar energy backscattered within the water column and emerging from the water surface). Radiance data were also obtained from a position .5 meters above and at right angles to a level 99% reflective Spectralon panel. Comparison of the lake and panel observations allows determination of reflectance percentages for each wavelength observed.

Radiance data (for determination of reflectance spectra) were collected at the same time as water sampling for eleven lakes during the April sampling period. Spectra were collected for six of these same lakes again during the August water sampling period; data were also acquired for two additional lakes in August (Table XXII-1).

Table XXII-1. Lakes, Dates, and Sky condition

Lake 1	4/6/94	clear and sunny
Lake 2	4/6/94	clear and sunny
Lake 45	4/7/94	clear and sunny
Lake 46	4/7/94	clear and sunny
Lake Burtschi	4/7/94	clear and sunny
Lake 28	4/8/94	high cirrus
Lake 49	4/8/94	high cirrus
Lake 29	4/8/94	high cirrus
Lake 7	4/8/94	alto stratus clouds
Lake 18	4/8/94	overcast (stratus clouds)
Lake Burtschi	8/18/94	thin high cirrus
Lake 45	8/18/94	clear
Lake 46	8/18/94	high cirrus
Lake 29	8/19/94	overcast (quite dark)
Lake 28	8/19/94	overcast
Lake 49	8/19/94	overcast (some breaks in the clouds)
Lake 27	8/19/94	overcast (some breaks)
Lake 26	8/19/94	overcast (some breaks)

C. REFLECTANCE CURVES AND INITIAL OBSERVATIONS

Reflectance curves are provided for three of the lakes that were sampled (Figures XXII-1 through XXII-3). We present reflectance statistics for wavelengths between 450 and 900 nanometers; relatively small amounts of available energy for wavelengths outside the 450-900 nanometer range result in data with comparatively high levels of noise. The reflectance data for Lake 46 (Figure XXII-1) exhibit considerable change in the period between April and August; with greater reflectance overall and pronounced effects of plant chlorophylls affecting the shape of the reflectance curve. April and August differences in reflectance spectra were very slight for the observations made from the end of a fishing dock on the south shore of Lake Burtschi (Figure XXII-2). The Lake Burtschi spectral data suggest a slight increase in plant chlorophylls for the August sampling period. The reflectance curve for Lake 1 (from the April, 1994 sampling period) is indicative of surface waters with a moderate suspended sediment problem (Figure XXII-3).

Comparison of spectral data with results from analysis of the water samples indicates probable relationships between reflectance data and several measures of water quality: Secchi depth, turbidity, and chlorophyll a concentration. The effects of organic activity are best expressed in the reflectance spectra in the lower reflectance values associated with the chlorophyll absorption band at 680 nanometers. The effects of chlorophyll absorption are also evident in the shorter, blue wavelengths (450 nanometers). Increases in suspended particulates (either inorganic or organic) are related to increases in overall brightness. If the suspended particulates are organic in nature, the reflectance data indicate a relative increase at about 705 nanometers. Seasonal variations in lake chemical and biological characteristics and corresponding reflectance spectra substantiate a need to monitor lakes throughout the entire limnological cycle.

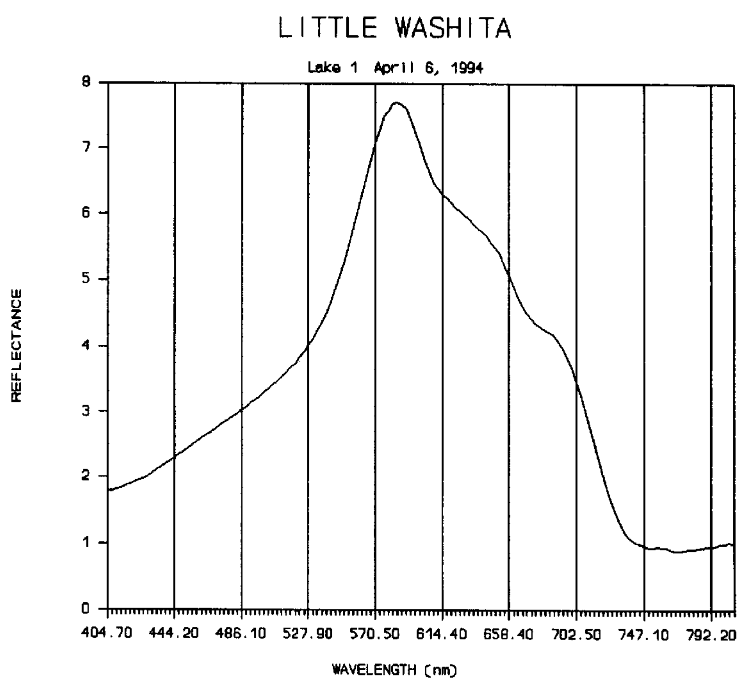

Figure XXII-1. Reflectance curve sampled at Lake 1, April 6, 1994.

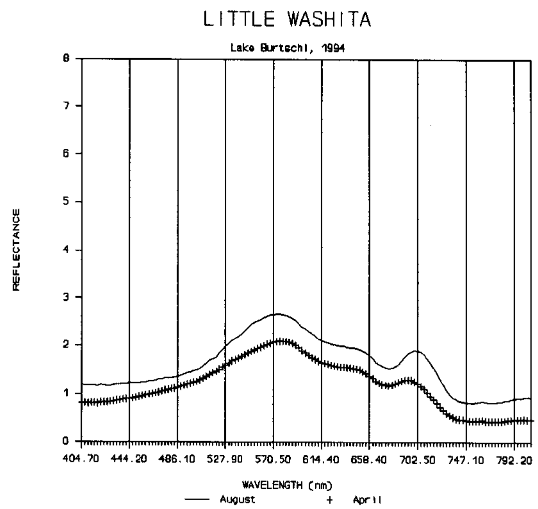

Figure XXII-2 Reflectance curve sampled at Lake Burtschi.

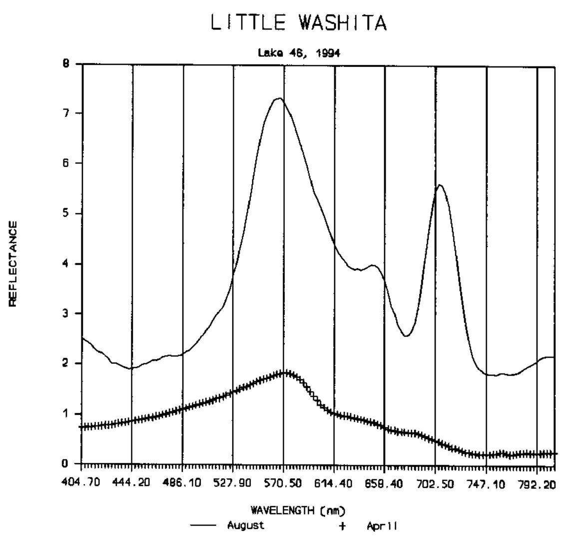

Figure XXII-3. Reflectance curve sampled at Lake 46.