SEDIMENTATION RATE ANALYSIS

INTRODUCTION

Pekin Lake has experienced significant sedimentation during the last century. The earliest detailed survey of Pekin Lake was completed about 1903 by J.W. Woermann. The maps created from this survey depict the lake when the Illinois River was at low water conditions (approximately 432.5 feet NGVD, 1929). Under these conditions some areas of the lake exhibited water depths in excess of 6 feet. Today when the Illinois River falls to that elevation, what little open water exists is only 0 – 2 feet deep. Slowkowski and Bhowmik (2001) describe the area under low river stages as a wetland complex rather than a lake.

Since the channelization of Lick Creek away from Pekin lake, the introduction of sediment to the lake has primarily been limited to over bank flow of the Illinois River under high flow conditions and inflow of water near the entrance to the lake (Slowikowski and Bhowmik, 2001). Many changes in river regulation and lake management over the period-of-record make it difficult to interpret the geomorphic changes that have occurred. What is clear is that lake surface area and volume have decreased and deep water is limited in extent. This loss of depth and bathymetric diversity can be related loss of biological diversity. Efforts to restore some portions of the lake which have been degraded by sedimentation, can benefit from a more detailed examination of the sedimentation processes that have occurred over the past 100 years. This study expands upon work done by previous researchers by more thoroughly examining historical data, converting the data to an electronic form which is compatible with commonly used GIS software and comparing those data to extensive surveys completed in 2001 and 2002.

PURPOSE

The purpose of this study was to utilize existing bathymetric and topographic information in order to examine geomorphic changes and determine historic sedimentation rates within Pekin Lake. While previous researchers have performed similar analyses (Lee and Stall, 1976 & 1977), this study expands upon their work by performing a more detailed analysis of historic data and utilizing data gathered in 2001-2002.

Sediment sources to Pekin Lake include the Illinois River, which drains an area of about 13,765 square miles upstream of Pekin Lake

The history of flow conditions on the Illinois waterway is well documented by others (Bellrose, et al., 1983; Larson, J.W.; Lee and Stall, 1976; Havera et al., 1980). Beginning as early as the mid 1800's and continuing to the present, the Illinois Waterway has been modified for the purposes of improving commercial navigation and carrying

waste materials away from the Chicago metropolitan area. These modifications included the construction of canals, locks and dams, channel training structures and levee systems, as well as extensive dredging and diversion of water from Lake Michigan. Major structural modifications culminated with the construction the 9-foot navigation system (consisting of 8 locks and dams) in the late 1930's. Dredging and flow diversion continue as part of the system maintenance activities.

Interpreting Bathymetric Survey Data and Converting to Digital Form

Before the various survey data sets were digitized, inconsistencies pertaining to coordinate systems, vertical datum systems and data densities were addressed. Unique characteristics of each data set are discussed in the following sections.

1903 Data

Between 1902 and 1904 J.W. Woermann of the U.S. Army Corps of Engineers, Chicago District (USACE-NCC) directed a bathymetric and topographic survey of the Illinois Waterway from river mile 287.5 to the confluence with the Mississippi River, including Pekin Lake. Survey range data were spaced approximately 500 feet apart. Data were plotted on maps showing water depths and some surrounding 1-foot topographic data.

For this project these maps were scanned using a 400 dpi gray scale color scheme. Georeferencing the maps was complicated by the fact that the coordinate system used for the Woermann's maps was different from any system used today. Attempts to convert the coordinates to a current projection system were unsuccessful. The maps did have section/township markings that were used wherever possible to rectify the maps. Four to six reference points (tic marks) were used per map. The scanned images were rectified to real world coordinates using the Illinois State Plane West NAD 83 projection.

The elevation data shown on the map were not in the current NGVD 1929 datum. Notes on the original maps document the vertical datum as follows:

> "The precise (bathymetric) levels are based upon elevations of U.S.P.B. Ms. 2, 3, and 4, at Grafton, Illinois, established by the Mississippi River Commission in 1880. The elevations are therefore in feet above the Memphis Datum plane, which is approximately 8.13 feet below mean Gulf Level at Biloxi, Mississippi. The soundings are expressed in feet and tenths below the low water of 1901, which is the lowest stage of water on record since the opening of the Chicago Drainage Canal. The Shore line is represented for this same low water stage."

Near the project site the Memphis Datum elevations are 7.44 feet higher than NGVD, 1929 elevations, so all elevations were adjusted accordingly when the data were digitally recorded.

Because the maps were created prior to the construction of the La Grange Dam, there was no established flat pool elevation. The 'low water surface' elevations noted on the

Woermann maps were determined for several locations throughout the study area. When the digitized depths were converted to elevations, the nearest downstream 'low water surface' elevation value was used.

1990's Data

Bathymetry was also gathered for much of Pekin Lake during the 1990's by the Environmental Management Technical Center. These data are still being reviewed. If it is determined that analysis of these data would materially add to this report, further analyses will be performed.

2001 - 2002 Data

In 2001, a complete bathymetric survey of Pekin Lake was performed by the Office of Water Resources of the Illinois Department of Natural Resources. Data were collected in a grid pattern with points spaced approximately 5 feet apart. In 2002, land survey data were gathered by the US Army Corps of Engineers, Rock Island District (USACE-MVR). Both surveys resulted in data sets which were used in this study. The field data from the 2001 – 2002 surveys were available in an electronic x,y,z format in the Illinois State Plane West NAD 1983 projection. The tabular data were imported into ArcGIS ArcInfo 8.1 ArcMap™ and converted to shapefiles

File Management and Analysis Techniques

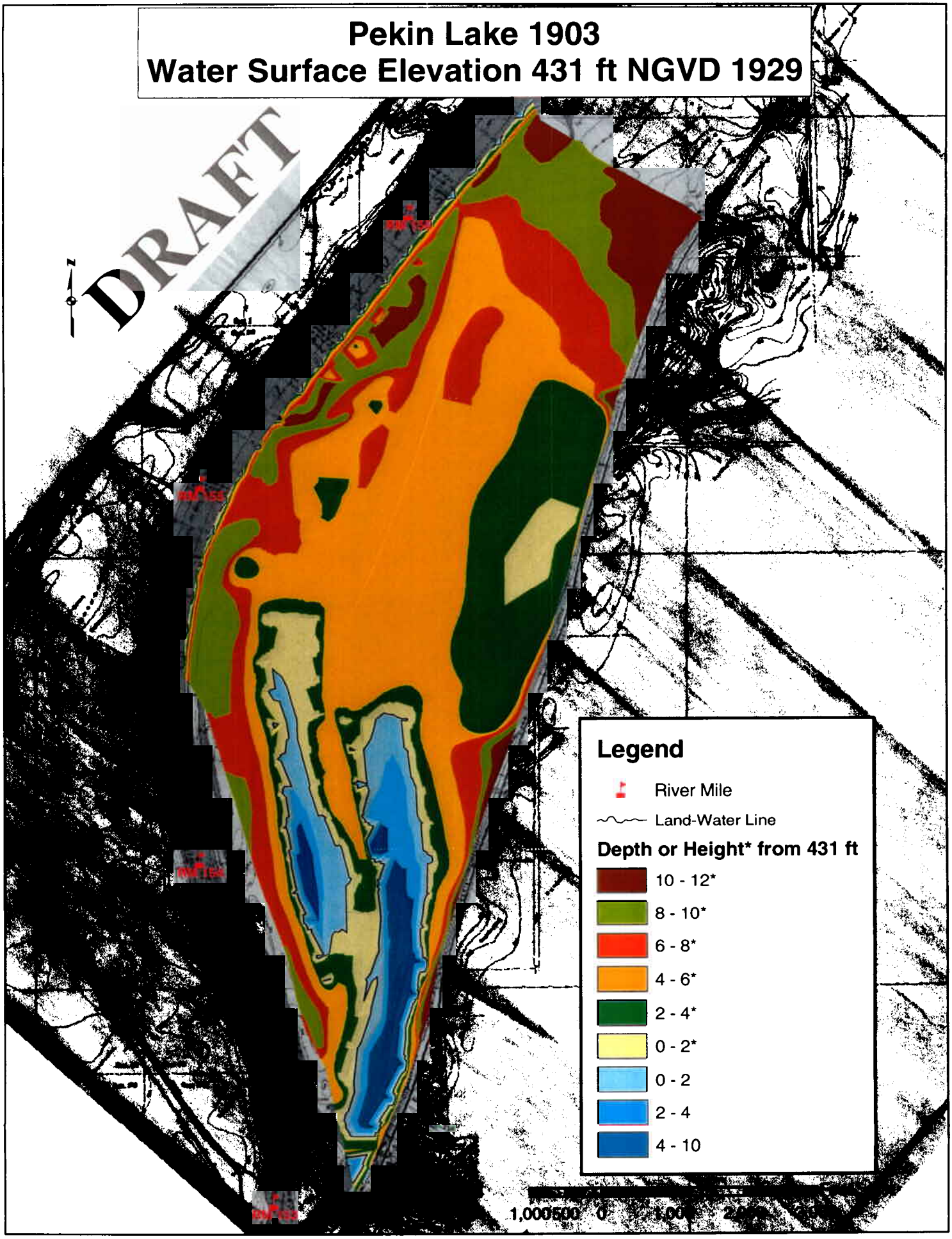
File Management

Once the Woermann maps were scanned, the files were saved in the .tif file format and the images were digitally rectified. Four to six reference points were selected to rectify each map. Points were chosen near the 4 corners of the map, and the center if deemed necessary, in an attempt to keep the root mean square (RMS) error as low as possible. Rectifying images created associated a ERSI "World File" (.twf) for each corresponding .tif image.

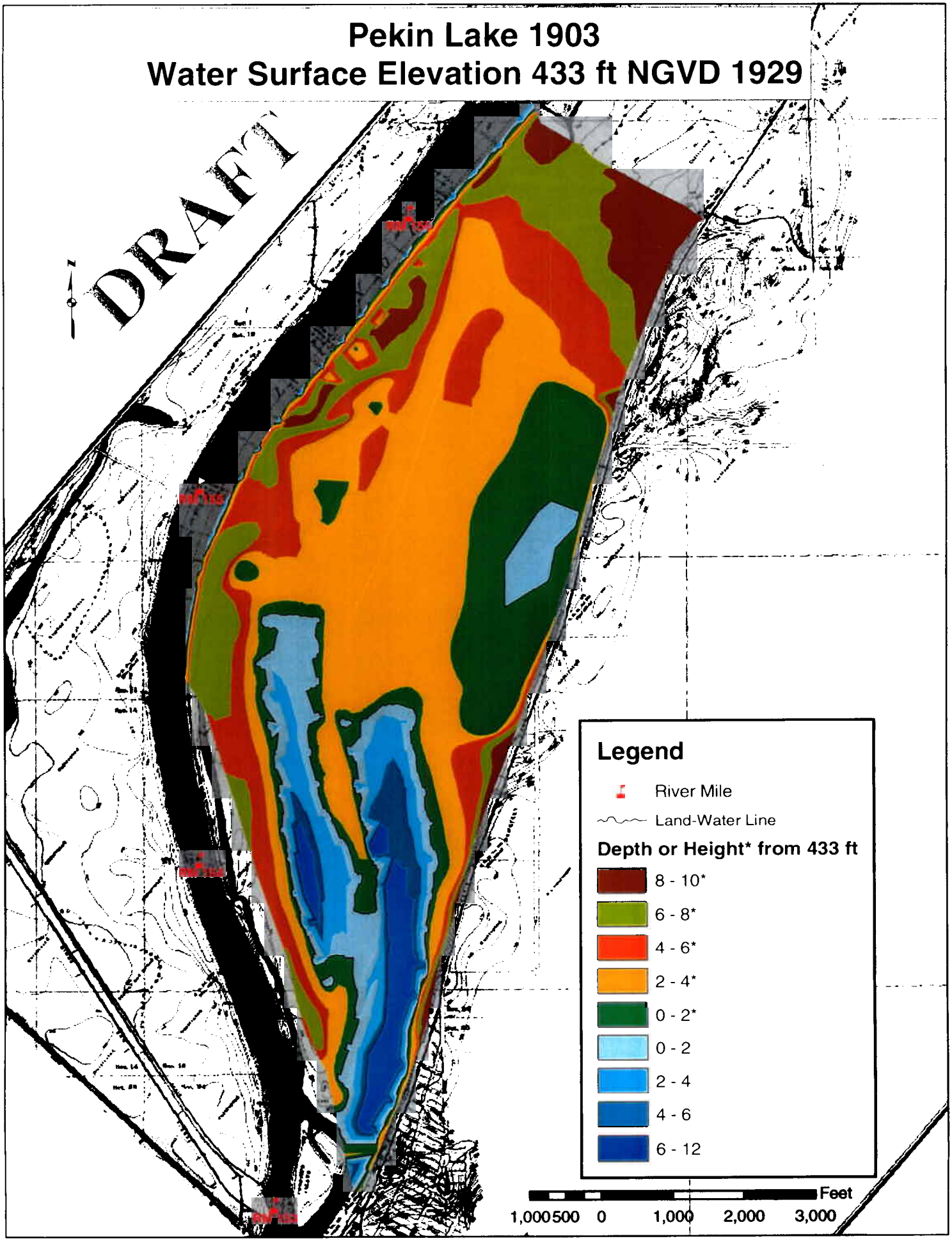
Rectified maps were digitized using ArcMap™ via on-screen or :heads-up" digitizing. This process was facilitated by creating a script using Visual Basic™ for Applications (VBA) language, which allowed the user to easily enter the bathymetric value after digitizing each point. The decimal point of the depth value recorded on the maps was used for the location of the bathymetry point. Once the depths were entered into the shapefile table they were converted to elevations using the nearest low water surface elevation documented on the map. Where available, some topography information was also digitized. This was done to create a better coverage near the land-water interface.

Analysis Techniques

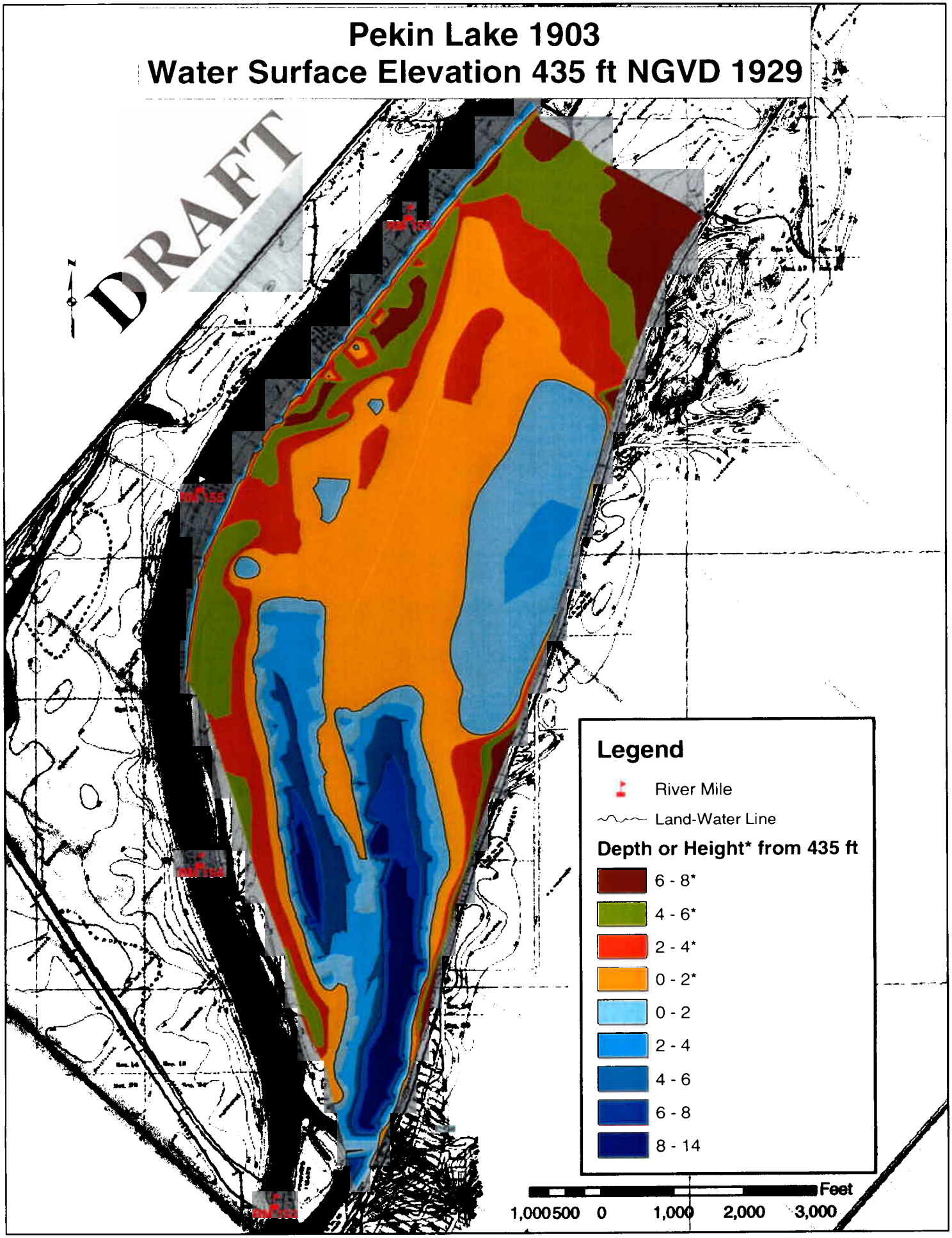
Point data for each time period were converted to a surface model (TIN) using ArcInfo™. These coverages were 'clipped' to eliminate data above elevation 440 NGDV from being


Pekin Lake 1903
Water Surface Elevation 431 ft NGVD 1929
DRAFT
Legend
River Mile
Land-Water Line
Depth or Height* from 431 ft
10 - 12*
8 - 10*
6 - 8*
4 - 6*
2 - 4*
0 - 2*
0 - 2
2 - 4
4 - 10
1,000500 0 1,000

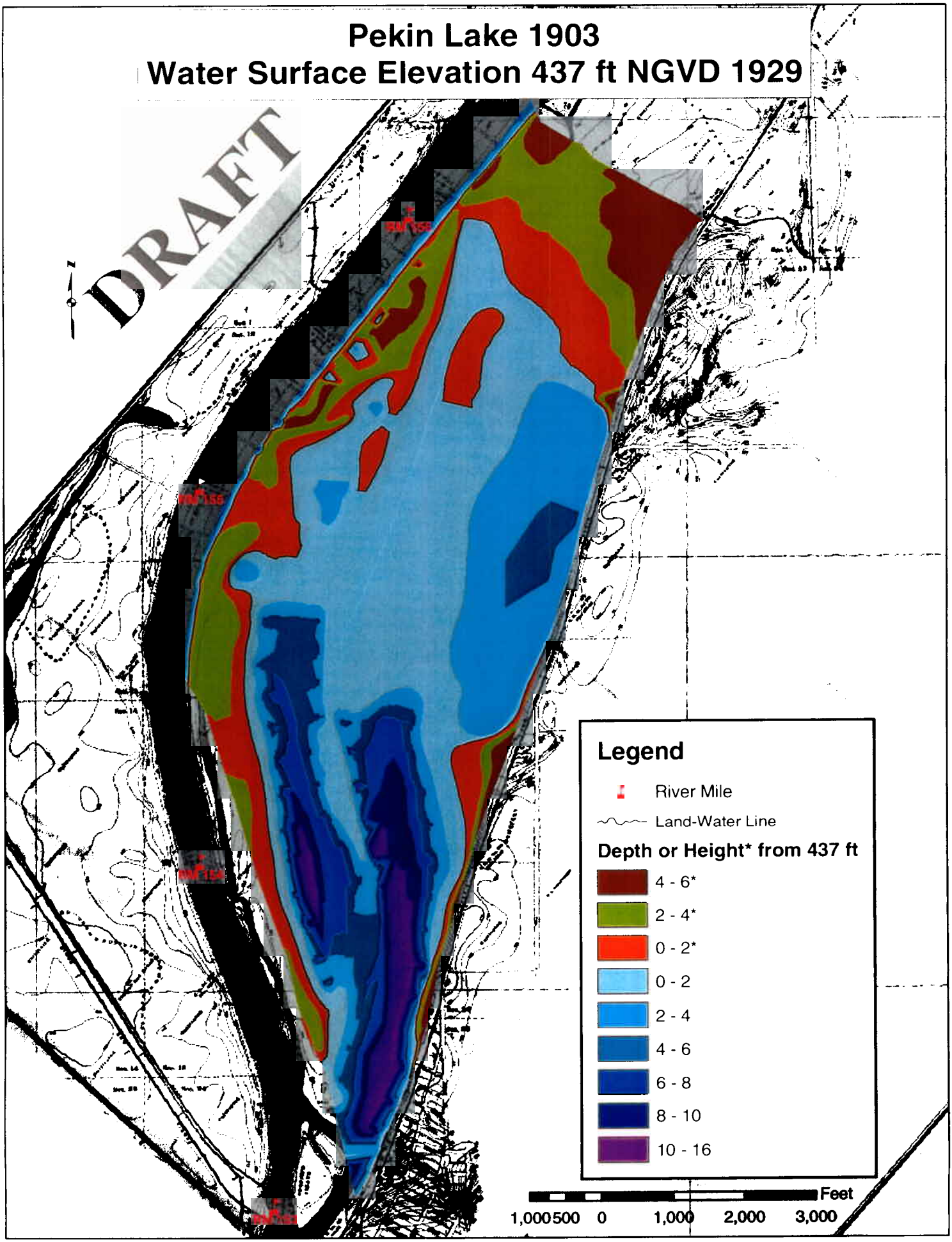
Pekin Lake 1903
Water Surface Elevation 433 ft NGVD 1929

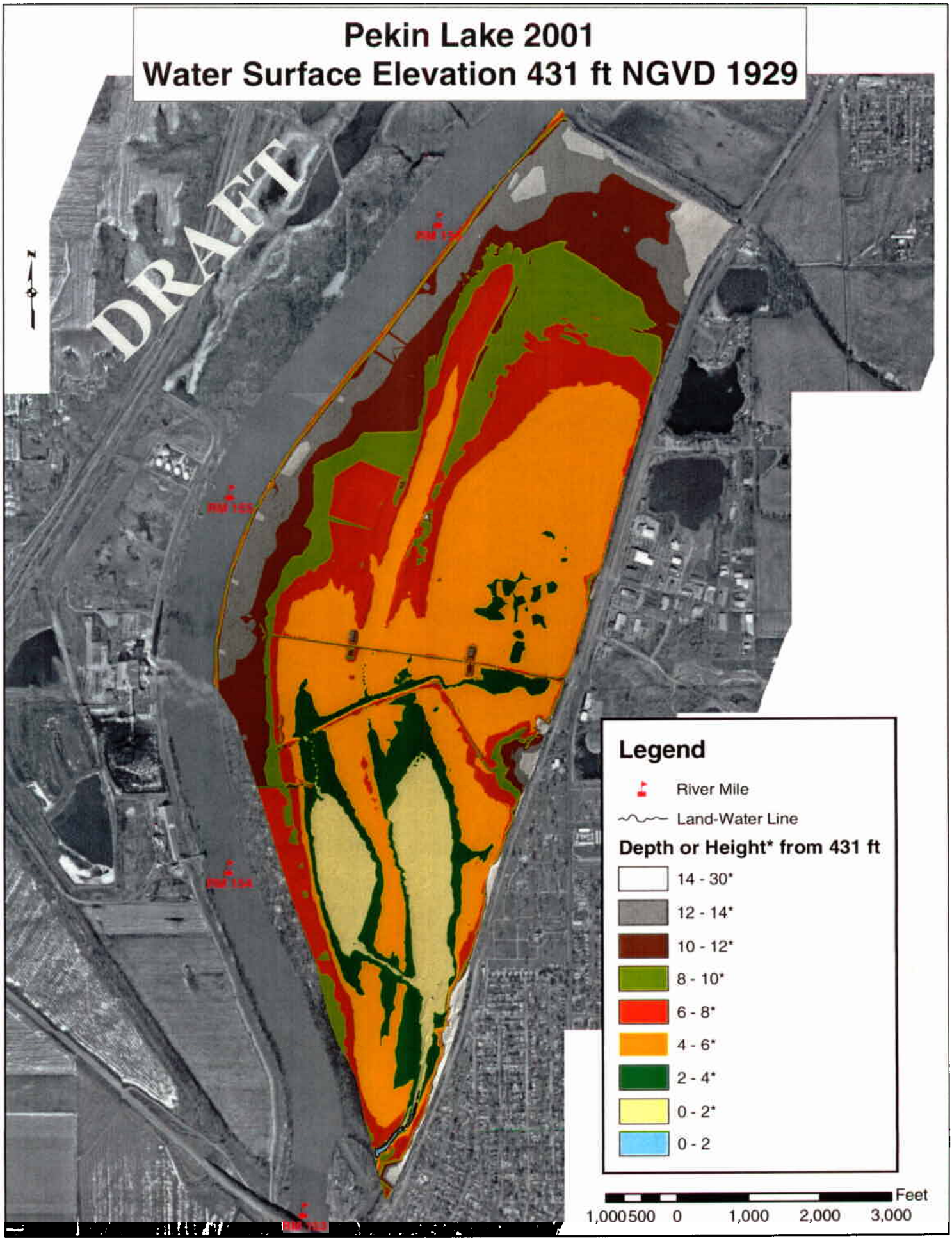


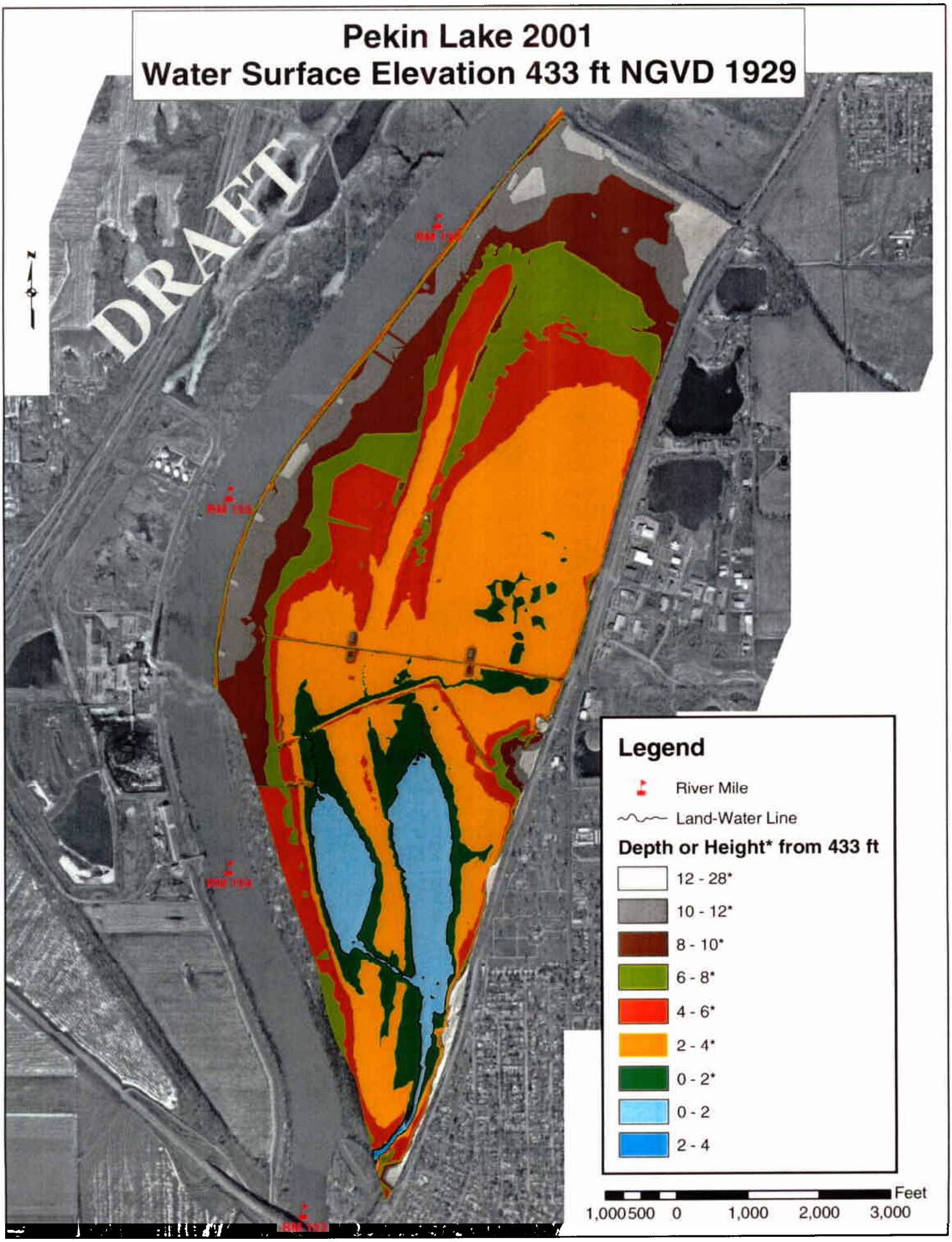
Pekin Lake 1903
Water Surface Elevation 435 ft NGVD 1929



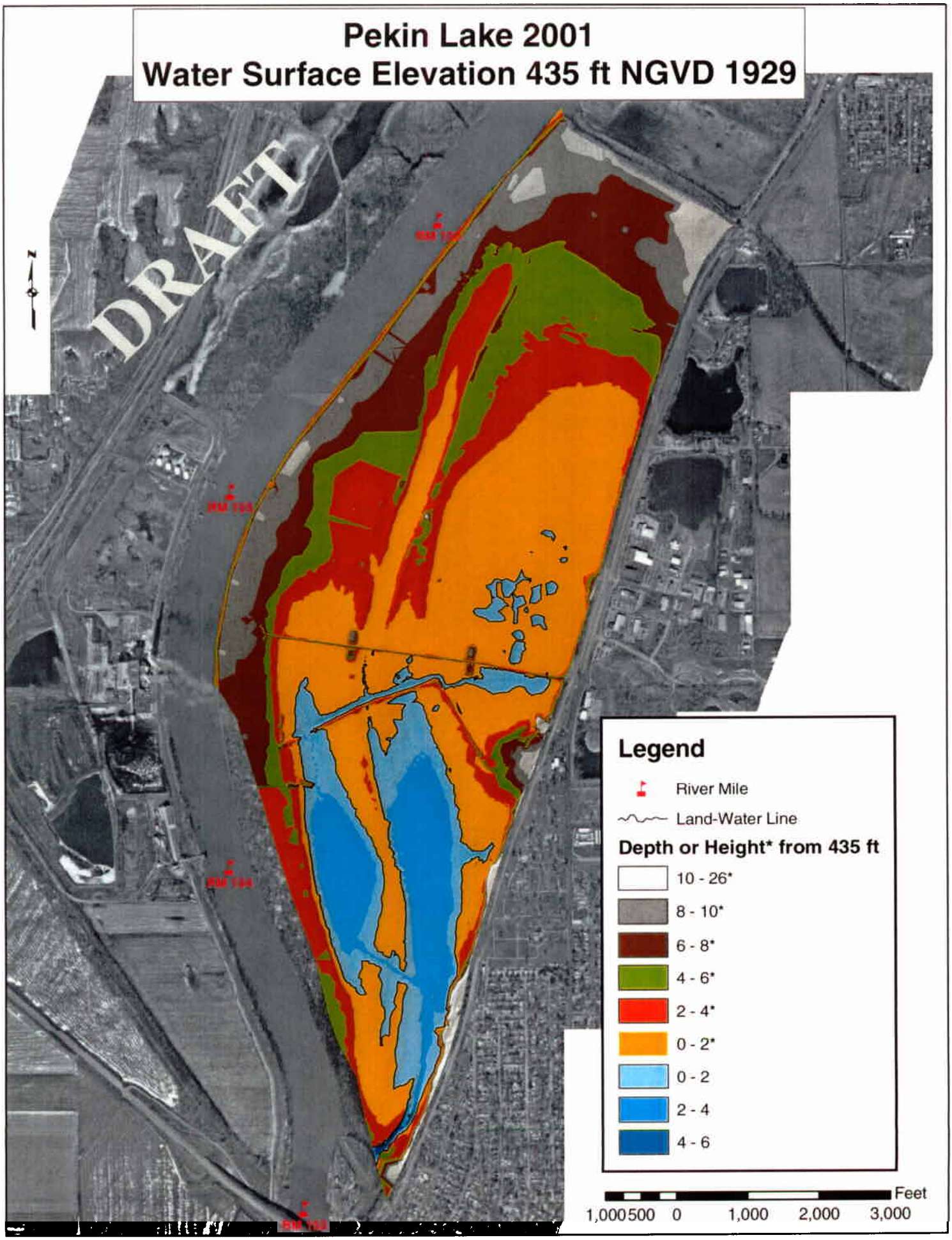
Pekin Lake 1903
Water Surface Elevation 437 ft NGVD 1929

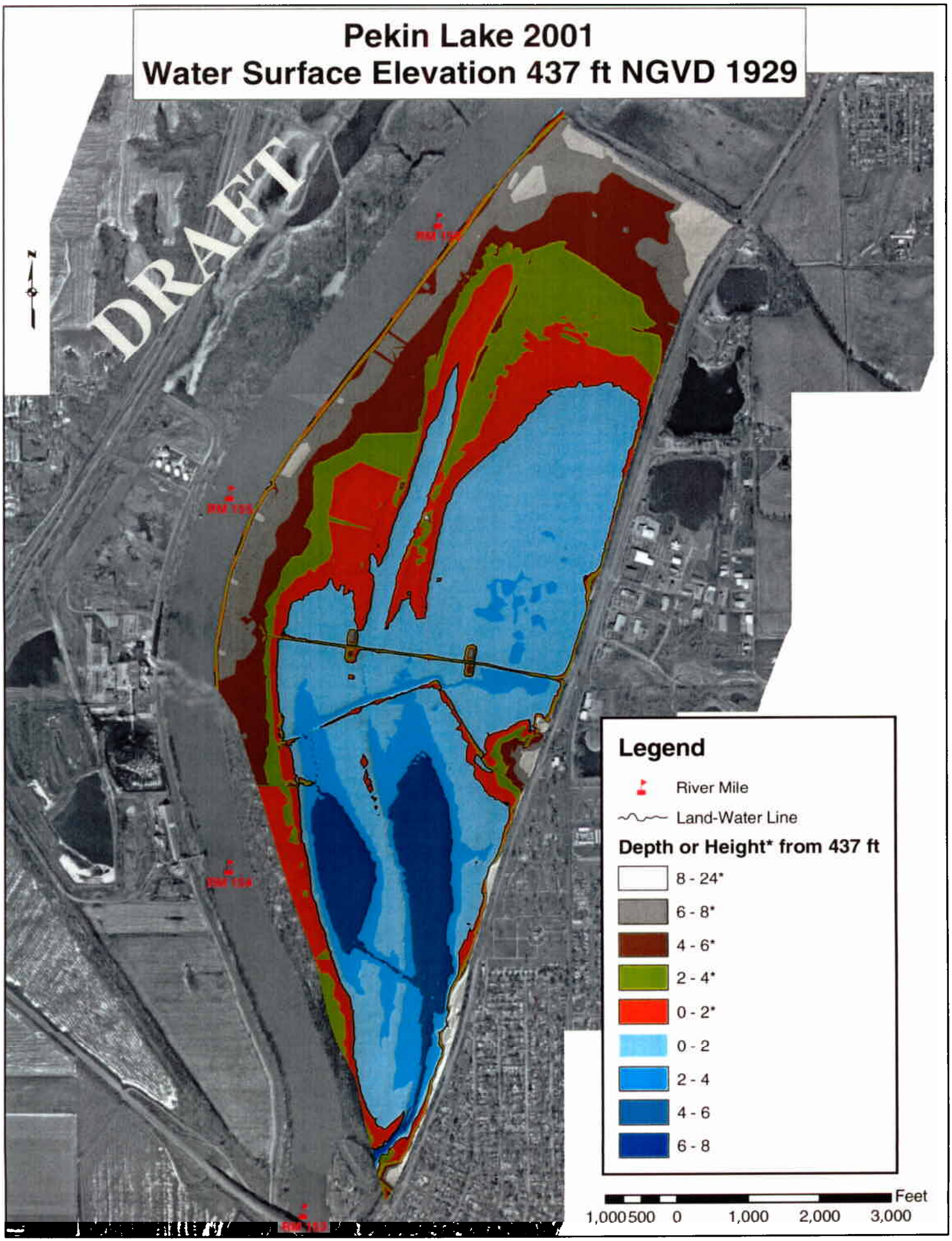



Pekin Lake 2001
Water Surface Elevation 431 ft NGVD 1929
DRAFT
N
RM 154
RM 153
RM 152
RM 151
Legend
River Mile
Land-Water Line
Depth or Height* from 431 ft
14 - 30*
12 - 14*
10 - 12*
8 - 10*
6 - 8*
4 - 6*
2 - 4*
0 - 2*
0 - 2
Feet
1,000 500 0 1,000 2,000 3,000


Pekin Lake 2001
Water Surface Elevation 433 ft NGVD 1929
DRAFT
RM 155
RM 154
RM 153
Legend
River Mile
Land-Water Line
Depth or Height* from 433 ft
12 - 28*
10 - 12*
8 - 10*
6 - 8*
4 - 6*
2 - 4*
0 - 2*
0 - 2
2 - 4
Feet
1,000 500 0 1,000 2,000 3,000

Pekin Lake 2001
Water Surface Elevation 435 ft NGVD 1929




Pekin Lake 2001
Water Surface Elevation 437 ft NGVD 1929
DRAFT
RM 135
RM 134
RM 133
Legend
River Mile
Land-Water Line
Depth or Height* from 437 ft
8 - 24*
6 - 8*
4 - 6*
2 - 4*
0 - 2*
0 - 2
2 - 4
4 - 6
6 - 8
Feet
1,000 500 0 1,000 2,000 3,000

included in later area and volume computations. This was done by first converting the tins to 5 foot grids, creating a point coverage from the grid, and converting the point coverage to finalized TINs. This process minimized distortions in the initial tins due to irregular spacing of the raw data. In limited situations, where data gaps existed, fill polygons were added to the TIN. These finalized TINs were used for all area, volume and sedimentation rate computations. Utilizing these TINs it was possible to calculate various statistics pertaining to the upper and lower areas of the lake for each time-frame analyzed. Separate TINs were created for the upper, lower and entire lake.

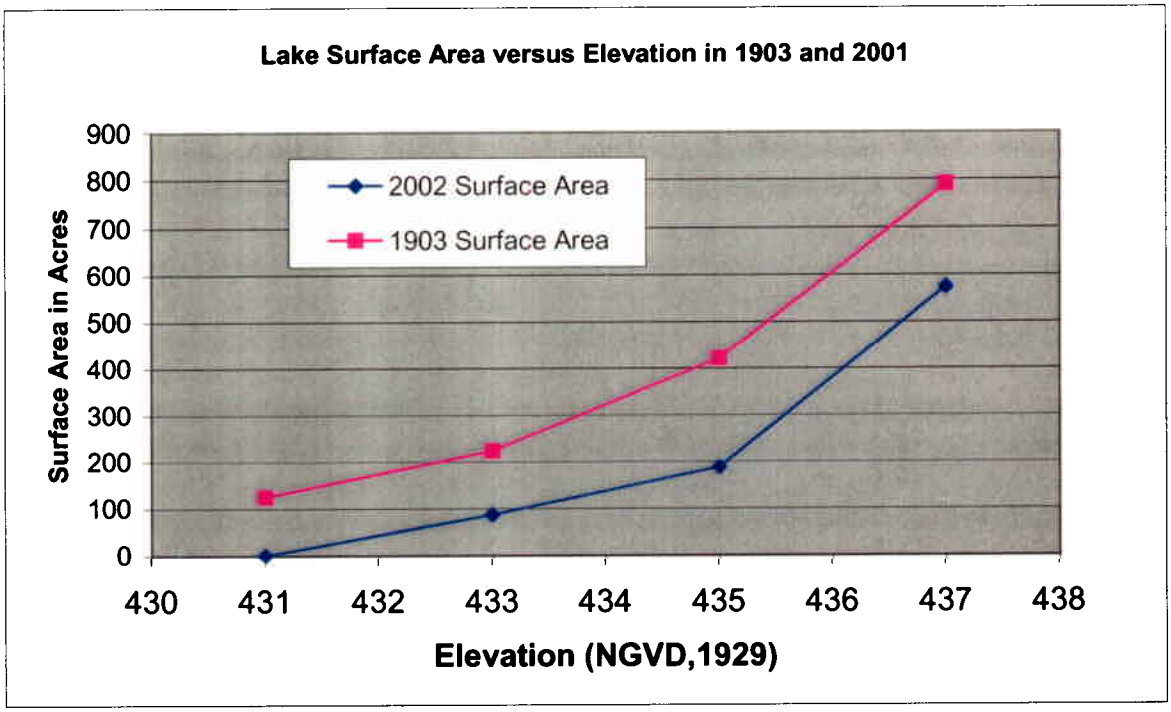
RESULTS

Sedimentation Rate Data

For the purpose of this study, 1903 is used to represent the baseline condition for Pekin Lake (since this was when the first detailed bathymetric data were collected). For comparison purposes, water depths were determined at water elevations 431, 433, 435 and 437 feet NGVD, 1929 for the baseline and current conditions (Figures X-X). Lake area and capacity in 1903 and 2001-2002 were determined at water elevations 431, 433, 435 and 437 feet NGVD, 1929. The results are shown in Figure XX and Table XX. A difference coverage showing where sedimentation and scour occurred between timeframes is shown in Figure XX.

Measures of surface area, volume and sedimentation rate from this study differ slightly from previous studies. This may be due to slightly different areas being included in the various studies or to the fact that this study was more detailed and probably more representative of the entire lake. All values listed were computed independently from girds, thus in some cases the total values may not equal the sum of the individual components due to rounding.

Rates of sedimentation over the period between surveys were computed for the upper. lower and entire lake complex from TINS. These data include elevations above 437 feet NGVD, 1929 which would be inundated by the larger floods. The average annual sedimentation rate based on the amount of sediment which has deposited between surveys is 0.23 inches/year in the upper lake, 0.3 inches/year in the lower lake and 0.26 inches/year for the entire lake complex.


Lake Surface Area versus Elevation in 1903 and 2001
Surface Area in Acres
900
800
700
600
500
400
300
200
100
0
2002 Surface Area
1903 Surface Area
430
431
432
433
434
435
436
437
438
Elevation (NGVD,1929)

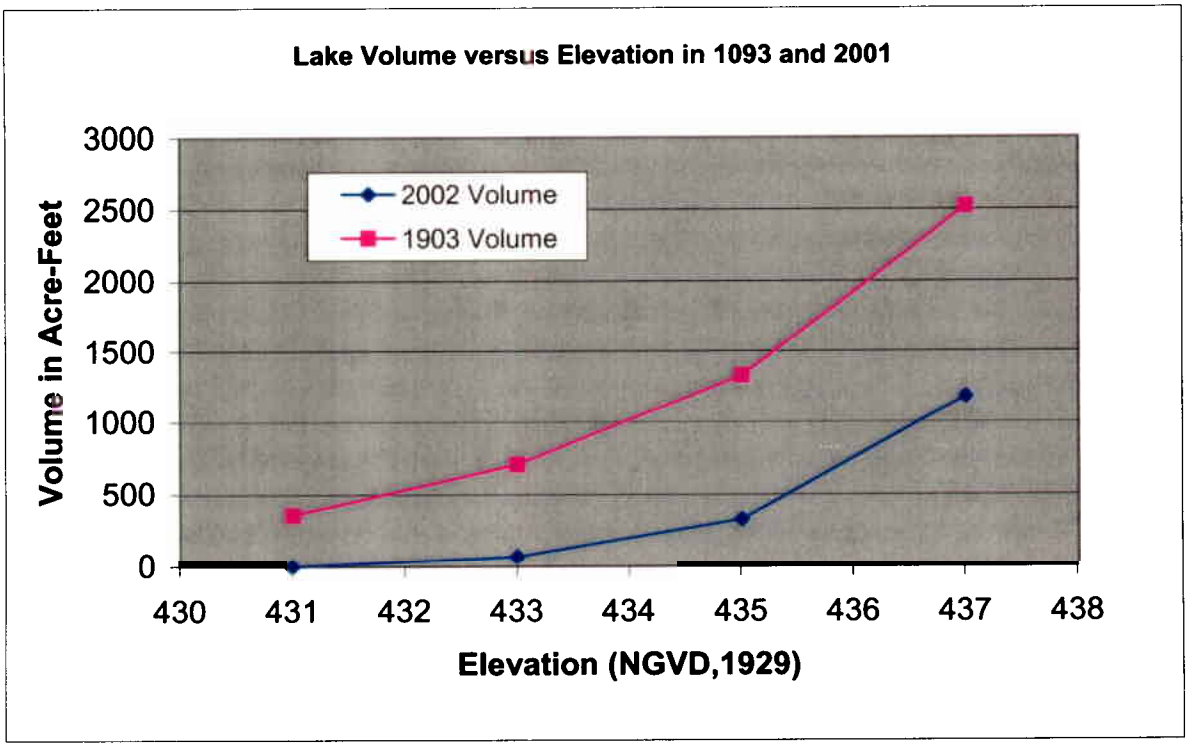

Lake Volume versus Elevation in 1093 and 2001
Volume in Acre-Feet
3000
2500
2000
1500
1000
500
0
2002 Volume
1903 Volume
430
431
432
433
434
435
436
437
438
Elevation (NGVD,1929)

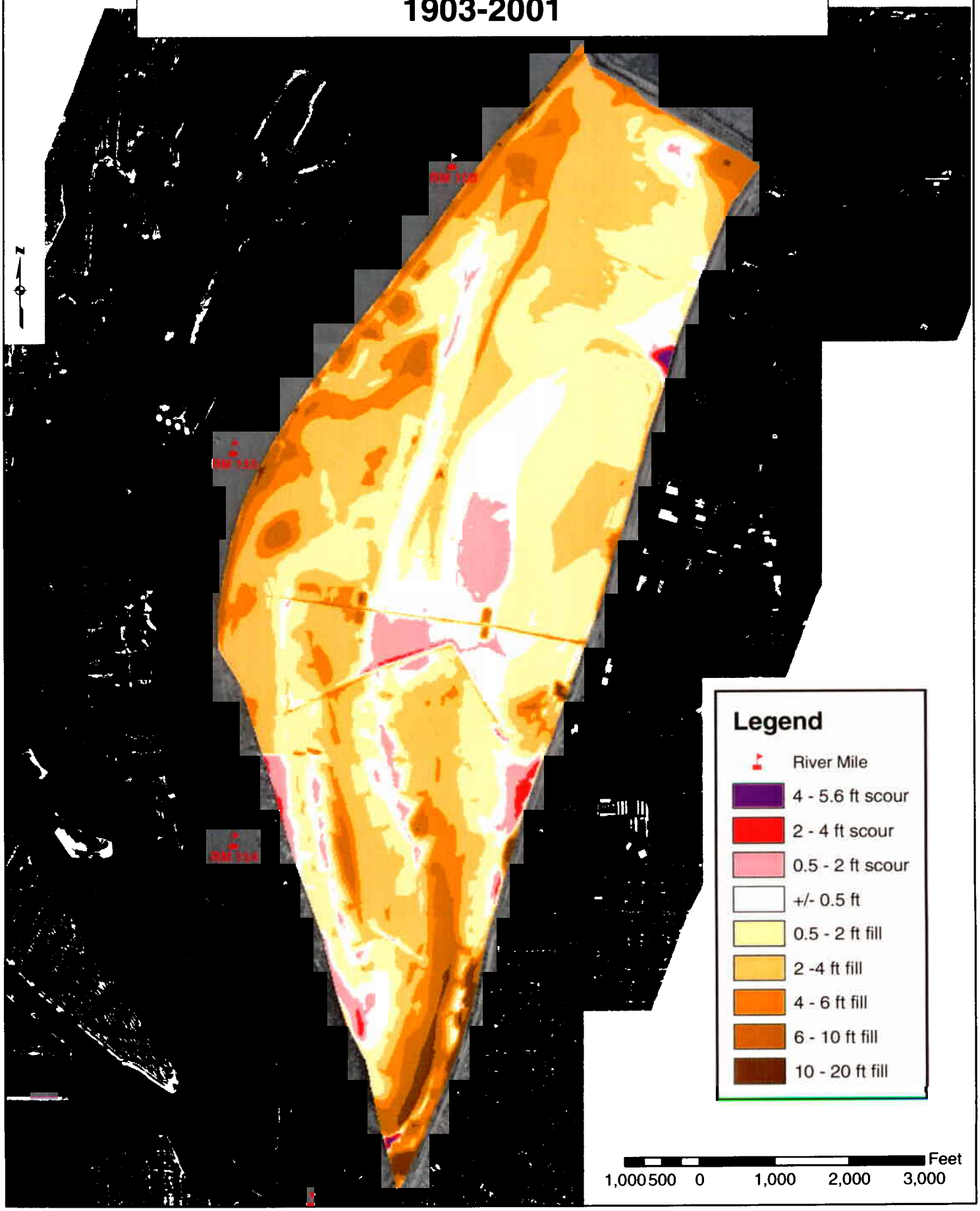
TABLE X. Surface areas and volumes for Pekin Lake.

Entire Lake Complex	Water Surface Elevation (NGVD, 1929)	Surface Area (Acres)	Volume (Acre-feet)
1903	431	125	357
1903	433	223	705
1903	435	422	1323
1903	437	790	2520
2001	431	1	1
2001	433	87	68
2001	435	188	326
2001	437	574	1176

Upper Lake	Water Surface Elevation (NGVD, 1929)	Surface Area (Acres)	Volume (Acre-feet)
1903	431	2	2
1903	433	29	27
1903	435	150	192
1903	437	422	738
2001	431	0	0
2001	433	0	0
2001	435	9	1
2001	437	238	297

Lower Lake	Water Surface Elevation (NGVD, 1929)	Surface Area (Acres)	Volume (Acre-feet)
1903	431	124	355
1903	433	196	681
1903	435	274	1138
1903	437	375	1797
2001	431	1	0
2001	433	87	67
2001	435	179	324
2001	437	342	882

Pekin Lake Sediment Accumulation/Scour 1903-2001



LITERATURE

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Lee, M.T. and J.B. Stall. 1976. Sediment Conditions in Backwater Lakes Along the Illinois River. Contract Report 176. Illinois State Water Survey, Urbana, IL. August 1976.

Slowikowski and Bhowmik. 2001.

Woermann, J.W. 1904. Map of the Illinois and Des Plaines Rivers from Lockport, Illinois to the mouth of the Illinois River. U.S. Army Corps of Engineers.