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ENVIRONMENTAL ASSESSMENT

On the Petition of the
Rock-Koshkonong Lake District
To Amend Order 3-SD-82-809, Regarding the
Indianford Dam and Lake Koshkonong Water Levels

Draft - December 14, 2004
Final March 18, 2005

Wisconsin Department of Natural Resources

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ENVIRONMENTAL ANALYSIS AND DECISION ON THE NEED FOR AN ENVIRONMENTAL IMPACT STATEMENT (EIS)
(DNR)
Form 1600-1 Rev. 6-2001

Department of Natural Resources

Region or Bureau SCR	
Type List Designation II	

NOTE TO REVIEWERS: This document is a DNR environmental analysis that evaluates probable environmental effects and decides on the need for an EIS. The attached analysis includes a description of the proposal and the affected environment. The DNR has reviewed the attachments and, upon certification, accepts responsibility for their scope and content to fulfill requirements in s. NR 150.22, Wis. Adm. Code. Your comments should address completeness, accuracy or the EIS decision. For your comments to be considered, they must be received by the contact person before 4:30 p.m., Insert Date.

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Applicant: Rock Koshkonong Lake District (RKLD)

Address: 374 E. Samuelsen Dr.,
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Title of Proposal: Increase Lake Koshkonong Water Level

Location: Counties: Jefferson, Rock and Dane **City/Town/Village:** Towns of Sumner, Koshkonong and Jefferson, Jefferson County; Towns of Fulton and Milton, Rock County;Town of Albion, Dane County **Township Range Section(s):** Town 4 North, Ranges 12 & 13 East, Town 5 North, Ranges 12, 13 & 14 East and Town 6 North, Range 14 East

PROJECT SUMMARY

Project Background

Introduction: On April 21, 2003, the Rock-Koshkonong Lake District (RKLD) filed a petition with the Wisconsin Department of Natural Resources, (WDNR) pursuant to Section 31.02, Wisconsin Statutes, to amend Order 3-SD-82-809 Regarding the Lake Koshkonong – Indianford Dam Water Level (Attachment 1). This environmental impact report meets the requirements in NR 150, Wisconsin Administrative Code.

The Indianford Dam is located in the NW ¼, Section 21, T.4N, R.12E, Town of Fulton, Rock County and is located approximately 7 miles South West of Lake Koshkonong and is located at 42°51'38" North, 88°56'25" West (42.860475, -88.940344) (See Basin Map Attachment 2).

Specifically, RKLD has petitioned the Department to:

Eliminate the winter drawdown and set maximum, minimum and target water levels on a year-round basis.

1. Set a minimum lake elevation, subject to lower water levels due to low discharge in the Rock River, of 776.4 feet above mean sea level (msl)
2. Set a maximum lake elevation, subject to higher water levels due to high discharge in the Rock River of 777 feet msl.
3. Subject to the above, set a target lake elevation of 776.8 feet msl.
4. Require that all of the gates at the Indianford Dam shall be opened when Lake Koshkonong is at or above 777.0 feet msl.
5. Require that all of the gates at the Indianford Dam shall be closed when Lake Koshkonong is at or below 776.4 feet above Mean Sea Level.
6. Require that a minimum of 64 cubic feet of water per second be discharged through the dam.

(source – April 21, 2003 letter from Wheeler, Van Sickle & Anderson, S.C.)

RKLD reports that this proposal is consistent with the goals established in the Comprehensive Lake Koshkonong Plan and refers to this document repeatedly within the Environment Impact Report prepared by the District for this project. While the district has worked on several lake grants with the goal of advancing a Comprehensive Lake Plan the Department is unaware of a final or draft comprehensive plan. Further, the Department could not find a final or draft copy of the referenced comprehensive plan within the Environment Impact Report prepared by the District for this project. This environmental assessment describes the aforementioned proposal and all available information and data to assess how this proposal, if approved, will affect the environment in Lake Koshkonong basin.

History

Lake Koshkonong, meaning, 'the lake we live by', was named by Native Americans. Prior to the 1850's, the open water area was limited to the main channel of the river. The remainder of the lake and the margins of the river channel as far upstream as Fort Atkinson were covered with a profuse growth of emergent vegetation, including wild rice, wild celery, cattails and sedges. In 1877, approximately 26 years after the first dam was constructed, Thure Kumlein (Kumlein 1877) described the area as follows:

> "The land surrounding the lake consists to a great extend of low and very extensive marshes, on which thousand of tons of hay are annually cut; but limestone bluffs exist in many places all around the lake…. The Lake, with its, in many places, marshy shores and hundreds of acres of wild rice, and grass-like plant, know to botanists as Vallisneria spiralis , growing in it in the greatest abundance, used to be a great favorite place for ducks, and especially the far-famed Canvasback (Aythya vallisneria), which, with the Redhead, is particularly fond of the Vallisneria spiralis . Geese, cormorants and white pelicans were also very numerous, and fifty to one hundred of those latter birds could be seen at one time in the latter part of April or first of May."

Construction of the Indianford Dam in the 1850's, subsequent dam modifications, changing bio-diversity and operation regimes have changed the ecology of the basin including impacts to wetlands, wildlife, water quality, aquatic life, and recreation. The positive and negative impacts of water level changes and other environmental factors are discussed in the Affected Environmental section of this report. See the Affected Environment section of this report for a more detailed description of the history of this area.

Physical Geography

Lake Koshkonong is contained wholly within the Lower Rock River Basin in South Central Wisconsin (See Basin Map, Attachment 2). The Rock River Basin drains an area of 2,630 square miles, all of which lies within the glaciated portion of the state in the southeast upland soil-landform region. The basin can be separated into 19 watersheds. Thirteen of these watersheds are in the Upper Rock Basin and six are in the Lower Rock Basin.

Lake Koshkonong is a shallow natural widening of the Rock River and was first dammed sometime around 1851. The current dam has created a pool of approximately 10,460 acres. Lake Koshkonong is a very eutrophic impoundment with a mean depth of 5 feet and maximum depth of 7 feet. The majority of the shoreline of the Lake remains undeveloped. The total length of shoreline is approximately 27 miles of which 10 miles is developed residential/recreational .

Surface Area	10,460 acres
Maximum Depth	7 feet
Mean Depth	5.33 feet
Volume at 775.5 feet msl	55,792.8 acre feet
Maximum Length	3.3 miles
Drainage Basin	2,594 square miles
Length of Shoreline	27 miles
Length of Developed Shoreline	10 miles
Average Gradient of Rock River - Watertown to State Line	1.2 feet per mile
Width of River Channel at Indiandford Dam	300-400 feet
Ordinary High Water Mark – 1980 (Maple Beach)	776.7 feet msl
Ordinary High Water Mark – 2001 (widespread)	778.1 – 778.3 feet msl

Current Conditions

Wetlands: An estimated 3080 acres of wetlands adjoin the lake and the mouths of its tributary streams. Wetland ecotypes include floodplain forests, forested wetland, shrub carr, emergent deep and shallow water marshes, and emergent meadows. Marshes are dominated by stands of cattails, river bulrush, reed canary grass, sedges, and other wet meadow species

Submerged Aquatic Vegetation: The greatest depth of rooted submergent macrophytes observed during 2000, 2001 and 2002 was approximately 4 feet or 1.3 meters. Photic zone depths may increase slightly in areas of submerged vegetation. However, the dominant submergent vegetation in Lake Koshkonong is sago pondweed (Potamogeton pectinatus) and this species does not grow in densities sufficient to affect water clarity.

Turbidity during the growing season from suspended sediment and algae blooms is likely a major factor affecting the submergent vegetation in Lake Koshkonong. Increased turbidity limits light penetration and the maximum depth that submerged macrophytes can survive at. Macrophyte beds provide refuge habitat for zooplankton. Without ample macrophytes, zooplankton populations are compromised (size and numbers), resulting in increased algae and consequently more turbid water (Kahl, 1991).

The overabundance of nutrients are caused by rough fish disturbance and wave action combined to create turbid conditions during the growing season resulting in algal blooms. In the shallow marsh areas, the turbid conditions favor certain species such as cattail and river bulrush and can have a negative effect on annual vegetation establishment by reducing or eliminating the light needed for germination.

Water Clarity: Typical Secchi disc measurements collected during 2000 – 2002 were in the range of 0.25 to 3.7 feet in depth during the growing season. Secchi depths reported for Lake Koshkonong for years 1986-1989 average 1.3 feet and are significantly less than reported measurements for other large shallow lakes in Wisconsin's Southeast Glacial Plains.

Water Quality: Due to shallow depths and high nutrient loading, Lake Koshkonong is classified as a hyper-eutrophic lake. In the Lower Rock River Management Plan the Trophic State Index (TSI) for Lake Koshkonong is listed as 57. Lakes with a TSI score above 50 are considered to be eutrophic. Frequent algal blooms and low water clarity dominate the condition of the lake during late spring through late summer each year. The high levels of phosphorus are a direct result from nutrient contribution from the Rock River and its tributaries and the re-suspension of nutrients due to the shallow nature of the lake and rough fish activity.

Fisheries: The fishery is productive. Species composition and dominance varies from decade to decade. Fish species found in the lake include carp, buffalo, panfish, catfish, walleye, largemouth and smallmouth bass, muskellunge, and northern pike. Carp reached nuisance level in the 1920s and began to affect the sport fishery. Carp removal by the Department or Commercial fisherman has been a fixture in the fish management schemes of lake Koshkonong since the 1930s.

Wildlife: The WDNR manages Lake Koshkonong as a multi-use waterbody that includes wildlife, fisheries, recreation and navigation. Historically, Lake Koshkonong contained large beds of persistent submergent macrophytes. Since the late 1950's, these plant beds and waterfowl numbers have been greatly reduced. One reason for the decline of waterfowl may be the reduction of fall food sources such as submerged macrophyte, seeds and tubers. The current local nesting population of waterfowl consists of puddle ducks including mallard, wood duck, teal and other waterfowl.

Historically, Lake Koshkonong has been very important waterfowl production area, as well as a key spot for migratory waterfowl. The lake and its adjacent wetlands provide habitat for herons, double crested cormorants, pelican, gulls, eagles, osprey, shorebirds, other raptors, neotropical migrants, and other species.

Purpose and Need

As stated by the RKLD in their Environmental Impact Report, the district's primary objectives are:

- To collect biological and hydrologic data on the lake to obtain a better understanding of the dynamic lake and wetland system;
- To use that understanding to educate the lake users on the importance of lake and wetland protection so that the lake and wetlands can be a resource for generations to come;
- To provide protection of sensitive shoreland and wetland areas from erosion and continued degradation due to various biologic and hydrologic factors, and
- To modify the current Indianford Dam operating orders to provide improved recreational opportunities on Lake Koshkonong and protect the environment and habitat.

According to the RKLD, "the purpose and need of the proposed (*change in water levels*) Operating Order is to provide a management strategy for Lake Koshkonong that; 1) provides the best compromise between user groups of the resource and, 2) protects or improves the ecological integrity of the waterbody, and 3) provides the lake with a more stable hydrologic environment. RKLD in cooperation with WDNR has undertaken the task of collecting data and modeling hydraulics of the Rock River in order to begin to prepare a Comprehensive Lake Management Plan."

From an examination of the history of water level actions on Lake Koshkonong and the Indianford Dam, water level issues are not new to the Lake. What has changed since the last set of judicial hearings is that there is now a District that purports to speak for the interest of all parties interested in Lake Koshkonong. The RKLD was formed in 1999 to address specific goals and objectives. Some of these goals and objectives are related to the litigation that occurred during the 1980s and 1990s over water levels which resulted in the addition of a winter drawdown. RKLD was organized with two main objectives since:

1) to maintain the existence of the Indianford Dam to insure that the lake would remain in its current state, and
2) to collect data to determine if, and at what elevation, a water level increase could be proposed that would provide a benefit to the lake users while not negatively impacting the aquatic ecosystem.

RKLD prepared and distributed a survey questionnaire to determine the consensus of opinion about many of the lake related issues. The survey responses were summarized in a Lake Planning Grant Report that was submitted to the Department in 2001.

With respect to water levels, 55% of those responding indicated that there was too much variation and 43% responded that water levels were too low. The survey response to lake management priorities was first water levels followed by water quality.

The value of the results from the survey is questionable, because the survey achieved an extremely low (8%) response rate. With 92% non-responding the likelihood of large non-response bias is great. Non-response to mail surveys is not a problem in itself; the problem is that non-response induces a non-response bias in the estimates. This happens because non-respondents usually differ in important characteristics from respondents. Non-response bias in mail surveys can be a major problem because non-response can be substantial. Even when a survey and its instrument have been well designed and three mailings have been made (Dillman Method 1978); the response rate may only reach 50-75%. Response rates >60% for statewide surveys are commonly deemed reasonable. Surveys achieving <50% response rate are typified as low (Pollock et. al 1994.) While RKLD uses this survey as an indicated of what the users want on Lake Koshkonong, the Survey Instrument was critically flawed and statistically indefensible. Further, the survey as conducted, cannot measure preferences of Lake Koshkonong recreationalists by sampling only RKLD members.

RKLD also justifies its proposal from a vote taken at its annual meeting. During the 2002 Annual Meeting a proposal was passed by an overwhelming majority of those attending the meeting to request a change in the Operating Order.

PROPOSED PHYSICAL CHANGES

The existing Indianford Dam/Lake Koshkonong water level order 3-SD-82-809 is dated April 25, 1991. A copy of the existing order is included as Attachment 1. The order sets summer and winter water levels and minimum flows as well as dam gate operations that are controlled by the Indianford Dam. Gate operations are determined by the impoundment level measured on the lake at Bingham Point Estates, about 10 miles upstream of the dam, and the incoming flow as measured on the Crawfish River at Milford and the Rock River at Watertown.

RKLD proposes to eliminate any level reductions in the winter and to raise the summer levels for year-round use. The District's proposal doesn't address dam operation dependent on inflow to the lake.

	Current MSL	**Proposed MSL**	**Increase Feet**
Summer (May 1-Oct. 31) target level	776.2	776.8	0.6' (7.2")
Summer maximum when all gates must be open	776.33	777.0	0.67' (8")
Summer - when all gates can be closed	776.10	776.4	0.3' (3.6")
Winter maximum level (Nov. 1- Apr. 30)	775.77	777.0	1.23' (14.8")

Winter minimum level	775.00	776.4	1.4' (16.8")

No change is being proposed to the minimum flow release of 64 cubic feet per second.

The existing order requires that the dam operator monitor the incoming flow to the lake by adding the flows from the Crawfish River at Milford and the Rock River at Watertown. The intent of this section of the order is to establish minimum performance standards to enable the operator of the dam to keep lake levels within the established limits. Specifically, the order requires:

> "(1) Whenever the lake level is above 776.20 feet, MSL, and the combined average daily flow of the Crawfish and Rock Rivers has increased more than 200 cubic feet per second from the previous day, the operator shall release at least 1.5 times the latest combined average daily flow measured at the Milford and Watertown gages.
>
> (2) Whenever the lake level falls below 776.20 feet, MSL, and the combined averaged daily flow of the Crawfish and Rock Rivers has declined over the four previous consecutive days, the operator shall release no more than 1.5 times the latest combined average daily flow measured at the Milford and Watertown gages."

A rating table for the slide and wicket gates is included within the existing order (Attachment 1). The table shows the flow that is released for different gate settings at lake stages between 776.1 to 776.3 msl.

The drainage area of the Crawfish River gage at Milford is 762 square miles and the drainage area of the Rock River at Watertown is 969 square miles. The combined drainage area of these gages at 1731 square miles is about 66% of the 2630 square mile drainage area at the Indianford Dam.

Since the existing water level order was written, a new gage has been installed on the Rock River at Fort Atkinson. The department has proposed to change the upstream gage monitoring stations from Milford and Watertown to the Fort Atkinson gage (Attachment 2).

No change to the minimum flow release is proposed in the District's request. No physical changes to the dam are being proposed. No direct manipulation of terrestrial resources (Agricultural Lands, Park Lands, State Natural Areas, Upland Forest, Recreational Areas,) are being proposed. No direct manipulation of aquatic flora and fauna are being proposed.

No construction or modification of buildings, treatment units, (wells, septic systems) and other structures (erosion control structures, piers, boat lifts, marinas, and boat landings are being proposed. Air quality and water quality discharges will not be directly affected by this proposal. The petitioner proposes no physical change (direct or indirect) that would alter the ordinary high water mark (OHWM) or any alteration of the private or public rights that would be affected by a change in the OHWM.

AFFECTED ENVIRONMENT

Historical Setting

Pre-impoundment conditions (before 1851)

Before construction of the Indianford dam Lake Koshkonong was a deepwater marsh with abundant and diverse emergent vegetation. There are observations such as recorded by Fifield (Fifield 1904) who reported that in 1837 his boat drifted across the river near Fort Atkinson and got caught in the wild rice beds. At that time the early pioneers referred to Koshkonong and Horicon as similar lakes.

The early ecology and natural history of Lake Koshkonnong is well described; as this area was settled by Thure Kumlien, a well-educated Swedish, Koshkonong naturalist and writer. Thure, an eminent naturalist kept meticulous notes, letters, and journals. Thure's grandaughter, Angie Kumlien Main has captured much of his writing in The Wisconsin Magazine of History and the Wisconsin Academy of Sciences, Arts, and Letters (Main 1943a, Main 43b, Main 1944, Main 1945). Thure's interests in ornithology drew him to Lake Koshkonong (he settled near present-day Busseyville), as he reasoned it to be centrally situated between the Mississippi River and Lake Michigan. Main (1945) recounts,

> "It is now a wilderness of white and black ash, willows, and soft maples. Along the edges of the tree the red osier and panicle dogwood, the button bush, the six-foot rushes and then the lower patches of blue flag and the big glossy arrow-shaped leaves of the arrow-head crowd the shore to the very water's edge, making the place a veritable jungle".

Lake Koshkonong is a widening of the Rock River and is fed by numerous springs. In the territorial and early days of this state, the lake as a whole was not as deep as it is now. Wild rice and wild celery grew abundantly in the bays and shallow parts of the lake (Main 1945). When Dr. Increase A. Lapham visited Lake Koshkonong in 1850, he wrote (Wisconsin Antiquities, p. 35), " The water is 4-12 feet deep. At the time of our visit in July, wild rice was growing abundantly over almost its entire surface, giving it more the appearance of a meadow than a lake".

The deepwater marsh of Lake Koshkonong at that time supported a rich diversity of flora and fauna. Thure Kumlien himself wrote of Lake Koshkonong (Kumlien 1877);

> "The land surrounding the lake consists to a great extent of low and very extensive marshes, on which thousand of tons of hay are annually cut; but limestone bluffs exist in many places all around the lake.... The lake with its, in many places, marshy shores and hundreds of acres of wild rice, and the grass-like plant known to botanists as *Vallisneria sprialis* (wild celery, *Vallisneria americana*), growing in it in the greatest abundance used to a great favorite place for duck, and especially the famed Canvasback (*Aythya vallisneria*), which with the Redhead, is particularly fond of the *Vallisneria sprialis.* Geese cormorants, and white pelican were also very numerous, and fifty to one hundred of those latter birds could be seen at one time in the latter part of April or first of May. In the marshes and on the shores were a greater variety of waders... Of the snipe family, twenty species, beside curlews, and godwits. Three species rails, and gallinules and coats (coots) very plenty".

Era of Early Dam Construction (1851-1900)

In April of 1843 the Wisconsin Territorial Legislature authorized Clouden and Luke Stoughton to dam the Rock River on their land in Section 21, T4N, R12E, the Indianford site (page 34, laws of 1843). The authorization included the right to use the water to propel machinery and to sell or lease such rights. The height of the dam was limited to not more than 4 feet above the normal river level. The Stoughtons were directed to construct a lock for barge passage and a slide or chute for the passage of rafts and to serve as a fishway. These aids to navigation were to be in readiness upon completion of the dam and were to be operated by the Stoughtons without charge. The authorization further specified that construction was to commence within one year and to be completed within three years. Provisions for flowing of lands were described and the right to repeal the authorization was reserved by the Territorial Legislature.

Apparently the dam was not constructed until after March of 1851. The Wisconsin State Legislature (Chapter 339, Laws of 1851) again authorized the Stoughtons to construct a dam but modified the 1843 authority. The maximum height of the dam above normal river level was raised to 6 feet and the necessity of a lock to permit navigation was reaffirmed. The Act clearly stated that the flowage of private lands without the consent of the owner was not authorized and water levels could not be raised to the extent that they damaged existing mills or potential mill sites.

The dam was constructed some time after 1851. The original structure consisted of rock filled wooden cribs and earthen dikes along with some masonry, stone work and a gristmill. There are reports in the record (state vs. Norcross, 132 Wis. 534) that until March, 1898 there were eight 5'x5' gates in the dam which were operated to regulate the height of the water and that sometime after that date (about 1900) those gates and their openings were permanently closed. Abutments were added to the dam which narrowed the channel of the river. Litigation had been commenced in Rock County Circuit Court by property owners who alleged that Pliny Norcross had exceeded the authorized 6 foot dam height and as a result and because the gate openings had been closed, 5,000-6,000 acres of private lands had been flooded (as well as cellars in Fort Atkinson) and roads were made impassable. Further, the locks and chutes required by both the 1843 and 1851 authorization had never been constructed and accordingly navigation had been limited and the movement of fish impeded. In 1907, this litigation found its way to the Wisconsin Supreme Court where judicial notice of navigability became the major issue. The matter was remanded to circuit court for further proceeding.

In the late 1800's and early 1900's Lake Koshkonong was the most important staging habitat for canvasbacks in the Midwest (Sinclair 1924, Frautchi 1945). Many of the local Lake Koshkonong landmarks we recognize today were derived from the early settlers and waterfowl hunting. The first white person located at what is now Beloit, was one THIEBAULT (sometimes spelled THIEBEAU, and pronounced Tebo). This French-Canadian trader, moved away from Beloit, having been employed by the Government as interpreter among the tribes in the northern part of the Territory. He finally settled on Lake Koshkonong, at a place called **Thiebault's Point,** where he was, it is believed, murdered in the winter of 1837-38, by his son and one of his wives. Whatever the motive, Thiebault was probably murdered, and his body disposed of by cutting a hole in the ice and throwing it into the lake (American Local History Network; http://www.usgennet.org/usa/wi/county/rock/City/Blt002.html).

Historic **Bingham's Point** was named for Ira Bingham, a local market hunter who designed a modified double-bowed flatboat, which was intended for rowing and nicknamed "the Monitor" after the Civil War warship. The nickname was due to the long narrow double-bowed boat which rode low on the water and had canvas extensions that could be raised to protect the hunter in rough weather. Once positioned, the decoys and the lapping water concealed the hunter completely. It is no wonder that old club records recount staggering bags of game, especially canvasbacks. The Carcajou Club was incorporated in 1896 by a group of Janesville men including H.L. Skavlem, C.L. Valentine and Alex McNaughton. As early as 1870, sportsmen organized into prestigious shooting clubs with names like **Blackhawk Club** and **Carcajou Club** that were frequented by such notables as General Phil Sherman, former US Vice President Tom Marshall and Wisconsinites like August Pabst, Governor George Peck, Charles Pfister and the Baraboo Ringlings brothers. The area's reputation for excellent shooting even drew members from New York and California. More than one group of wealthy Chicago sportsmen formed their own clubs here (Donna Tonelli; website; http://edecoy.org/Homme.html.).

By the late 1800's Thure Kumlien (Kumlien 1877) concluded changes to the landscape, local fauna, and the lake were already evident. Thure writes,

> "As for the fish in the lake, the time is past when twenty-eight to thirty-five pound pickerels can be found, or twenty-five pound catfish. Bullheads, perch, sunfish, garpikes, and dogfish are common yet; but the pike, pickerel, bass, redhorse, sucker, and catfish are not near as plentiful as formerly. Perhaps the dams across the Rock River, below the lake are too powerful hindrances for the fish of the Mississippi River to up to our water to spawn; if so, were effectually, prevented from ever having shad successfully planted in this part of Rock River".

Thure, (Kumlien 1887) also commented on the Indianford dam,

> "In 1844, there was a steamboat going through the lake, said to have come up from St. Louis. The new settlers hailed this occurrence with great pleasure and hopes...The idea never occurred to them that this big Rock River, on which with their own eyes they had seen a steamboat from St. Louis, ever could be, by any authority, pronounced an un-navigable stream, and dams allowed to be built across it".

Era of Dam Reconstruction and Dam Heightening for Power Production (≅1900-1939)

Anecdotal reports indicate the deep water marsh habitat of Lake Koshkonong remained healthy through 1910. Threinen wrote, "Mr. Cole from Fort Atkinson stated that in 1907 looking out over the lake it looked like a vast meadow so thick was the vegetation. A Mr. Knoepfel said that in 1910 the east shore of the lake was a vast bed of wild rice. A Mr. Boese said that Blackhawk Island extended into the lake a great distance and was covered with wild rice".

A March, 1915 field report by C. Gross of the Wisconsin Railroad Commission illustrated the construction at that time. In an August 1916 memo to the Commission, C.A. Halbert states that the Indianford Dam owned by the Janesville Electric Company is under reconstruction, involving some 275 feet of wood crib spillway being replaced with concrete. At this time the eastern hundred feet of the main spillway was being constructed. The elevation of this section evidently varied from 10.11 feet to 11.18 feet, Railroad Commission datum (W.R.C.). The elevation of the reconstructed concrete spillway is given as 11.54 feet and it is noted that the spillway is provided with bolts intended to secure flashboards. The easternmost 40 feet of the dam had previously been reconstructed with concrete with an average spillway elevation of 12.11 feet (W.R.C.). This section replaced, what were the eight slide gates from the original dam. This is the section that was to be rebuilt and fitted with lift gates in 1917. Halbert established the datum base still in use (0.00 Commission datum = 763.54 mean sea level (msl)).

John W. Robbins, et. Al., vs. Janesville Electric Company before Wisconsin Railroad Commission – volume 19, page 608 (WP-60; 7/31/1917). Property owners upstream of the dam alleged that Janesville Electric Company had maintained water levels higher than had been authorized and that as a result there had been extensive flooding and damage and in addition that there were no gates at the dam sufficient to pass floods and that an adequate fishway had never been provided. The petitioners asked that the Railroad Commission establish minimum and maximum water levels and direct the owner of the dam to construct adequate floodgates and fishways. The Commission ordered that the owner of the dam remove any flashboards on top of the concrete spillway and directed that a floodgate section be constructed pursuant to plans approved by the Commission. The Commissions committed itself to an investigation of the dam and an order regulating the operation of the new gates. The Commission further stated that a minimum level would be established if it were necessary to protect the public interest and emphasized that for the interim the concrete crest of the spillway would be the maximum height authorized for the dam.

In November, 1917, W.G. Hoyt of the Wisconsin Railroad Commission investigated the relationship between the water levels at Lake Koshkonong and Indianford to enable the Commission to issue an order regulating operation of the newly installed floodgates. Hoyt's investigations and conclusions are particularly valuable:

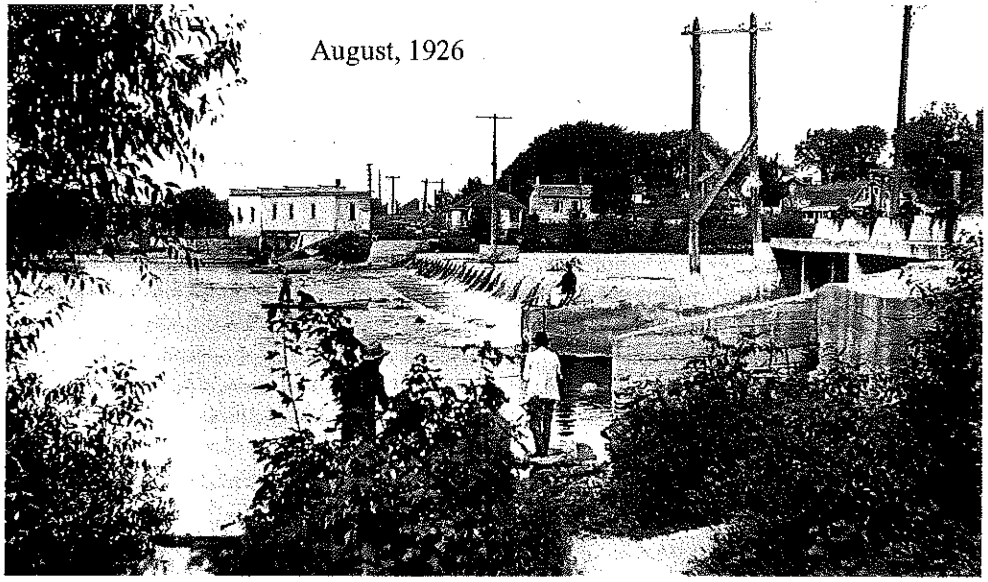
1. He concluded that the difference between the water surface at the lake and dam may vary from 0.30 feet during normal flows to in excess of 3 feet during the highest flow.

2. He stated that the backwater effect of the railroad bridge upstream from the Indianford Dam (C.M.&St.P.) was probably minimal below a flow of 2,000 feet per second or at a dam stage of 13.1 feet (W.R.C.) with the gates closed or 12.5 feet with the gates open.

3. The consensus of the investigating engineers was that the normal elevation of Lake Koshkonong was between 12.1 (775.64 feet msl) and 12.6 feet (776.14 feet msl) (W.R.C.) and that the gates should be opened when the stage at the dam was between 11.7 and 12.1 feet (W.R.C.). Having surveyed the damage around the lake, the engineers recommended opening the gates at the lower point.

4. The investigators emphasized that although the six gates would discharge a maximum of 1500 feet per second at an elevation of 14.0 feet (W.R.C.), that this discharge capacity would not entirely alleviate high water conditions on the lake.

W.G. Hoyt's investigations of 1917 correspond well with summer pool elevations reported at the Fort Atkinson Water Plant during the early 1930's (Hoyt normal pool=775.64 msl and WDNR analysis in Attachment 5 = 775.52 msl).



August, 1926

John W. Robbins et al vs Janesville Electric Company before Wisconsin Railroad Commission – volume 20, page 397 (February 1918). The floodgate section at the east end of the dam had been completed. The construction included six wooden lift gates averaging 6 feet in width. The nature of the lifting gear is not apparent, but probably consisted of a cog and wheel apparatus. The sill elevation at the gate section was approximately 7.6 feet (W.R.C.) and the elevation of the main spillway crest was described as **11.44 feet** (W.R.C.), 0.18 feet higher than the old spillway which it had replaced. Because the new floodgate section gave the dam a discharge capacity much in excess of the old dam, Janesville Electric Company was not directed to restore the spillway elevation to 11.26 feet (W.R.C.) by flashboards or other means. In addition, the electric company was directed to remove an old coffer dam obstructing the floodgates by dredging a channel 45 feet wide at the bottom (with bottom elevation not higher than 8.0 feet W.R.C.), leading from the main channel of the river to the floodgate section. The Commission directed that at least two gates be fully open when the water elevation at the dam exceeded 12.1 feet and that all six gates be fully open when the water elevation exceeded 12.6 feet (W.R.C.). The gates were to be closed when the water elevation dropped below the crest of the spillway unless special authority had been received from the Commission.

J.P. Robbins et al vs. Janesville Electric Company before the Wisconsin Railroad Commission – volume 23, page 146; 6/21/1919. Petitioners alleged that the old coffer dam partially obstructing access to the floodgate section had not been removed pursuant to the 1918 Commission order and argued further that delaying the opening of all six gates until water levels had exceeded elevation 12.6 feet (W.R.C.) did not provide sufficient relief from flooding. Property owners described damage that had occurred during high water in the spring of 1919 and related that while waters at the lake rose to levels causing damage, the water level elevation at the dam was too low to require that all floodgates be opened. The Commission recognized that opening gates sooner would detract from the efficiency of power generation, but decided that greater relief from flood damage was due upstream property owners. The Commission modified the 1918 order and directed that all six gates by fully opened and remain open whenever the water elevation at the dam exceeded 12.1 feet (W.R.C.). Further, Janesville Electric was given the option of removing the remnants of the coffer dam above the gates in accordance with the previous order or opening all six gates fully from February 15 to June 15 yearly when the water level elevation at the dam exceeded 12.0 feet (W.R.C.).

The Commission's direction that all gates were to be closed when the water level receded below the crest of the spillway remained in effect. However, no absolute minimum water level was established and the entire stream flow could be diverted through the powerhouse during periods of low flow as long as it was economical for power generation.

Carp were first introduced into Wisconsin in 1881, but records indicate little mention of carp population problems in Lake Koshkonong until about 1912. By 1923 Lake Koshkonong's vegetation had largely disappeared and fishing and hunting dropped off drastically. This dramatic shift in the ecosystem prompted Sinclair's national sporting magazine article about Lake Koshkonong's woes (Sinclair 1924). Sinclair was convinced that the carp and high water were at fault for the disappearance of the vegetation. The loss of vegetation was so bad that a biologist from the Federal Biological Survey was called in (Hylan 1923). He reported no vegetation and blamed it on the carp and water levels.

In 1952 a report by C.W. Threinen (WDNR 1952), *History, Harvest and Management of the Lake Koshkonong Fishery*, came to the following conclusion:

> "Looking back over the history of the vegetation in Lake Koshkonong and adding to it our most recent information, it is apparent that the greatest single event in the epochs in lake ecology was the extra two feet added to the dam at Indian Ford in about 1917. This changed the lake from a marsh to an unstable lake."

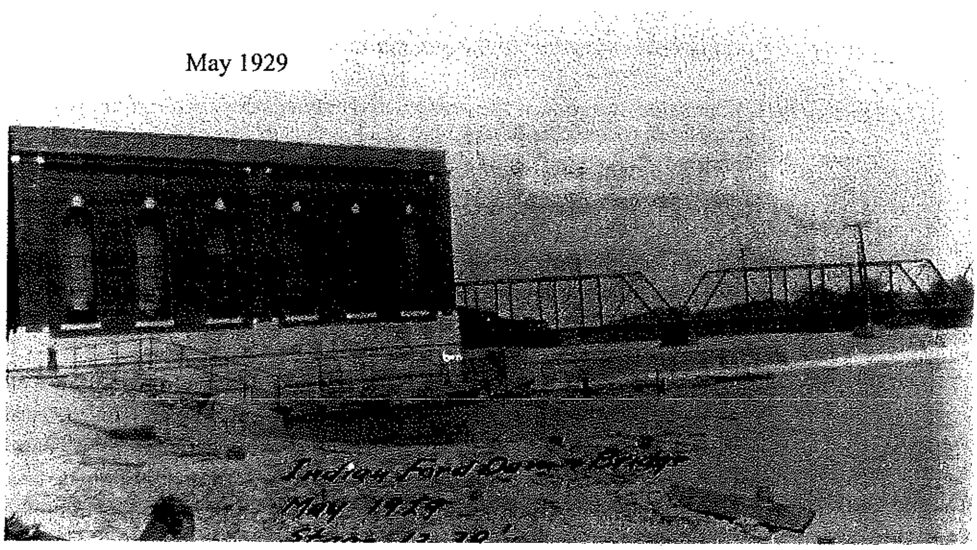
Main (1945) reports, "When this dam was changed from a height of four feet to six or seven feet, the depth of the lake was greater. This killed the wild rice, except that which grew in the shallow bays".

Threinen came to the following conclusion in 1952,

> "It appears that most of the erosion takes place at high water when unstable peat or alluvial soils are exposed to wave action. To prevent shoreline erosion water levels must be watched closely and the dam operated with precision to prevent damaging high waters."
>
> "Before creation of the large expanse of open water by an increase in the dam in 1917 when the lake was a "sea of green" largemouth bass, perch, bluegills and probably northern pike were important fishes. This condition could be produced again by aggressive and continued control of carp and by lowering the water level somewhat."

A June 4, 1929 Railroad Commission memo submitted by George P. Steinmetz noted that the water level elevation of the dam was 12.38 feet (W.R.C.) and that all floodgates were opened and water was passing through them with no obstruction. Steinmetz stated that new wheels and generators were being installed in the power plant by the Wisconsin Power and Light Company, which had acquired the dam.

The main spillway was reconstructed in 1931 and Railroad Commission engineers confirmed construction of the spillway crest at an average elevation of 11.44 feet (W.R.C.). There was no modification of the floodgate section. However, the coffer dam upstream of this section had apparently been entirely removed by this time. In 1931, representatives of Wisconsin Power and Light Company and property owners on Lake


May 1929

Koshkonong met before the Railroad Commission. An informal agreement resulted in which the company agreed not to reduce water levels more than 6 inches below the crest of the spillway.

A June 16, 1932 Commission memorandum by C.M. Dahlen generally describes the channel cross section at the C.M.St.P.&P. railroad bridge. The water level was 2 inches below the crest of the spillway at the Indianford Dam and three channels were very shallow (about 12 inches deep) while the fourth channel at the east end of the bridge had a three foot depth. It was noted that within the past two or three years the railroad company had repaired the bridge by replacing stone piers with concrete slabs. The demolished stone piers were evidently discarded in the river channel at the site thus prompting Dahlen's investigation of this alleged obstruction of navigation.

Another Commission memorandum submitted by W.A. Muegge on December 1, 1933, relates an investigation and response to complaints of high water above the dam on Lake Koshkonong. Muegge confirmed the original elevation of the sills of the floodgates and the main spillway. He took soundings of the channel upstream from the floodgate section which demonstrated that the old coffer dam had in fact been removed.

Before the Public Service Commission of Wisconsin – A petition was presented by property owners in the vicinity of Lake Koshkonong to raise the level of the Rock River at Indianford Dam six inches above the exiting normal level. (2-WP-461, volume 21, page 705; 11/28/1939). Owners of low lying lands and farmers appeared at a hearing on this question and objected to any increase in water levels at the Indianford Dam citing concerns about flood damage and poor drainage of agricultural lands. The Commission relied upon investigation by its staff, the United States Geological Survey and the United States Army Corps of Engineers in reaching the following conclusions:

1. *During periods of low flow, the Indianford Dam controlled water levels as far upstream as Fort Atkinson. The installation of flashboards during such low water periods would be generally unobjectionable provided they did not cause increased water levels during spring floods or summer storms.*

2. *During major flood events, the railroad bridge upstream from the dam was a control section determining the elevation of Lake Koshkonong.*

3. *Floodwater storage made available by adding 6-inch flashboards to the dam was not significant amounting to 4715-acre feet or 0.03 inches of runoff from the drainage area.*

4. *The Commission concluded that the reduction in discharge capacity of the dam caused by the placement of 6-inch flashboards was not acceptable.*

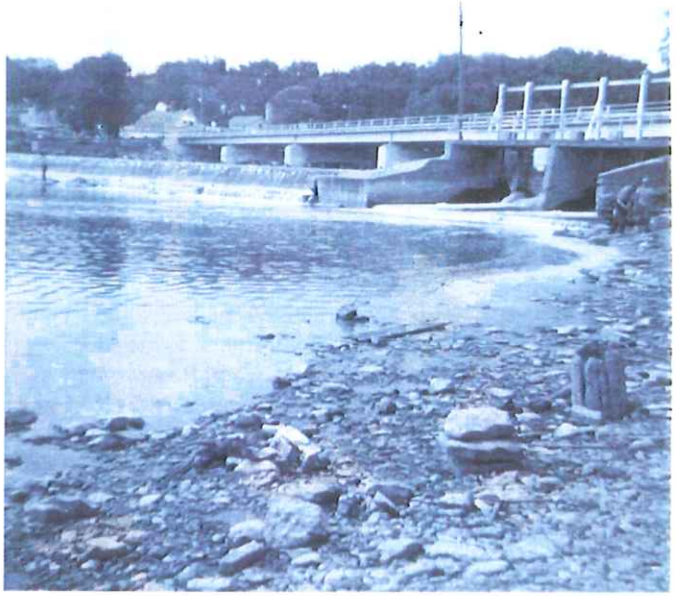
5. *The Commission further stated that the owner of the dam and its predecessors had maintained the spillway at the elevation of 11.44 feet (W.R.C.) and had operated the floodgates as required for more than 20 years and thus had acquired prescriptive flowage rights to maintain the dam at that height and operate the gates in the manner authorized by the Railroad Commission in 1919 (WP-60).*

6. *The Commission stated that the prescriptive rights described did not extend to the flowage of lands by placement of flashboards during the periods of low stream flow. The Commission further stated that the Wisconsin Power and Light Company could apply for authority to place flashboards on the dam if the appropriate flowage easements were first obtained.*

The Commission dismissed the order generally citing its lack of authority to require that the owner of the dam usurp private property rights by flowing lands which at least periodically had not been flowed before. (note: ck applicability of WP/414 obstruction)

12/27/1965 Transfer of the dam from Wisconsin Power and Light Company to Rock County (2-WP-2251). This docket described how power generation by Wisconsin Power and Light had ceased in 1962 due to a net operating loss on the facility. An inspection of the dam by the Public Service Commission pursuant to Section 31.184(4), Wisconsin Statutes, and Wisconsin Power and Light engineering staff itemized a list of necessary repairs to the concrete structure and its gear. The maintenance was performed at the expense of Wisconsin Power and Light and generally consisted of repair of cracked and spalled concrete resetting the floodgate frames, installing new metal gates, manual lifting gear and reconstruction of the east downstream wing wall, and the dike on the east bank.

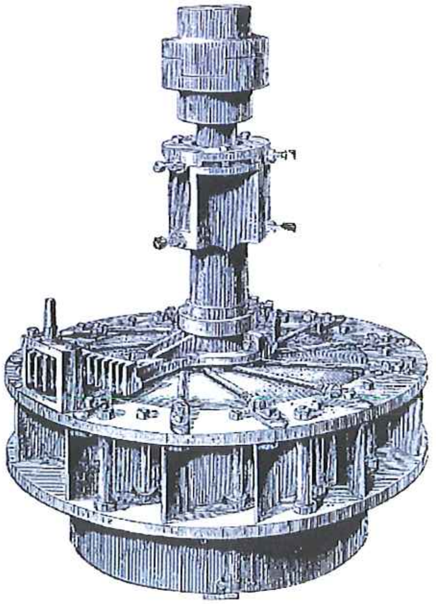
June 1961



In testimony a Public Service Commission staff engineer stated that the Commission did not generally consider the discharge capacity of a powerhouse to evaluate the effect of a dam on flood flows (pages 28 and 29). The engineer stated that the Public Service Commissions did not generally object to removal of wicket gates (see figure 1) from the powerhouse and that Rock County could apply to the Commission for authority to fill the headrace at some future date. A contract between Wisconsin Power and Light Company and Rock County granting the dam, powerhouse and real estate along with certain unspecified flowage rights for the sum of $1 was presented to the Commission as an exhibit.

The Commission found that the county met the requirements of Section 31.14(2) Wis., Stats. and was financially capable of maintaining the dam for a period of ten years and no objection being heard conditioned the transfer on the performance of the repairs itemized by Wisconsin Power and Light and upon the acceptance of the transfer by Rock County. Public Service Commission staff recommended the continuation of the operating orders designated in WP-60 (Railroad Commission Orders of 1917 and 1918).

Figure 1. Generalized schematic of a wicket gate. Wicket gates are a series of vanes arranged radially around a opening that open and close to allow variable amounts of flow to drive the turbine.



1956-1981

In the late 1960's wicket gates in the powerhouse became rusted shut making that discharge capacity unavailable. Manipulating the manually operated floodgates was a very time consuming proposition and the operating orders for the lift gates were not rigidly adhered to. This period is marked by extreme vacillation in water levels, accelerated erosion and loss of peripheral wetlands on Lake Koshkonong. These conclusions are documented in Department of Natural Resources memoranda and in correspondence from the general public.

Wisconsin Electric Power Company in a December 20, 1974 report investigated the restoration of the powerhouse at Indianford as a means of stabilizing water levels on Lake Koshkonong. The report was authorized by the Rock County Planning Commission and the Wisconsin Department of Natural Resources. The report describes three metal head gates in place upstream of the wicket gate in flume no. 1. This wicket gate had frozen in the 7/10 open position and the wicket gates in unit no. 2 were frozen completely shut. The report detailed two alternatives:

1. The wicket gates could be rejuvenated and used to regulate flow through the powerhouse.

2. The head gates in unit 1 could be rejuvenated and new gates installed in unit 2. Both sets of gates would have to be fitted with a lifting mechanism. The wicket gates would then have to be jacked fully open or removed.

Either alternative was judged to be equally feasible with the second alternative being more economical by virtue of lower long-term maintenance costs. A 1974 investigation by the Department of Natural Resources (3-WR-1835) relating to the hydraulic capacity of the dam resulted in a suggestion that Rock County consider the installation of two 20-foot wide taintor gates at the dam. The matter was closed when it became evident that the discharge capacity of the powerhouse was to be restored by leasing the power rights.

10/28/1976 Rock County entered into a lease agreement with Peter Burno. Mr. Burno agreed to act as an agent for the county in operating the dam in exchange for the right to restore the generating capacity of the powerhouse and enjoy the profits of that power production.

During 1978 at least one of the wicket gates was made operative and during the major flood in spring of 1979 both flumes of the powerhouse were open. During the past two years, one wicket gate has generally been left open to provide for increased discharge capacity at the dam.

4/25/91 The Department reestablished water levels for Lake Koshkonong in 3-SD-82-809. This order moved control elevation from the Indianford Dam to Lake Koshkonong, established minimum gate operations, established a winter draw down and required dam operations based upon current hydrologic conditions. The order was challenged and affirmed by a Jefferson County Circuit Court. The order to affirm was challenged to the Court of Appeals where it was remanded back to the Department for hearing. Order # 3-SD-82-809 was changed and was a result of a compromise between all parties to the appeal.


April 1993, High water

Physical Environment

Lake Koshkonong lies within the Southeast Glacial Plains Ecological Landscape. The Southeast Glacial Plains Ecological Landscape makes up the bulk of the non-coastal land area in southeast Wisconsin. This Ecological Landscape is made up of glacial till plains and moraines. Most of this Ecological Landscape is composed of glacial materials deposited during the Wisconsin Ice Age, but the southwest portion consists of older, pre-Wisconsin till with a more dissected topography. Soils are lime-rich tills overlain in most areas by a silt-loam loess cap. Agricultural and residential interests throughout the landscape have significantly altered the historical vegetation.

Erosion

Lake Koshkonong was born with an irregular shoreline. The lake has been seeking a natural shoreline of rock, gravel or sand. Such names as Black Banks, and exposed, eroded peat bank typifies the problem. Threinen (1952) identified the problem over 50 years ago and stated, "Further evidence can found from the sight of uprooted trees and from duck hunters who will exclaim that what was their duck blink has now been claimed by the lake". Due to the combined effects of ever-increasing water levels and the loss of aquatic plants, erosion of the wetlands and some adjacent uplands continues to date. Lake Koshkonong ranks 12th in the number of erosion control permits issued in the South Central Region (Table 1). Lake Koshkonong's relatively low number of erosion control permits seemingly belies this environmental concern. This is due to the fact that over 35% of Lake Koshkonong's shoreline is lowland and contains no adjacent residential development. Erosion control permits are typically the result of residential development along lakeshores.

Table 1. Number of Erosion Control Permits by lake issued in the South Central DNR Region. Lakes with 20 permits or less are not shown. Data are taken from the Waterway and Wetland Protection Database and reflect the years 1968-1998.

Lake Name	Number of Erosion Control Permits
Lake Wisconsin	648
Beaver Dam Lake	165
Lake Redstone	155
Lake Mendota	146
Lake Monona	113
Lake Kegonsa	103
Lake Waubesa	85
Green Lake [Big Green]	72
Rock Lake	59
Fox Lake	50
Park Lake	46
Lake Koshkonong	40
Lake Ripley	34
Swan Lake	33
Buffalo Lake	32
Puckaway Lake	30
Lake Delton	29
Little Green Lake	24
L Montello	23
Sinissippi L	22
Lawrence Lake	22
Lee Lake	20
Total	2144

The District has actively pursued this habitat protection strategy through a cooperative effort with the Department to 'armor' wetland shorelines to reduce wetland loss. The District considers this to be the most effective practical means of preventing further loss of wetland habitat on the lake. The Department, the District and private landowners have cooperated to construct these breakwater structures in order to protect exposed wetland shores. RKLD and WDNR are conducting a Cooperative Lake Study to assess the erosional conditions in the lake's wetland areas.

Based on consultants recommendations, RKLD has sought grant programs and legislation to permit structures on the bed of Lake Koshkonong specifically to protect and restore aquatic habitat. RKLD has sponsored ten (10) $10,000 Wetland Restoration grants from the State of Wisconsin to limit erosion on many of the privately owned riparian wetlands of Lake Koshkonong. The majority of these projects included riprap armor of wetland shoreline areas that have been eroded and lost over time. Riprap armor has been used to reduce erosion loss and is actively supported by RKLD as a remedy for both upland and wetland shorelines.

During 2002 and 2003, the RKLD worked cooperatively with wetland owners to protect approximately 38% or 4.7 miles of the 12.5 miles of wetland shoreline. In 2001 Act 16, the Legislature granted authorization to the District for a Lake Koshkonong Comprehensive Project (Table 2). That legislation recognized the placement of breakwater structures was another suitable management approach to prevent wetland losses resulting from wind and seasonal flood conditions.

RKLD is currently involved with the U.S. Army Corps of Engineers (ACOE) in a Section 206 Ecosystem Restoration Program to further restore and protect wetlands and near-shore shallow water areas. The ACOE has identified several off shore breakwaters that if built would provide similar protected habitat to those structures constructed on the Lake Winnebago pool. ACOE's project has a focus of not only arresting waves but also excluding carp from shallow near shore areas. On the Lake Winnebago pool this concept has been effective in reestablishment of submergent vegetation. The status of this program is tenuous at this point. In Federal FY 04, a $112,000 congressional addition was placed within the Water Resources Development Act specifically allotting money to the ACOE to work on the Lake Koshkonong 206 project for planning and design of the Lake Koshkonong breakwater project. There is currently $160,000 of congressional additions within the House vision of the Water Resources Development Act for FY 05, which if enacted, would allow for continued funding of the Lake Koshkonong 206 project at the Feasibility level. ACOE officials have estimated that the report is approximately 40% to 50 % complete. However, the project manager has expressed great concern about moving forward with a project design until they are certain of the water level regime that will be established, and further that the new water level regime will yield the same environmental benefits from the off shore breakwaters. Accordingly, the ACOE project management team has decided to suspend all work on this project until the District's petition to raise water level is resolved.

It should be noted that the ACOE project includes structures that are substantial and engineered to withstand the forces from ice action and wave action that can reasonably be expected to occur on Lake Koshkonong. These proposed structures are substantially larger in size and scope than the structures built by RKLD in recent years.

Table 2 2001 Legislative Act 16 related to Lake Koshkonong.
30.2025 Lake Koshkonong comprehensive project.

(1) DEFINITION. In this section, "district" means the Rock–Koshkonong public inland lake protection and rehabilitation district.

(2) AUTHORIZATION. The district may implement a project developed and approved by the U.S. army corps of engineers to place structures, or fill, or both on the bed of Lake Koshkonong for any of the following purposes:

(a) To improve navigation or to provide navigation aids.
(b) To restore or protect wetland habitat or water quality.
(c) To create, restore, or protect fish and wildlife habitat.
(d) To enhance the natural aesthetic value or improve the recreational use of the lake.

(3) LOCATION OF STRUCTURES AND FILL. Any structure or fill placed as part of the project authorized under sub. (2) shall be located in Lake Koshkonong within the area that consists of Secs. 10, 13, 18, 19, 20, 24, 33, and 35, T 5 N., R 13.

(4) PRELIMINARY REQUIREMENTS. (a) Before beginning any activity involving the placement of a structure or fill as part of the project authorized under sub. (2), the district shall submit plans and specifications for the project to the department and obtain the department's approval for the project.

(b) Before the department gives its approval for a project authorized under sub. (2), the department shall do all of the following: 1. Comply with the requirements under s. 1.11. 2. Review the plans and specifications submitted to the department under par. (a) and obtain any other information that it determines is necessary to effectively evaluate the structural and functional integrity of the structure or fill. 3. Hold a public informational meeting to discuss the plans and specifications submitted under par. (a). 4. Determine that the structure or fill is structurally and functionally sound and that the structure or fill will comply with the requirements under sub. (5).

(5) REQUIREMENTS FOR STRUCTURES AND FILL. A structure or fill placed as part of a project authorized under sub. (2) shall meet all of the following requirements: (a) It may not materially affect the flood flow capacity of the Rock River. (b) It may not materially obstruct navigation. (c) It may not cause material injury to the rights of an owner of lands underlying the structure or fill or to the rights of a riparian owner who owns lands affected by the project. (d) It may not cause environmental pollution, as defined in s. 299.01 (4). (e) It may not be detrimental to the public interest. (f) It must further a purpose specified in sub. (2).

(6) MAINTENANCE BY THE DISTRICT. (a) The district shall maintain the structures and the fill that are part of the project authorized under sub. (2) to ensure that the structures and fill do not impair the safety of the public. (b) The district shall maintain the structures and the fill that are part of the project authorized under sub. (2) so that the structures and fill remain in compliance with the requirements listed under sub. (5).

(c) If the department determines that any structure orany fill that is part of the project authorized under sub. (2) does not comply with the requirements under sub. (5), the department may require the district to modify the structure or fill to bring it into compliance or to remove the structure or fill.

(7) USE OF STRUCTURES OR FILL. Any structure or fill placed as part of the project authorized under sub. (2) may be used only for any of the following:(a) As a site for the placement of navigation aids approved by the department.(b) Activities to protect or improve wildlife or fish habitat, including the placement of fish or wildlife habitat structures approved by the department. (c) Open space for recreational activities.

(8) OWNERSHIP. (a) The structures or fill that are part of the project authorized under sub. (2) are owned by the district. Except as provided in par. (b), the district may not transfer ownership of any structure or any fill that is part of the project authorized under sub. (2). (b) The district may transfer ownership of any structure or fill that is part of the project authorized under sub. (2) if all of the following apply: 1. The district transfers ownership of the structure or fill to a public entity, as defined by the department by rule. 2. Before transferring ownership of the structure or fill, the district obtains written approval of the transfer from the department.

(9) ACCESS TO PROPERTY. An employee or agent of the department shall have free access during reasonable hours to the structures or fill that are part of the project authorized under sub. (2) for the purpose of inspecting the structures or fill to ensure that the project is in compliance with the requirements of this section. If the department determines that any structure or any fill that is part of the project authorized under sub. (2) does not comply with the requirements of this section, the department may require the owner of the structure or fill to modify the structure or fill to bring it into compliance or to remove the structure or fill.

(10) EXEMPTIONS. Section 30.12 does not apply toactivities that are necessary for the implementation or maintenance of the project authorized under sub. (2).

Winter Drawdown: Ice jacking, Ice Ridges, and Shoreline Alterations

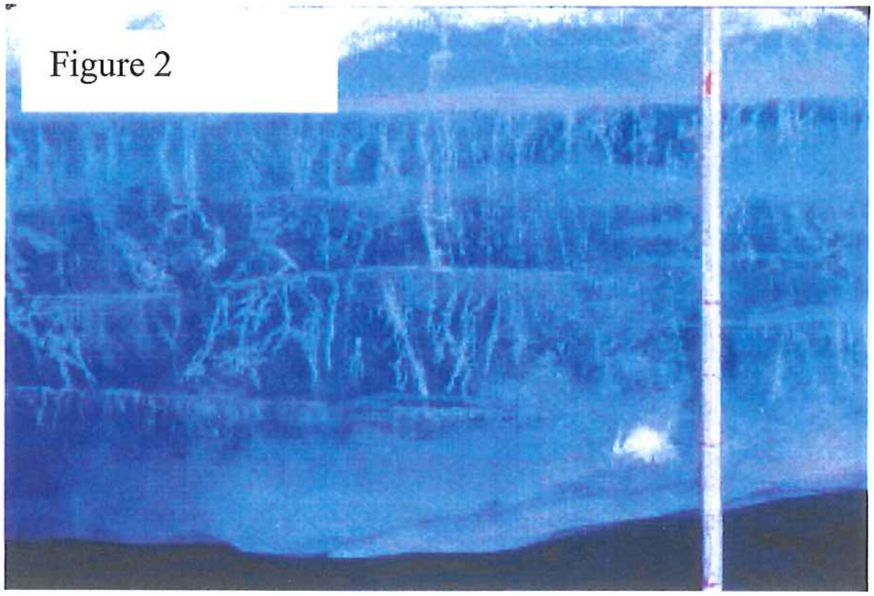


Figure 2

The expansion effect of lake ice, however, does not make itself felt until the ice layer is at least five inches thick. Lake shores are subjected to modification by ice action. The final result of the freezing process is a dense, water-tight sheet of floating ice ranging in temperature from a few degrees above freezing at its bottom surface to as low as –40 degrees F. at the top. The ice cover is normally in a state of almost complete flotation with the exception of its edges, which may be frozen solidly to the shores, projecting boulders, piers of bridges, dams, walls, or other objects to which it may have had an opportunity to attach itself. Ice on a lake surface expands or contracts with the rise and fall of the air temperature, and since air temperatures have a considerable range of fluctuation in winter, the ice changes in volume. What actually happens is that the ice sheet will expand a small amount during a temperature rise, with the resultant force of its compressive strength directed to its point of contact with the shoreline But as the temperature drops, the ice sheet then tries to shrink back to its original shape – like a piece of steel that expands when heated and contracts when cooled. The ice tries to pull its massive weight inward in a tensile force struggle within itself. But since the ice's tensile strength is weaker, than its compression strength, the ice literally ruptures itself, breaking open into shrinkage cracks (see Figure 2). Some cracks can be wide, others no more than "hairline cracks", but collectively their widths equal the amount that the ice sheet has contracted. The cracks subsequently refill with more ice (freezing water). When a subsequent rise in temperature produces an expansion of the whole ice mass, a tremendous force is exerted against the shore. As each successive expansion/contraction event occurs, the ice sheet creeps further, scraping, gouging and pushing as it goes. Some people call this process "ice-jacking" because of the ratcheting effect that each subsequent and cumulative push exerts upon the shore. The coefficient of linear expansion of ice is 0.000052 per degree of temperature rise, and thus for a 10° F variation in an ice sheet a mile long, the change in length would approximate 2.75 feet while the force exerted is probably not less than 30,000 pounds per square foot. If the shore is of such a nature that the ice cannot shove, it may buckle. Buckling is not uncommon, even in very thick ice sheets (see Figure 3). If the ice is weaker than the friction on shore it heaves and cracks near the center of the lake, resulting in ice plates that slide past each other and rest one atop the other, leaving open water. If this occurred now the pressure of the ice on shore would be relieved.


Figure 3

Figure 4

Whether or not expanding ice will push up the shore or buckle (Figure 4) depends on whether weak spots in the ice sheet permit the release of this pressure by the buckling of the sheet or crumbling of its edges, both of these conditions being somewhat dependent on the water depth near the shore. If the shores are gently sloping, the expanding ice overrides them, but if the shore materials are of a yielding sort, an irregular ridge called an ICE RAMPART is likely to be formed by shoving a portion of the marginal material to a higher level, and leaving it in the form of a ridge (Figures 5 and 6). Such ice ramparts may be several feet in height, and may contain large boulders. Where conditions are such that ice ramparts once formed become permanent, successive shoves may build up a considerable accumulation of displaced materials, thus forming an ICE-PUSH TERRACE. Shorelines resist the outward movement of expanding ice.

Ice-jacking and the formation of ice ridges is most dramatic during winters with extreme temperature fluctuations and little snow cover. A dense layer of snow on top of the ice not only reduces the freezing rate, but also forms an insulation blanket that reduces temperature changes in the ice, and subsequent frequency of ice-jacking events. In conclusion, it appears that the effects of the "jacking" action of ice are most severe during those periods when there is little or no snow-cover, and temperatures fluctuate greatly. One intent of winter drawdown is to purposely move the zone of ice-jacking offshore; in the interest of minimizing shoreline alterations and the formation of ices ridges at the bank.

Figure 5

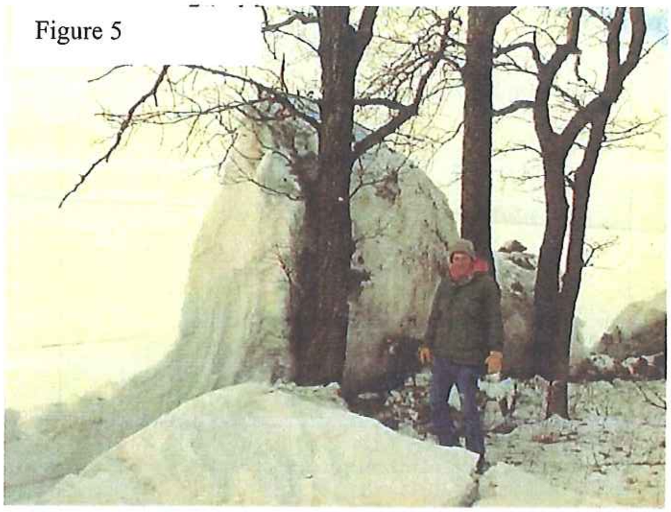


Figure 6

Flooding

Flooding has historically been a concern on Lake Koshkonong and on the Rock River upstream of the Lake. There have been three studies in recent history that speak to the effects of dam operation on flood flows. USGS studied the relationship of the Indianford dam and flood levels on Lake Ksohkonong in a report dated March 1983 and titled ***Evaluation of Alternative Reservoir-Management Practices In The Rock River Basin, Wisconsin.*** USGS studied 12 different operating rules and concluded that "There are some significant differences at certain flow rates among some of the rules. At other times, the different rules produce no detectable difference in stage." With regard to the winter drawdown USGS concluded that "winter drawdown had very little effect on the peak stages the following spring." The Rock Koshkonong Lake District commissioned Montgomery Association Resource Solutions to conduct a hydraulic analysis in 2003. Their January 2003 report titled ***Hydraulic Analysis of Indianford Dam and***

Lake Koshkonong had similar conclusion regarding the operation of the dam and Lake flooding as the earlier USGS report. Specifically Montgomery concluded, " Comparison of Rock River discharge data from gages at Fort Atkinson and Indianford indicate that Lake Koshkonong, as large as it is, has relatively little effect on attenuating flood peaks that move through Lake Koshkonong." And Further " ...changes to Indianford Dam operational procedures may be able to produce noticeable effects on Lake Koshkonong at relatively low flow conditions, but the control of large water fluctuations during major floods or attenuation of flood flows downstream of Indianford Dam were not likely to be possible."

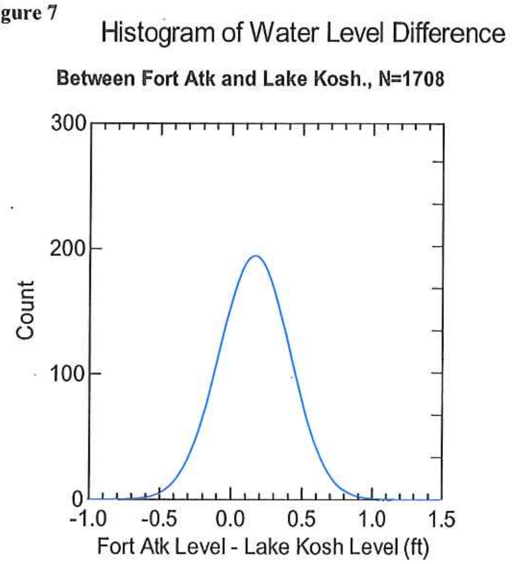
Low flow The Department's last order, 3-SD-82-809, reaffirmed the minimum release from the Indianford Dam as 64 CFS. Wis. Stats., Section 31.34 requires that all dams release at least 25% of the normal low flow "except as otherwise required by law." Normal low flow has not been statutorily or administratively defined. It has been the long standing practice of the Department to interpret the requirement's of Section 31.34 as the same as the $Q_{7/10}$. The $Q_{7/10}$ is a statistical representation of normal low flow used routinely in the WPDES program when applying discharge limits. It represents the 10 year recurrence interval for a 7 day cumulative low flow. It has been the experience of the Department that requiring discharges of $Q_{7/10}$ as the minimum dam release is generally protective of downstream water quality, but fails to fully consider impairments on in-stream habitat. The Department has used more sophisticated Incremental In-stream Flow Analyses at several hydroelectric sites around the state to help establish more scientifically protective discharges. However, due to cost and needed time to perform these analyses the Department has only applied this technology in situations where there is demonstrated need. The most recent determination of $Q_{7/10}$ at Fort Atkinson for the discharge from the Fort Atkinson WPDES permit was 53 CFS and was based upon the flow records from 1953 to 1992. The current minimum release of 64 CFS appears to be protective of down stream resources, and consistent with the $Q_{7/10}$ on the Rock River at Fort Atkinson. The petition from RKLD does not propose a change in the minimum release from the dam and it is unlikely that a change in water levels will alter the $Q_{7/10}$ in the future.

Koshkonong Water Level Time Series Analysis

The USGS in cooperation with Rock County operates a water-stage recorder for Lake Koshkonong (USGS 05427235 LAKE KOSHKONONG NEAR NEWVILLE). However, the period of record for this station is limited to recent years (July 1987 to current).

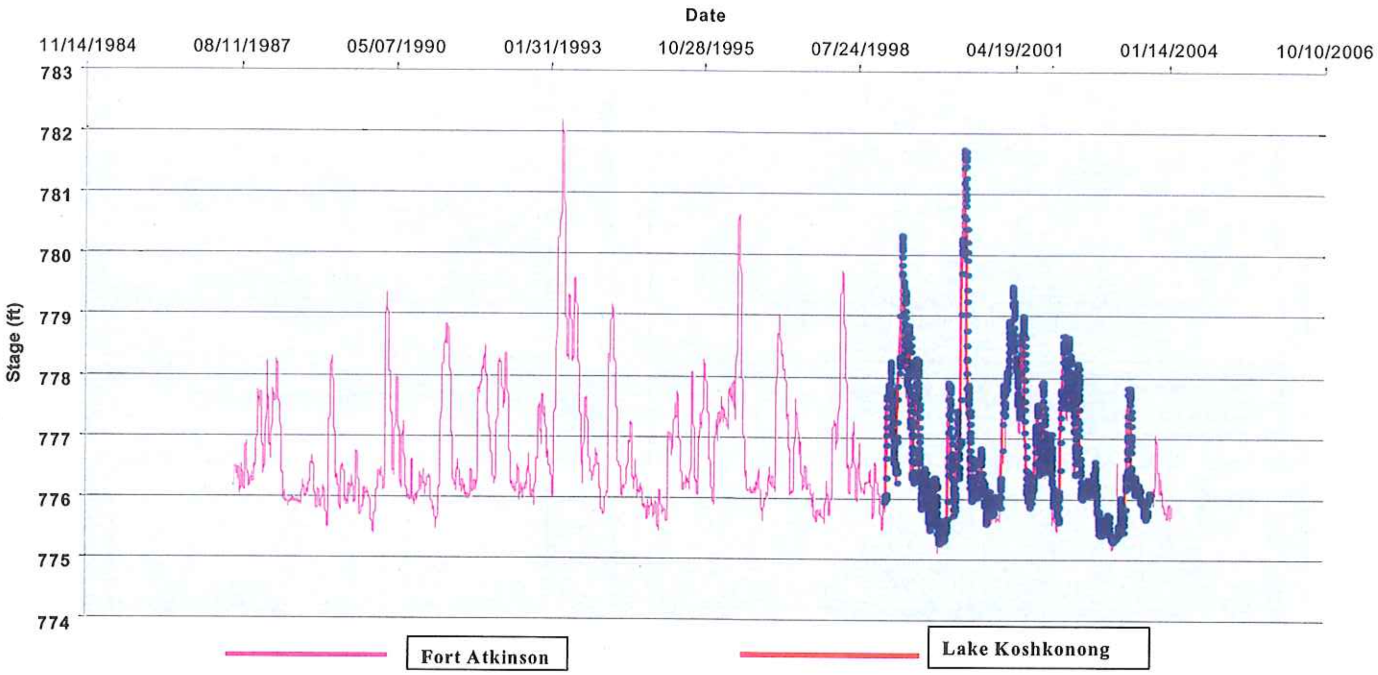
Fort Atkinson Water Plant staff has recorded daily water levels of the river adjacent to the plant since 1932. DNR staff received detailed annual graphs (1932-1998) of these water level records (Attachment 3). The reach of river between the water plant and Lake Koshkonong is very low gradient. Because of its extremely low gradient, changes in water levels recorded upstream at Fort Atkinson reflect lake levels and accurately track annual trends in water levels of the lake (Figs. 7 and 8).

Figure 7



Our primary objective is to examine long term trends in water level during the summer period, when flow is reflective of base levels and is not so strongly affected by the extreme runoff events that occur in spring. Data points from the Fort Atkinson Water Plant graphs were systematically interpolated on days 1,5,10, 15,20, and 25 of each month and entered into a database for analysis. For data after 1998, daily water level records were electronically available. Mean water levels were calculated by month and by season (spring, summer, fall winter) for each year. **For a complete description of the methods and results please refer to Attachment 5.**

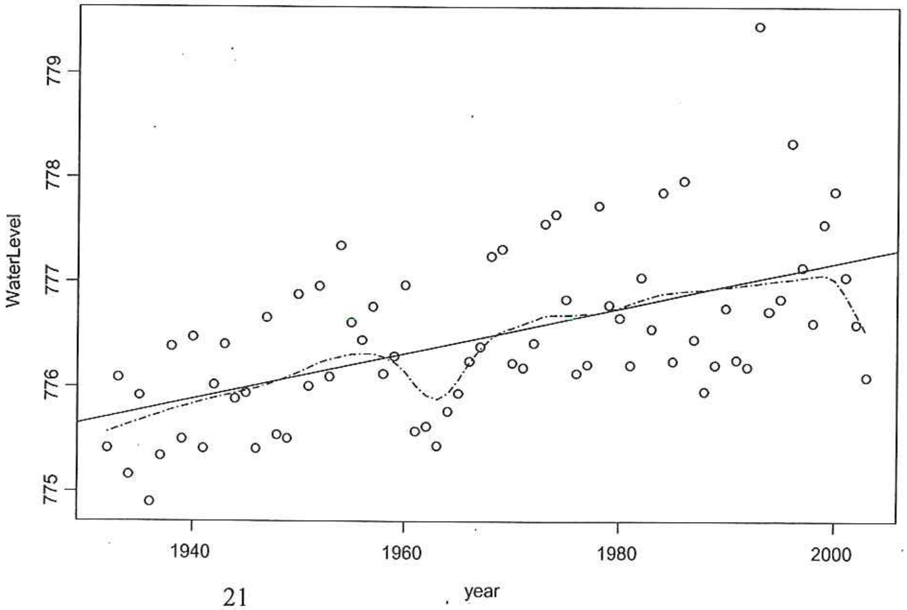
Figure 8 **1987-2004 Rock River, Water Level Data from Fort Atkinson and Lake Koshkonong**



Annual Trends in Summer Water Levels

Mean summer water levels have markedly increased through the years 1932-2003 by 1.532 feet. Mean summer water levels for the period 1932-2003 is shown in figure 9. The solid line in figure 9 is the simple linear regression line (water level = 734.0195 + 0.02158*year, SE of the intercept is 7.506, SE of the slope is 0.00381, P < 0.001 for both, residual standard error is 0.6727). The change in water level predicted by this model for the period 1932-2003 is 1.5 feet (predicted level of 775.709 in 1932 and of 777.241 in 2003).

Figure 9.



Annual Trends in Spring, Fall, and Winter Water Levels

Water levels have significantly increased through the years 1932-2003 (Figure 10-13; P<0.001) for all seasons. Trends for spring, fall, and winter mean water levels are somewhat similar to summer water-levels trends, although less variance is explained by year. Annual variation in water levels is greatest in the spring, followed by fall, winter, and summer (Figures 10-13). R^2 values for the seasonal relationships were 0.099 for spring, 0.314 for summer, 0.179 for fall, and 0.236 for winter.

Figure 10 Spring (Mar, Apr, May)

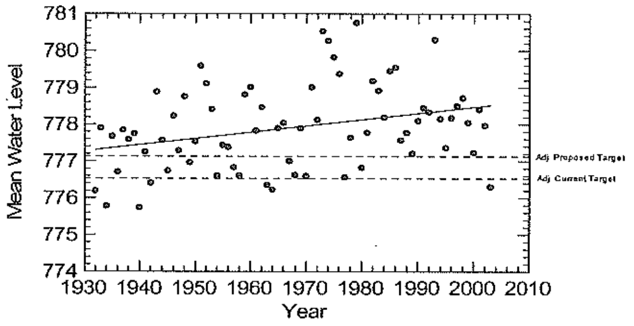


Figure 11 Summer. (June, July, Aug)

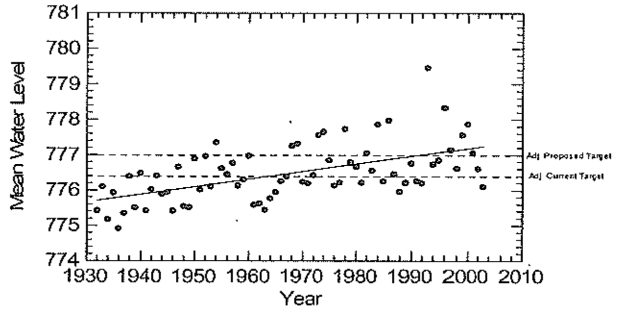


Figure 12 Fall (Sept, Oct, Nov)

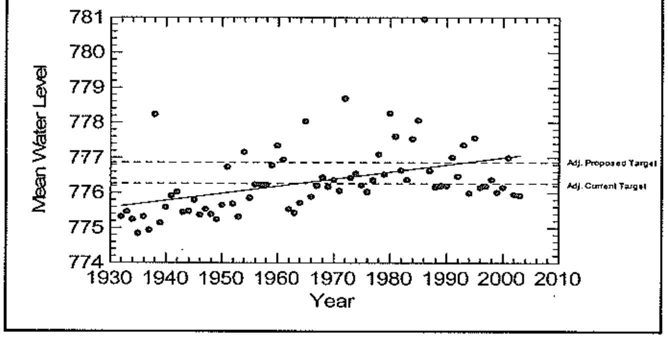
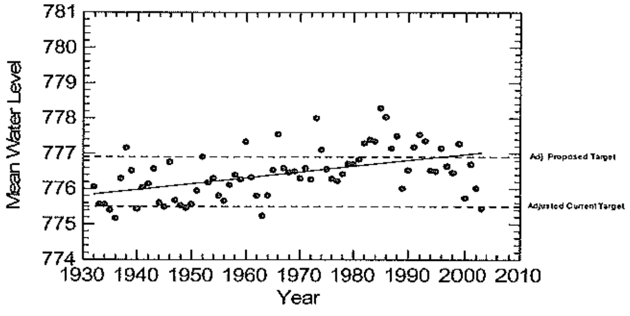


Figure 13 Winter (Dec, Jan, Feb)



Summary of Koshkonong Water Level Time Series Analysis

- Average summer water levels of Lake Koshkonong (as recorded at Fort Atkinson) has increased by approximately 1.5 feet between 1932 and 2003.
- Linear regression results of time series data of water levels predicts (after Fort vs. Lake differential adjustments) a mean summer water level of 775.52 ft in year 1932, which is 0.68 feet below the water level target in the current order and a mean summer water level of 777.05 ft in year 2003, which is 0.8 feet above the water level target in the current order.
- Trend analysis of summers typified by "base-flow" conditions (Elimination of Wet and Variable Summers--data Subset Method) predicts a peak summer level of 775.19 in 1932 and a peak summer level of 776.56 in 1998; an increase of 1.37 ft. in summer water levels during the period.
- After upstream flow was accounted for, there was still an increase in summer water levels of Lake Koshkonong over time (slope = 0.00854, $P < 0.001$).
- A comparison of the slopes of the time series among seasons indicates that water level increases during the summer and fall has been greater than those for spring and winter periods.

Ordinary High Water Mark Determinations

The Ordinary High Water Mark (OHWM) has a long history in Wisconsin Water law. Probably the most famous case defining the OHWM was Diana Shooting Club v. Husting in 1914. The definition used in Diana Shooting Club v. Husting is still the definition of the OHWM used today and was recently codified in State of Wisconsin Administrative code as, "...the point on the banks or shore up to which the presence and action of water is so continuous as to leave a distinct mark either by erosion, destruction of terrestrial vegetation or other easily recognizable characteristics." The significance of the OHWM is that it defines the demarcation point between public trust land and private property. Essentially the state claims public interest in all land below the OHWM elevation. In Wisconsin, the state actually owns title to natural lakebeds and asserts a qualified interest in streambeds and those portions of the beds of natural lakes raised above their original levels.

In regulation of dams, the OHWM is important because a change in operation or water levels that affects the OHWM could result in a change in property from public to private or vise versa. In September and October of 2001 the Lake District and the Department surveyed several OHWMs around Lake Koshkonong. The details of that survey can be found in a report by RSV Engineering dated November 18, 2002 and titled ***Ordinary High Water Mark Study Lake Koshkonong Jefferson County, Wisconsin.***

Figure 14 shows the location of those OHWM determination and Table 3 shows the result of that survey. The Montgomery report assumed OHWM based upon Table 3 of 778.11 MSL. The Department's order 3-SD- 82-809 referred to an OHWM of 776.7 MSL, a difference of 1.41 feet. It is difficult to explain this large difference. The most likely explanation is that the lake now reaches higher levels more often than it did in 1979 when the original OHWM work was done. This simple supposition is supported by the fact that the wicket gates have not been in a state of good repair and would have significantly reduced the capacity of the dam to pass flows, resulting in more fluctuation of the Lake. The Montgomery study had to assume a reduced area of the wicket gates in order to achieve calibration of their model. While the actual opening of the turbine area is about 150 square feet. Montgomery used a reduced area of 53.6 feet to achieve calibration. This reduced flow wicket area could in part explain more pool fluctuation and a higher OHWM. A review of past water levels before the 1979 OHWM and the 2001 OHWM seem to indicate that the water levels have increased to a point were the OHWM could have been influenced (Figure 15). Of particular interest is the mode of the distribution for the spring period. The mode of course is the most frequently appearing point in any distribution. The mode of the water level distribution leading up to the 1979 OHWM and again leading up to the 2001 OHWM falls almost exactly on the OWHM. While the overall mean of the spring distribution did not change, the mean of the summer, fall and winter water level distributions have all increased by 0.7 feet, 0.17 and 0.32 feet respectively.

There are several likely explanations for the apparent rise in water levels between the two series discussed above; First, there is simply more runoff flowing into the lake in the last twenty years. A review of Attachment 5 in part supports this explanation since the trend line for water levels has increased 1.5 feet over the course of the monitored water levels at Fort Atkinson; Second, a lack of operation of the spillway gates including lack of maintenance of the trash racks and wicket gates has resulted in higher water levels; Third, implementation of the last water level order (3-SD-82-809) has resulted in raising the water levels; Fourth, a combination of all of the above has resulted in higher water levels and a higher OHWM.

Another possibility is that the 1979 OHWM was simply wrong. In any event the Department concurs with the RSV report and for the purposes of this analysis will use an OHWM of 778.11 MSL.

Figure 14.

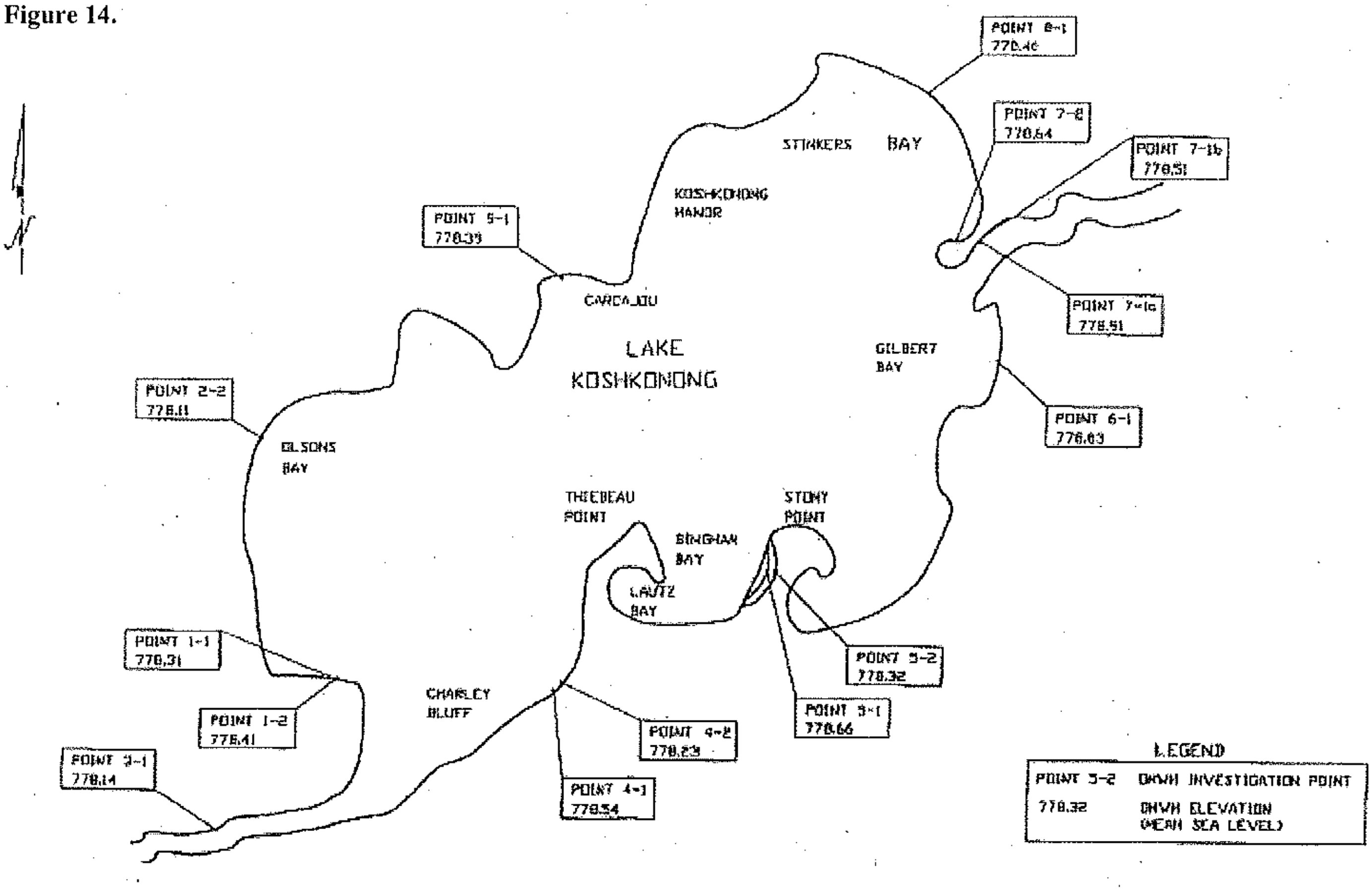
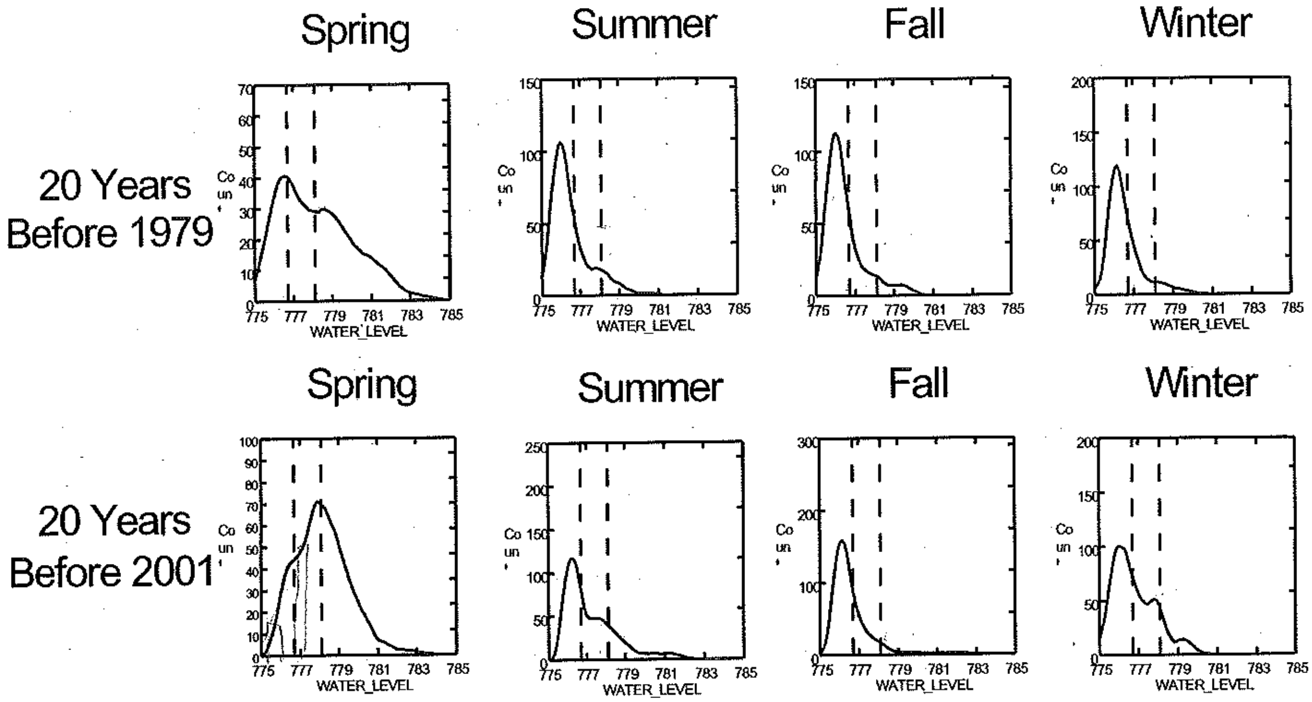


Table 3

OHWM Identifier	Elevation of OHWM	Benchmark Used	Location
1-1	778.31	Chiseled Square , SW corner of Slab, Pump House	Maple Beach
1-2	778.41	Chiseled Square , SW corner of Slab, Pump House	Maple Beach
2-1	778.11	N. Rim San MH, E-1.3, Lot 41	Glen Oaks Point
2-2			Glen Oaks Point
3-1	778.14	B53-146-90	Highway 59 Bridge
4-1	778.54	BM CB 79	Charlie Bluff Point
4-2	778.23	BM CB 79	Charlie Bluff Point
5-1	778.66	BM 299	Binghams Bay
5-2	778.32	BM 299	Binghams Bay
6-1	778.83	BM 297	Vinnie Ha Ha
7-1a	778.91	BM 295	Blackhawk Island
7-1b	778.51	BM 295	Blackhawk Island
7-2	778.64	BM 295	Blackhawk Island
8-1	778.4	BM 298	North Shore
9-1	778.39	PK in Cul-de-Sac	Carcajou Point

Figure 15. A comparison of water level density distribution curves between the two ordinary high water mark (OHWM) determinations reported in 1979 and 2001. Lines shown are nonparametric kernel density estimators, thus make no assumption regarding normal distributions. Kernel density functions are like continuous histograms and show areas where the data are most concentrated in the sample. Water levels at the Fort Atkinson Water Plant are shown on the x-axis and frequency of data points are shown on the y-axis. Spring (Mar, Apr, May), Summer (June, July, Aug), Fall (Sept, Oct, Nov), and Winter (Dec, Jan, Feb) are arranged in columns. Density distributions are comprised of all data for a period 20-years prior to the OHWM determination year. For example, the top row of plots includes all data from the years 1960 through 1979. Lower and upper x-axis range lines show the Oct. 1979 OHWM (776.7) and the Sept. 2001 OHWM (778.1).



OHWM & Hydraulic Modeling

The Rock Koshkonong Lake District (RKLD) supports their request to raised water levels with a report, "Hydraulic Analysis of Indianford Dam and Lake Koshkonong" by Montgomery Associates: Resource Solutions, LLC dated January 2003. The Montgomery report uses mathematical hydraulic models to simulate the operation of the Indianford Dam and the resulting water levels on Lake Koshkonong and concludes that the proposed increase in lake levels will not change the ordinary high water mark (OHWM). The report uses a hydraulic model to determine the still water level and adds a calculated wave height to predict the lake effects on the OHWM. The calculation doesn't take into effect the human impacts that affect the OHWM like boat-generated wakes or waves.

Montgomery 's hydraulic study indicates that the Indianford Dam affects water levels during low flows to small, more frequent flood flows. The model predicts that the dam controls small floods up to about 1000 cfs. The hydraulic study also indicates that the dam submerges during larger floods, meaning that the channel downstream of the Indianford Dam controls the outflow of Lake Koshkonong, not the dam structure. During large floods, observers viewing the dam would see that the water level downstream of the dam is approximately the same as the water level upstream of the dam, which means the dam is submerged.

Though the Montgomery hydraulic model has merit, it has some limitations when predicting lake levels, flow at submergence and lake impacts primarily due to uncertainties in the dam's flow capacity through the powerhouse. Other factors contributing to the model's limits include the lack of accurate inflow data, debris blockage of the wicket gate trashracks, poor outflow data at the Indianford Dam, lack of calibration data for a fully-operating dam and the HEC-RAS hydraulic model restrictions.

The basis for most of the Montgomery report's hydraulic conclusions is the comparison of computer simulations of alternative dam operations compared to a simulation of the Indianford Dam operated in accordance with the current water level orders. Figure I5 of the Resource Solutions' report shows a stage-duration comparison between the Lake Koshkonong gage and current water level order model simulation. The current order simulation is about 0.4 feet lower than the actual lake stages measured at the US Geological Survey gage more than 50% of the time. It might be expected that actual lake levels were higher than necessary over portions of the 1987–2001 period of record that was used for this study due to flow capacity problems at the dam, including trashrack debris blockage and inoperable wicket gates. Additionally, the models' stage results are too high due to inaccurate flow capacity for functional wicket gates. It's impossible to determine the actual amount of water level difference that these problems caused based on available records. The basic assumption that the current water level simulation is accurate cannot be concluded. Since the current water level simulation can't be shown to be accurate then the conclusions drawn from the comparisons aren't accurate enough to conclude that the OHWM will not be affected by raising water levels.

The Indianford Dam passes flow over a 277-foot, concrete, fixed-crest spillway, through six lift gate sections on the east side of the dam and through two wicket gate sections in the powerhouse on the west side. Trash racks are located on the upstream side of the powerhouse at the entrance of the turbine bay and are considered necessary appurtenances to hydro electric dams to protect wicket gates and turbines from damage from large debris. Roughly, the capacity of the six open gates and the capacity of the fixed-crest spillway to pass water are equal to the flow that can pass through the fully-opened wicket gates in the powerhouse. For example at the target lake level of 776.2, the fixed-crest spillway and the 6-lift gates fully open can pass about 1050 cfs, and the wicket gates can pass 1090 cfs.

Flow through the wicket gates is calculated with an orifice equation. The variables in the equation are the orifice coefficient, the head (the difference between the upstream and downstream water levels), and the area of the opening through the wicket gates or discharge tube. The head is determined by the flow in the river and the operation of the dam as long as the dam isn't submerged.

The orifice coefficient represents the energy loss due to the physical configuration of the opening. Coefficients are most accurately determined when the flow, head and area are measured at the site and the resulting coefficient is calculation. These measurements have not been complete at the powerhouse to determine the wicket gates' coefficients. In the absence of actual measurements, literature references of actual measurements taken at other sites can be reviewed and a coefficient selected to best fit the Indianford Dam wicket gates. Orifice coefficients can range from 0.5 to 0.99. The larger the coefficient the more flow that can pass through the opening.

Several literature sources were reviewed to select orifice coefficient to compare to the coefficient used in the Montgomery calculation. *Handbook of Hydraulics* by Brater and King, sixth edition states that the orifice for a converging bell-mouth opening can range from 0.959 to 0.994. *Hydroelectric Handbook* by Creager and Justin, second edition states that the orifice for a bell-mouth is 0.97. Based on the dam plans and that hydro dams attempt to create an efficient system to generate power and profit, it is reasonable to assume that an orifice coefficient of 0.97 is appropriate.

There are two wicket gates in the dam controlling openings with a total cross sectional opening area of 127 square feet. The Montgomery model uses 60-square feet or only 47% of the available gate area in an attempt to best match the dam's actual outflow. There are not good records of wicket gate flow conditions or a time relationship of clean, partially obstructed, or fully blocked trash racks to adequately calibrate the Montgomery model. The Montgomery model underestimates the outflow of the dam when the wicket gates are open and the trash racks are clean. It also overestimates the outflow when the wicket gates are significantly obstructed.

The combination of a low orifice coefficient and lower opening area results in significantly lower discharges from the wicket gates. Using standard orifice flow equations, the table below demonstrates the difference between the flow though the wicket gates for the Montogomery analysis and the values supported in literature and the dam plans.

Table 4. Estimated Discharge of the dam at lake level of 776.2 msl – slide gates closed

Information Source	Orifice Coefficient	Wicket Gates Total Area	Discharge (cfs)
Montgomery Report	0.6	60 sq. feet	970
Dam Plans	0.6	127 sq. feet	1540
Literature* and Dam Plans	0.76	127 sq. feet	1650
Literature* and Dam Plans	0.97	127 sq. feet	1930

*see *Hydro Electric Handbook by Creager and Justin*

Table 4 shows that the Montgomery hydraulic analysis underestimates the discharge of the dam resulting in higher modeled lake levels than actual would occur if the trash racks are kept clean. This means that the Montgomery model underestimates the discharge at which the dam submerges and therefore underestimating the elevation at which the lake is no longer controlled by the dam. Montgomery concludes that the purposed higher water levels plus the affect of wind driven waves not impact the OHWM. However such a conclusion cannot be supported without a better understanding of flow through the power house.

Debris, such as leaves, branches, floating lake vegetation and dead fish, collect on the trash racks at the entrance of the wicket gates. The debris decreases and can eliminate flow through this portion of the dam, which may mean reducing the dam's total flow capacity by as much as half. When the dam was used to generate power, the racks would be cleaned very often to make sure that water could flow to the turbines. Debris in the trash racks would mean a loss of power generation and income. Since the dam is not used to generate power, trash rack cleaning is irregular. It is difficult to determine the amount of trash rack blockage and records of the amount of daily debris blockage are not kept. Therefore trash rack blockage couldn't be accurately considered in the Montgomery hydraulic model.

The affects of trash rack cleaning can be shown with the flow records and the wicket gate cleaning records. The dam's operational logs indicate when the trash racks are cleaned. The Montgomery report figure E2 and the flow gage at the Indianford Dam shows that the flow increased about 300 cfs after the trash rack were cleaned on March 14 & 16, 2000. In figure E3, the trash rack cleaning on October 24, 2000, and one lift gate opened increased flow through the dam by about 700 cfs. About 230 cfs of the flow increase would have been due to the gate opening.

Montgomery calibrated their hydraulic model using the estimated inflow and the 'poor' outflow from the Lake measured at the Indianford Dam. To make the model best match this inflow and outflow data, Montgomery drastically reduced the flow capacity of the wicket gates. Two factors in the equation representing the wicket gate flow capacity appear to be underestimated. The orifice coefficient and the gate opening area appear to be too low in the Montgomery report compared to the actual physical dimensions of the dam and literature research. Actual stream gaging during debris free condition would be necessary to definitively establish an appropriate flow relationship and an appropriate coefficient for orifice flow.

Because the amount of blockage effects on the wicket gates'capacity cannot be reliably determined and is not documented, USGS rates the gage measuring the flow at the dam to be 'poor' as of October 2000. A 'poor' rating means that the gage data cannot meet the standard of 95% of the daily discharges are within 15% of actual flow. Though the gage's rating changed in 2000, the reasons for the change have existed for many years. USGS is confident of the historical flows when the wicket gates are not open. Going back to at least 1979, the USGS gaging notes state, "During the period from July 5 to Aug. 18 and Sept. 17-30, the wicker(t) gate of the powerhouse was open. Current ratings do not account for this flow." In November 1980, USGS's gaging notes state essentially the same with the following addition, "A turbine rating was studied but was found unfeasible due apparently to trash collecting on the trash barriers upstream of the wickets in the powerhouse." In December 1981, the USGS gaging notes were similar to the 1980 notes with the following addition, "Since the powerhouse is not yet generating, a regular maintenance of the trash barriers is not performed". The 1982 notes state, "During the fall and winter of the

1982 water year, 1 turbine was open but measurements showed negligible flow through the wicket gates and this was attributed to trash buildup on the upstream trash barriers of the power house."

The calibration data was further compromised by the wicket gates being inoperable during the periods used for calibration and for the lake level analysis. The wicket gates were found to be inoperable in October 1998. It is unknown how long the gates were inoperable prior to the discovery. The east wicket gate wasn't fully operational until late 1999 and west wicket gate was fully operational in November 2002. The Montgomery analysis of data ends in August 2002. At no time was the hydraulic model calibrated with data when both wicket gates were known to be operable, fully-opened and fully-cleaned of debris.

Due to the limitations and lack of data, the Montgomery analysis is not a sufficient prediction tool to assure that the OHWM will not change do to the increase in water levels.

Influence of Wind and Wave Events on the OHWM

There is no known relationship between recurrence interval (the presence and action of water) and the OHWM. While we do not know how often water has to be present to influence the OHWM we do know the presence of water on the shoreline is a function of three elements: 1) still water level, 2) wave action generated from wind or boats, and 3) shoreline configuration. The river hydraulics, including the presences of a dam, controls the still water levels. Wind-induced (wind-driven) water level rises along the shore consist of two elements: 1) wind set up (a temporary rise in the water level at the downwind edges of the lake), and 2) wave runup (the vertical elevation of water rising on the shore as a wave breaks and "runs up the shore). Ultimately, still water plus, wind set-up plus wave run-up result in an elevation at which the water reaches on the shore land.

Assuming the Montgomery report is an accurate predictor of lake levels, we can make a prediction of the water level when different operating regimes no longer have an impact on still water levels, roughly 777.3 msl.

The Montgomery report used the Automated Coastal Engineering System (ACES) to develop the resulting wave run-up which is appropriate. However, the report did not consider wind set-up component. According to Phillip Keillor, Coastal Engineer, "ACES does not contain a program suitable for estimating wind set-up (storm surge)."

The Montgomery report used a 20-mph wind to determine the wave run-up. Wind speed varies significantly and the actual speed and wave action that forms the OHWM is unknown. To assure that the OHWM is not changed as a result of the proposed water level orders, a conservative approach must be used to determine the wind-induced water levels.

The most appropriate shoreline to assess wave generated water levels is a beach shore line (Keillor). "Wave runup on beach slopes is more straightforward and useful in considering whether or not to change planned lake level elevations."

The Montgomery report used a beach slope of 20H:1V and described it as conservative assumption. A review of the x-sections (Figures 54-60) taken by the Department in March of 2004 indicate that for most areas of the lake 20H:1V is conservative but there are areas where slopes do approach 20H:1V.

The Montgomery report concluded that the still water level of 777.0 added to the wave run up on 1-foot for a 20-mph wind was less than the OHWM elevation of 778.1 so the OHWM would not change. Keillor's calculation of wind set-up for a 20-mph wind was 0.3 feet. Adding set up to the Montgomery water level yields an elevation of 778.3 – higher than the 778.1 OHWM elevation. If you assume a 20 mile an hour storm at the still water elevation of 777.3, the point at which the proposed regime would no longer have an impact, the ultimate water level would become 778.6, 0.5 feet above the OHWM.

Clearly, over decades there will be higher wind speeds than 20 miles that could affect wave action. Keillor suggest wind speeds of 38 miles per hour are more appropriate to assess structural design. Keillor's calculations for wave run-up and wind set-up for a wind speed of 38 mph was 2.6 to 3.1 feet. Using the Lake Koshkonong's summer target still water level of 776.2, the resulting could be as high as 779.3.

Table 5. Estimated temporary water level rises on Lake Koshkonong. (feet) including setup calculated by Phillip Keillor.

Parameter	Montgomery Report (20 mph wind) estimate	Keillor (20 mph wind)	Keillor (24 mph wind)	Keillor 38 mph wind)
1. Wave runup on beaches (20:1)	1.0	1.0	1.1	1.6–1.9 @ 777.0 MSL 1.5–1.7 @ 776.2 MSL
2. Wind set up @ 777.0 MSL	0	0.3	0.3-0.5	1.1-1.2
3. Wind setup @ 776.2 MSL	0	0.4	0.4-0.6	1.1-1.4
4. Sum of wave runup and wind set up	1.0 @ 777.0	1.3 @ 777.0 MSL 1.4 @ 776.2 MSL	1.4-1.6 @ 777.0 MSL 1.5-1.7 @776.2 MSL	2.7-3.1 @777.0 MSL 2.6-3.1 @776.2 MSL

Terrestrial vegetation of SE Glacial Plains

Historically, vegetation in the Southeast Glacial Plains consisted of a mix of prairie, oak forests and savanna, and maple-basswood forests. Wet-mesic prairies, southern sedge meadows, emergent marshes, and calcareous fens were found in lower portions of the Landscape. End moraines and drumlins supported savannas and forests. Agricultural and urban land use practices have drastically changed the land cover of the Southeast Glacial Plains since Euro-American settlement.

The current vegetation is primarily agricultural cropland. Remaining forests occupy only about 10% of the land area and consist of maple-basswood, lowland hardwoods, and oak. No large mesic forests exist today except on the Kettle Interlobate Moraine, which has topography too rugged for agriculture. Some existing forest patches that were formerly savannas have succeeded to hardwood forest due to fire suppression.

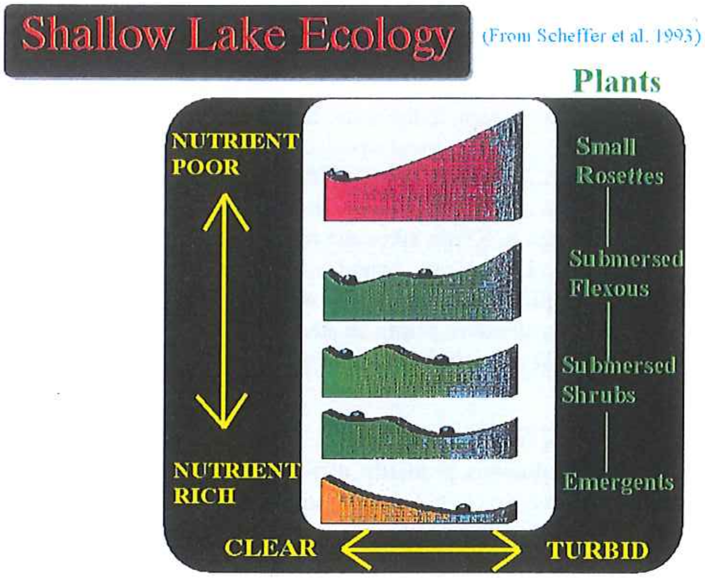
Hydrologic Features

The Southeast Glacial Plains has the highest aquatic productivity for plants, insects, invertebrates, and fish, of any Ecological Landscape in the state. Significant river systems include the Mukwonago, Wolf, Sheboygan, Milwaukee, Rock, Sugar, and Fox. Most riparian zones have been degraded through forest clearing, urban development, and intensive agricultural practices. This Ecological Landscape contains several large lakes, including those in the Madison area and in the Lake Winnebago Pool system. These lakes are important to many aquatic species including the lake sturgeon. Kettle lakes are common on end moraines and in outwash channels. In addition to Horicon Marsh, this Ecological Landscape contains important fens, tamarack swamp, wet prairies, and wet-mesic prairies that contain rare plants and animals. However, most wetlands have experienced widespread ditching, grazing, and infestation by invasive plants. Watershed pollution in the Ecological Landscape is about average according to rankings by Wisconsin DNR, but groundwater pollution is worse than average compared to the rest of the state.

Ecology of Shallow Lakes

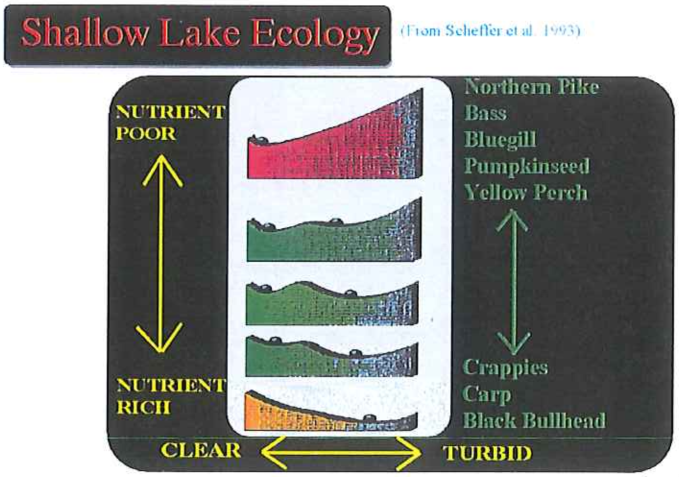
Human perturbations, primarily, non-point and point source nutrient loading, introduction of exotic species, and water-level changes have caused changes in the ecosystem function of shallow lakes in the Southeast Glacial Plain. Nature is often assumed to respond to gradual change in a smooth way. However, studies on shallow lakes, and other ecosystems like coral reefs, oceans, forests and arid lands have shown that smooth change can be interrupted by sudden drastic switches to a contrasting state (For review see Scheffer et. al. 2001). Researchers in Europe and North America have been studying shallow lakes intensively and we have gained much understanding from their work. Many formerly clear wetlands and shallow lakes in North America have shifted to an alternative stable state characterized by high turbidity, phytoplankton blooms, loss of submersed macrophytes and encroachment by emergent plants, low waterfowl use, and altered fish communities (benthivores/planktivores dominate). These patterns of ecological changes are detrimental to water quality, and to the biodiversity of wildlife and fisheries. The turbidity state of a lake immediately affects its economic and recreational value for humans. From most perspectives, the clearwater state is to be preferred to the turbid state. The production of drinking water, for example, can seriously be impeded by the formation of algal blooms that may lead to clogging of filters or that may result in a bad taste or odor of the water. These problems are even worse in the case of blooms of cyanobacteria, of which several genera (e.g. *Microcystis, Anabaena,* and *Aphanizomenon*) are known to produce substances that are toxic to cattle or humans. Also with respect to fisheries, the clearwater state is preferred. Fish kills through acute anoxia are much more common in phytoplankton infested eutrophied lakes than in transparent water lakes. Furthermore, fish species quality (species composition, e.g. the presence of pike) as well as fish meat quality (for consumption) is generally higher valued in clearwater lakes. Finally, the amenity value of clearwater lakes with a well-developed macrophyte vegetation is much higher than of lakes in the turbid state, increasing their value for recreation.

Figure 16



Martin Scheffer (Scheffer 1989) developed an ecological minimal model that describes bi-stability in the ecological properties of shallow lakes (Figure 16). Scientists now recognize that shallow lakes may have two alternative stable conditions, a clear or turbid state. The valleys in the landscape diagram correspond to stable ecological conditions. Each picture shows the stability properties at different nutrient conditions. In the oligotrophic situation a clear state is the only stable condition, and likewise in the hypereutrophic condition the turbid state is the only stable conditions. Continued enrichment gradually causes the stability of the clear state to shrink to nil, where the lake is more vulnerable to perturbations that would shift the equilibrium to the turbid state.

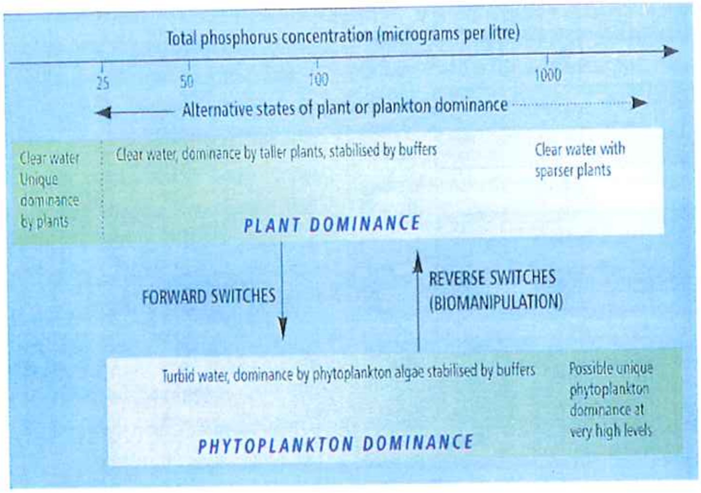
Figure 17



Fish communities also respond to these changes in habitat and water quality (Figure17). Lakes with dense macrophytes support northern pike and bass as the top piscivores with bluegill, pumpkineseed and yellow perch as the primary benthivore/ planktivores. In turbid open water lakes species like carp, black bullhead, and white crappie tend to dominate. The biomass of the piscivore populations like northern pike is often very low in these ecosystems. The health of Littoral zone habitat in terms of aquatic plants is dependent on the nutrient status of the waterbody and shallow water habitat of lakes undergoing cultural eutrophication are much more dynamic, variable, and it's difficult to sustain their resource quality of their shallow water habitat.

Switches
Water-level dynamics, nutrient loading regimes, biotic interactions, and severe weather events are often cited as the causal mechanisms for this drastic shift in ecological condition. The events or manipulations to a shallow lake system that cause a change between plant-dominated and algae-dominated states are known as a switch (Moss, 1998b). A change from plant dominance to algal dominance is referred to as a forward switch (Figure 18). Reverse switches cause a change from algal dominance to a plant-dominated system and are often associated with intentional human efforts to restore a shallow water system.

Figure 18



Forward Switches
Two types of forward switches occur in shallow lakes: those that directly destroy the plant structure, and those that indirectly affect the plant structure by preventing buffer mechanisms from operating. The direct type includes mechanical harvesting of plants, the application of herbicides, or damage done by boating. It can also include natural damage from wind, storms, ducks, and geese (Moss 1998b, Sondergaard et al 1996). Examples of indirect forward switches include the leakage of pesticides and other toxins that kill zooplankton, higher water levels, the addition of nutrients from surface run-off, and introduction of common carp. There is a strong correlation between the presence of pesticides in sediment and zooplankton mortality (Stansfield et al 1989). With populations of zooplankton reduced, lakes become susceptible to algal domination.

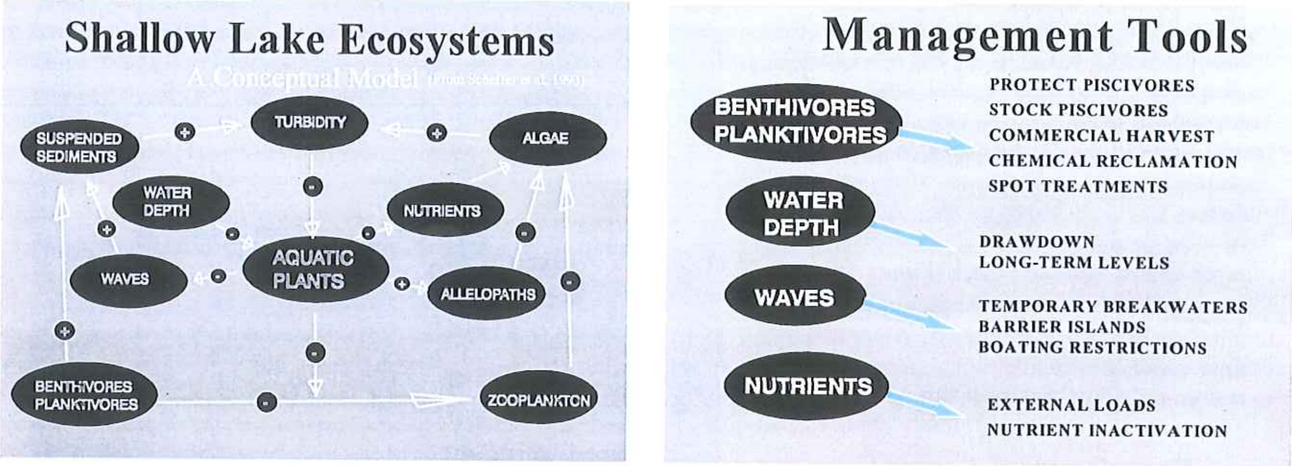
Water-level fluctuations are among the major driving forces for shallow lake ecosystems (Coops and Hosper 2002; see (Attachment 6). Water level in a lake is an important control variable with respect to aquatic macrophyte dominance. Vegetation can withstand turbid water more easily if a lake is shallower. High water levels are identified as a cause that induces a shift from macrophyte dominance to turbid algal dominance conditions in shallow lakes. A small shift in critical turbidity resulting from a higher water level can cause a loss of macrophyte coverage and a forward switch to the algal-dominated state (Scheffer 1998). This phenomenon for shallow lakes (raising water levels—decline in vegetation; lowering water levels—increase vegetation) is widespread. Numerous examples are found in North America and worldwide; Lake Tamnaren, (Wallsten and Forsgren, 1989; Bengtsson and Hellstrom, 1992), Rice Lake (Engel and Nichols, 1994), Upper Winnebago System, Lake Okechobee (Steinman et al. 2002), Lake Krankesjon (Blindow 1992; Blindow et al. 1993), Lagoon of the Islands (Sanger 1994).

Reverse Switches- Shallow lakes suffering from turbid water and algal blooms tend to be resistant to recovery and reducing external nutrient loading alone has been often shown to be insufficient to restoring clear water conditions and aquatic habitat (Hosper 1998, Scheffer 2001, Moss 1996). Major fish-kills and reductions in water-levels are the most frequent natural causes cited for reverse switches in shallow lakes.

Restoration projects aim to induce a reverse switch in Wisconsin's shallow lake management often involve; 1) water level drawdowns; 2) reductions in benthivorous (carp, black bullhead) and planktivorous fish (white crappie, shad, young-of-year carp) by mechanical removal or chemical treatment; 3) Stocking of piscivorous fish (northern pike, largemouth bass, walleye); 4) Protective sportfishing regulations to maintain high biomass of piscivorous fish and by piscivory a comensurate lower biomass of planktivorous and benthivorous fish; 4) Reductions in external loading to a range where bi-stability is anticipated (see figure 19); and 5) reducing the impacts of motorboats on aquatic plants (Kahl 1991).

Fish play an important role in maintaining the stable condition, whether it is turbid or clear. In the turbid condition, fish can either recycle nutrients within the pelagic habitat or transport nutrients between habitats. The transport of nutrients from benthic to pelagic habitats provides a source of "new" nutrients that are fundamentally different from

Figure 19



PROTECT PISCIVORES
STOCK PISCIVORES
COMMERCIAL HARVEST
CHEMICAL RECLAMATION
SPOT TREATMENTS

DRAWDOWN
LONG-TERM LEVELS

TEMPORARY BREAKWATERS
BARRIER ISLANDS
BOATING RESTRICTIONS

EXTERNAL LOADS
NUTRIENT INACTIVATION

recycled nutrients because nutrients released by benthic-feeding fishes can increase the total nutrient content of pelagic waters. Thus, they are best compared with external nutrient loading or other net sources of nutrients (anoxic sediment transport-phosphorus from sediments). Common carp can often be a big part of the problem because they root out aquatic plants when feeding, causing turbidity that prevents the regrowth of plants. Wetlands with high carp populations have noticeably less diverse and abundant aquatic plants, invertebrates, fish, and wildlife populations than those without carp.

Figure 20

Cladocerans, or water fleas "vacuum" the algae from lake water. When they are abundant, the water is more clear. If conditions are unfavorable, i.e. zooplanktivorous fish abundant, refuge absent, the lake water remains turbid from algae.

Biomanipulation- is an ecological management approach that manipulates the biomass of a particular level of the food web to have an effect on the biomass of another. The term originally encompassed a range of techniques applied to terrestrial and aquatic ecosystems. In aquatic systems it typically refers to top-down manipulation of fish communities, i.e. enhancement of piscivorous (fish-eating) fish populations and reduction of zooplanktivores and/or benthivores (Perrow et al, 1997). In one of the earliest published reports, Caird (1945) hypothesized that stocking of Largemouth Bass was responsible for reductions in phytoplankton through food chain interactions. Several researchers (Hrbacek et al, 1961; Brooks and Dodson, 1965; Hurlbert et al, 1971) found that planktivorous (plankton-eating) fish can severely reduce or eliminate *Daphnia*, the largest, most efficient grazers of phytoplankton (Figure 20). These results suggested that lowered planktivorous fish densities would maintain greater densities of *Daphnia*, and thus control algal biomass. A reverse switch involves biomanipulating the fish community to reinstate the plant buffers and destroy the buffers of algal-dominance. An abundance of small, zooplanktivorous fish can quickly reduce the population of *Daphnia* that efficiently graze algae. Biomanipulation seeks to replenish the zooplankton population by reducing the population of their predators. To decrease populations of small zooplanktivorous fish, top predators, such as pike, are added to the system. Biomanipulation to attain a plant-dominated state can also involve eliminating Common Carp from the system, not just because of their zooplanktivorous habits, but more importantly, their behavior of stirring sediments and the resultant turbidity that inhibits plant growth. Carp impact both water clarity and aquatic vegetation growth through their benthic, or bottom feeding activities. Studies have demonstrated a positive relationship between benthivore biomass and re-suspension of solids (Breukelaar, et. al., 1994) and phosphorus concentrations (Personn and Hamrin, 1994). Carp obtain their diet of insects, small clams, and worms by grazing along the lake bottom. Food and bottom sediments are sucked into the mouth cavity where the gill rakers pass the food organism and separate out the larger non-food items, which are then forced out of the gills, causing re-suspension of sediments. The suspended sediments then impede the ability of sunlight to penetrate through the water, and lack of light reaching the bottom of the marsh leads to no growth of aquatic plants. Because it is often impractical to selectively remove carp while maintaining desirable fish species, total fish eradication is often performed for a biomanipulation project. The lake is then restocked with healthier balance of fish including more "top predator" piscivorous fish. These fish keep the population of zooplanktivorous fish under control by preying on eggs and juvenile fish so that large zooplankton such as *Daphnia* are allowed to flourish and consume phytoplankton (algae). As a result, the water becomes clearer, allowing sunlight penetration and the proliferation of the submergent aquatic plant community. The established aquatic plant community utilizes the nutrients (i.e. nitrogen and phosphorus) that were the main food source of the algae, and the algae diminish.

Water-level- Lowering of water level simulates a natural disturbance event, drought, and can buffer the plant-dominated state or even induce a reverse switch from algal-dominance to a plant-dominated state (Scheffer, 1998). Drawdown can consolidate sediments, reduce internal nutrient loading, and provide opportunities to conduct habitat and shoreline improvement projects (Figures 21 and 22). Coops and Hosper (2002) suggest that shallow lake managers consider a combined strategy of restoring natural water level fluctuations and managed manipulations designed for a specific process to occur. For further discussion on the influence of water levels on the ecology of shallow lakes see Attachment 6.

Figure 21

July 12, 2001

Figure 22

August 27, 2001

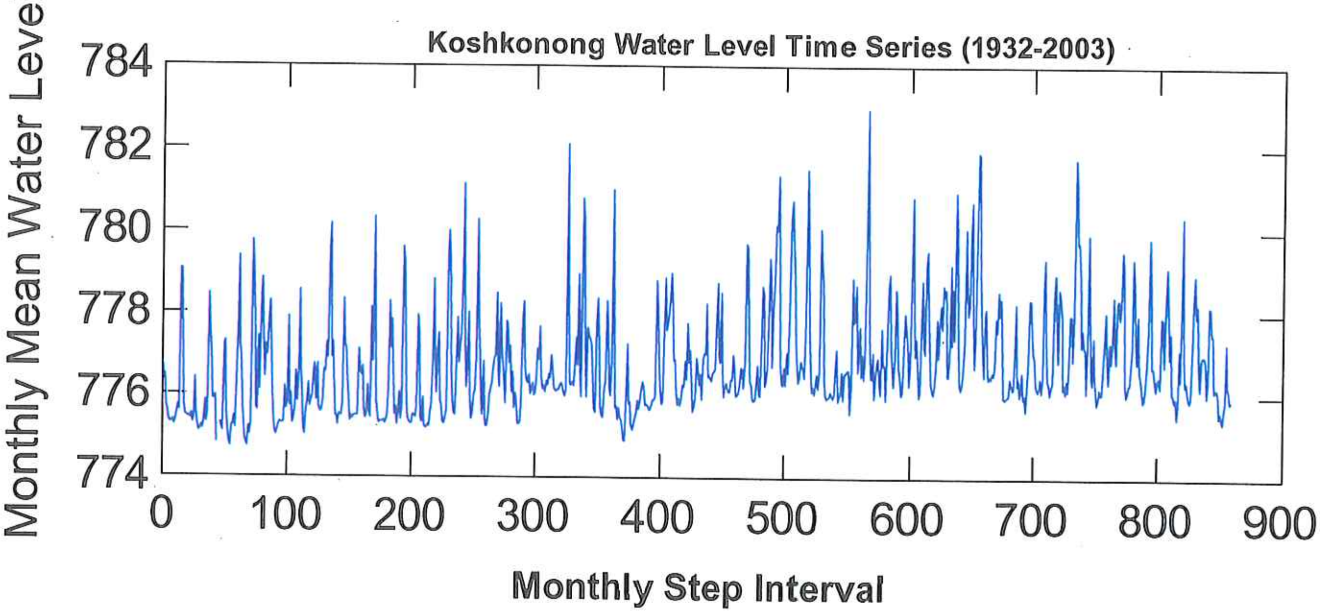
Example of vegetation response to drawdown on Pool 8 of the Upper Mississippi River Pool 8. Substrates were exposed between 6-10 July. Plant response dominated by flatsedges, teal lovegrass, rice cut-grass, common arrowhead, and nodding smartweed.

The Role of Wetlands

Several processes in wetlands are important for shallow lakes: transport and settling of suspended solids, denitrification, nutrient uptake by marsh vegetation (increasing nutrient retention), and providing critical habitat conditions for predatory fish. Within limits, the presence of a wetland zone around lakes may thus increase the ability of lakes to cope with nutrients and enhance restoration. Model calculations have revealed that nutrient concentrations are lowered by the presence of a marsh area, and that the critical loading level for a shift to clear water is increased (Janse et. al 2001).

Fluctuating water levels play a key role in the dynamic process of marsh rejuvenation, promoting and maintaining high levels of species richness and habitat diversity (van der Valk 1981). Many of the emergent macrophyte beds that dominate the marsh are killed during sustained periods of high water (Coops and Vander Velde 1996; Rea 1996; Clevering and Lissner 1999). Once water levels fall again, the exposed mudflats are initially colonized by ruderal, opportunistic plants, and later by emergent species. Water Levels for Lake Koshkonong exhibit distinct seasonal variation (due to being a floodplain flowage). But water level regulation has further inter-annual variation in summer levels. This water level management eliminates water levels that typically occur during drought conditions (Figure 23). Note that in figure 23 the annual differences in the summer lows (lowest points in the time series plot) are minimal throughout the whole period of record. Stabilization in this context generally refers to a reduction in the magnitude of water level fluctuations. A number of researchers have noted that prolonged stabilization of water levels has highly detrimental effects on shallow marshes (Harris and Marshall 1963; Van der Valk 1981)

Figure 23. Monthly mean water levels reported at the Fort Atkinson Water Plant from 1932-2003 .



A case study in water level management – Delta Marsh, Manitoba, Canada

An excellent case history of water level management and coastal wetland habitat changes can be found for Delta Marsh (Gordon Goldsborough, Personal Communication; Dale Wrubleski Personal Communication; Kenkel 1995). The Delta Marsh is at the south end of Lake Manitoba, 90 km north-west of Winnipeg. It is one of the largest and traditionally most important marshes in the prairies. It consists of shallow bays of water interconnected by winding channels. It covers more than 15,000 ha (37,065 acres), but it's size varies somewhat depending on water levels. The area is particularly important as a staging marsh for waterfowl now averaging over 50,000 ducks during the fall. In the past, peak staging populations have exceeded two million ducks and geese.

Delta Marsh is one of only two Wetlands of International Importance identified as Ramsar Sites in Manitoba. The Convention on Wetlands of International Importance (Ramsar Convention) was adopted in Ramsar, Iran, in 1971, and came into force in 1975. The Convention's mission is the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world.

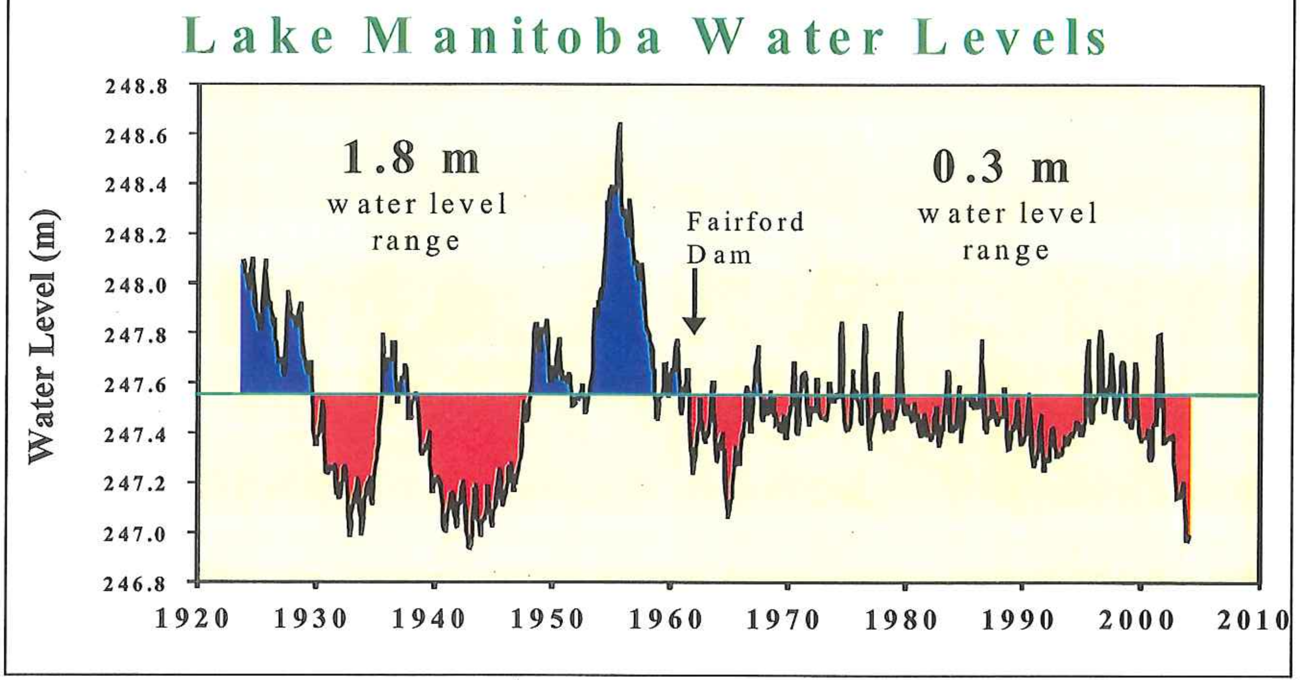
The nutrient-rich, shallow water of Delta Marsh supports a luxuriant growth of algae and submerged aquatic plants, as well as bulrushes (e.g. hardstem bulrush) which border the open water and also form small islands. Common throughout the marsh is the cattail and on slightly higher ground the giant reed forms dense stands. Whitetop grass and sedges characterize the wet meadows that usually dry out at some point during the growing season. Better drained, more upland sites are colonized by sand bar willow, Manitoba maples, green ash and cotton wood. Invariably, as water depth decreases there is a change in species from pondweeds to emergent macrophytes such as bulrushes, cattails and reeds, then wet meadow species such as sedges and whitetop grass, followed by willow and other upland species

In order to avoid the low water levels of the 1930's and 1940's a dam was built at the Clandeboye channel in 1944 at elevation 247.8 m. This allowed water to enter the marsh when lake levels exceeded 247.8 m but water could not drain out when lake levels fell. Several other connections between the lake and marsh were blocked.

High water levels in Lake Manitoba in the mid-1950's overtopped the Clandeboye dam, killed marsh vegetation, and rejuvenated the marsh but it flooded marginal haylands. Agricultural lobbying resulted in the construction of a dam at Fairford to regulate Lake Manitoba with a target of 247.5 m (reducing it's fluctuations from 2 m to 60 cm).

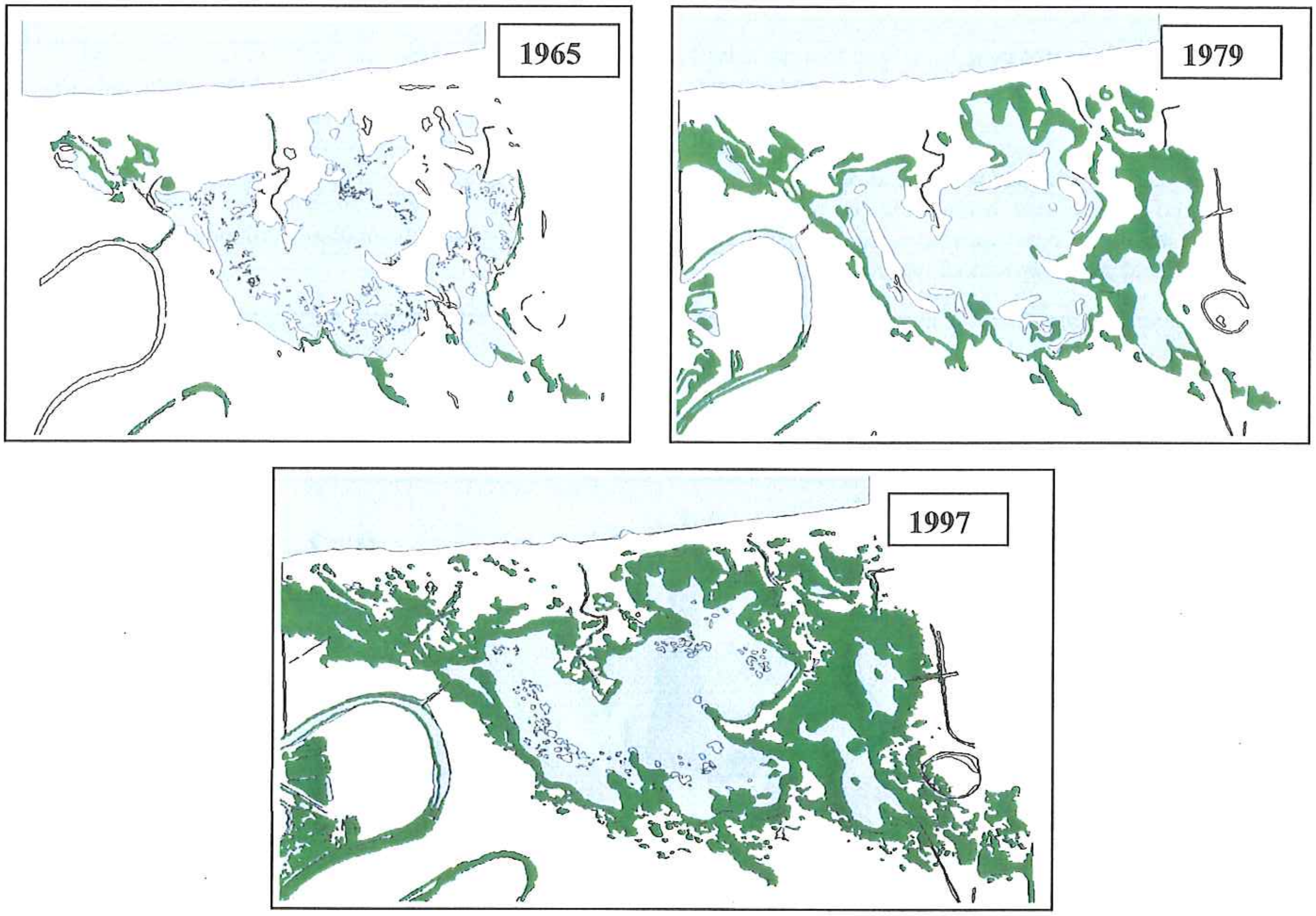
For example, since 1924 there have been four periods of 3 to 15 year-duration when water levels in Lake Manitoba were higher than the long-term average. These have alternated with conditions as in the drought of the 1930's and 1940's (Figure 24). The high water in the 1950's resulted in the death of more than 20% of the reeds and cattails in the marsh. When the water levels fell, seeds buried in the mud that had lain dormant for years were able to germinate and the mudflats were colonized by damp ground annuals soon to be replaced by whitetop grass or cattails and a rejuvenated marsh came into being. It is this type of dieback and recolonization that has allowed the marsh to survive. To remain viable, marshes need high water levels of long enough duration to kill emergent vegetation and drawdowns to allow revegetation.

Figure 24



Since regulation of the Fairford Dam in 1960, drought and flood conditions have been largely removed and the following changes for Delta Marsh have occurred; erosion of emergent macrophyte "islands"; higher water column turbidity; abundant cyanobacterial blooms; fewer submersed plants; fewer wildlife; and encroachment of hybrid cattails (*Typha x glauca*) into shallow areas (Figure 25).

Figure 25. Green shaded area represents aerial coverage of hybrid cattails in Delta Marsh in 1965, 1979, and 1997.



Water Quality

The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water nor with water quantity issues). The statute employs a variety of regulatory and nonregulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." For many years following the passage of CWA in 1972, EPA, states, and Indian tribes focused mainly on the chemical aspects of the "integrity" goal. During the last decade, however, more attention has been given to physical and biological integrity. Also, in the early decades of the Act's implementation, efforts focused on regulating discharges from traditional "point source" facilities, such as municipal sewage plants and industrial facilities, with little attention paid to runoff from streets, construction sites, farms, and other "wet-weather" sources. Starting in the late 1980s, efforts to address polluted runoff have increased significantly. For "nonpoint" runoff, voluntary programs, including cost-sharing with landowners are the key tool. For "wet weather point sources" like urban storm sewer systems and construction sites, a regulatory approach is being employed. Evolution of CWA programs over the last decade has also included something of a shift from a program-by-program, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining state water quality and other environmental goals is another hallmark of this approach.

As of May 19, 2003, Wisconsin has identified and EPA approved a listing of 604 impaired waters under section 303(d) of the clean water act. The Rock River watershed contains 50 impaired waters, this is the largest number of impaired waters reported among Wisconsin's watersheds (after excluding atmospheric deposition related impairments).

The DNR has identified and EPA has approved 15 impaired lakes and flowages within the SE Glacial Plains Ecological Landscape, 10 of those are shallow lakes (Table 6). Lake Koshkonong is among 8 of the 10 shallow lakes impaired due to excessive sediment and phosphorus.

Table 6. Approved (2002) 303(d) Impaired lakes and impoundments within the Southeast Glacial Plains Ecological Landscape. Bolded waters are impaired due to excessive sediment and phosphorus.

Water Body Name	**County**	**WBIC**	**DNR Watershed**	**Pollutant**	**Impairment**	**Cont. Sediment**	**Atmos Dep.**	**Physical Habitat**	**NPS Dom.**	**Point S. Dom.**	**NPS/PS Blend**
Barstow Imp.	Waukesha	742500	FX07	sediment, phos.	DO, turbidity						x
Sinnissippi Lake	Dodge	788800	UR08	sediment	sedimentation						x
Crawfish River at Columbus Millpond	Columbia, Dodge	829700	UR02, 06	PCB	FCA	x					
Fox River (Ill), including Lake Tichigan	Waukesha, Racine, Kenosha	742500	FX	PCBs	FCA	x					
Horicon Marsh	Dodge	861200	UR12	sediment	degraded hab.						x
Lac La Belle	Waukesha	848800	UR09	pcb	FCA	x					
Lake Butte des Morts	Winnebago	139900	UF	Hg,pcb,sed,phos.	FCA, DO,eutro.	x			x		
Lake Koshkonong	Jefferson, Rock, Dane	808700	LR11	phosphorus, sediment	DO, eutro, sed, hab						x
Lake Mendota	Dane	805400	LR09	pcb	FCA						
Lake Monona	Dane	804600	LR08	Hg,pcb	FCA						
Lake Waubesa	Dane	803700	LR08	Hg	FCA						

Lake Winnebago	Winnebago	131100	UF	sediment,phos.,Hg, PCB	sed., eutro.,DO,FCA	x			x		
Lake Winneconne	Winnebago	241600	UF	sediment,phos.,Hg	sed., eutro.,DO,FCA	x	x		x		
Pine Lake	Waukesha	779200	UR09	TBD	Aq. Toxicity	x					
Poygan Lake	Winnebago	242800	UF	sediment, phos, PCB	sedimentation, DO, FCA	x			x		

***Bolded waters are shallow lakes**

Existing, Potential and Codified Uses

BOD = biochemical oxygen demand;Cold = Cold water fish community; DO = dissolved oxygen; deg. Hab. = degraded habitat; FCA = fish consumption advisory; Hg = mercury; WWSF = warmwater sport fishery; pcb or PCB = polychlorobiphenyls WWFF = warmwater forage fishery; LFF = limited forage fishery; LAL = limited aquatic life; FAL = fish and aquatic life = cold, WWSF or WWFF; Bact. = bacteria; sed = sediment; SOD = sediment oxygen demand

Eutrophication is the natural process of physical, chemical, and biological changes ("aging") associated with nutrient, organic matter, and silt enrichment of a lake. If the natural process is accelerated by human influences, it is termed "cultural" eutrophication. Lakes are subject to a variety of physical, chemical, and biological problems that can diminish their aesthetic beauty, recreational value, water quality, and habitat suitability. Among the most common lake problems, and the conditions that often occur with eutrophication are the following.

Algal blooms – Extensive and rapid growth of planktonic (floating and suspended) algae, caused by an increased input of nutrients (primarily phosphorus, but occasionally can also be caused by nitrogen), is a common problem in lakes. Lakes normally undergo aging over timescales of centuries or thousands of years, but the process can be accelerated rapidly to only decades by human activities that cause increases in sedimentation and nutrient inflow to the lake. Accelerated eutrophication and excessive algal growth reduces water clarity, inhibits growth of other plants, and can lead to extensive oxygen depletion, accumulation of unsightly and decaying organic matter, unpleasant odors, and fish kills.

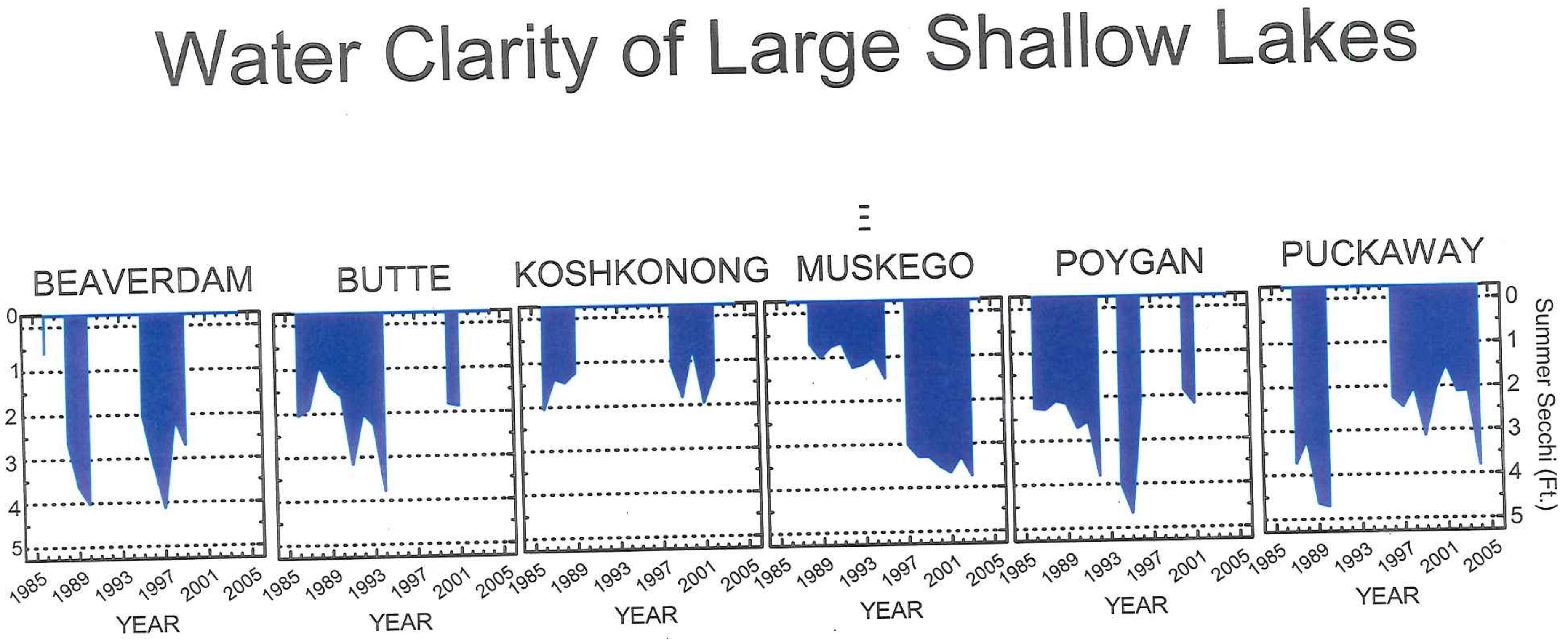
Sedimentation/turbidity – Increases in accumulation and/or resuspension of sediments can be a detriment to water quality and habitat for many aquatic species. Such events usually are caused by heavy rains that produce erosion and intense runoff, carrying heavy sediment loads into lakes. High winds, boating activity, and bottom-feeding fish, such as carp, may also resuspend bottom sediments and increase turbidity.

Oxygen depletion – Decreases in dissolved oxygen to less than 3 mg/L (milligrams per liter) in the water can be harmful or lethal to many desirable species of aquatic life. The primary mechanism of oxygen loss is consumption by high rates of respiration and organic decomposition. Ideally, such consumption is offset by oxygen inputs from the atmosphere and from photosynthesis by aquatic plants. However, in stratified lakes, the atmospheric source is cut off from the hypolimnion (deep lake layer), and oxygen concentrations in the hypolimnion may decline to zero (anoxia) until the lake mixes again. Under anoxic conditions, phosphorus may be released from the bottom sediments into the overlying water. This "internal loading" may be considerable with phosphorus-enriched sediments and prolonged anoxia. Prolonged low oxygen concentrations in the summer or under ice in the winter can lead to fish kills.

Growth of aquatic plants (macrophytes) – Normal macrophytic growth generally is beneficial for the lake ecosystem; among other benefits, the plants provide refuge for fish and other organisms. However, in some lakes, the growth of aquatic plants ("weeds") can become excessive and create a serious nuisance for lake users, interfering with swimming, boating, and other recreational activities. Excessive macrophytes commonly are caused by increased nutrients, invasion of exotic species, or accumulation of organic sediment. The improvement of water clarity resulting from management actions designed to control algal production can provide better conditions for growth of rooted plants.

Species shifts – Populations of desirable animal and plant species might decline sharply or disappear, to be replaced by other species. Usually, the new dominant species will become a nuisance and degrade some or all desirable qualities of the lake. Species shifts can be caused by introduction of invasive species that may have little or no natural controls on their population growth, or are stimulated by changes in environmental conditions (for example, climate changes, acidification from "acid rain" or other changes in water chemistry, or physical changes.

Figure 27. Water clarity for six large shallow lakes as measured by secchi depth (ft) for the years 1986 - 2004. Lakes respectively shown are Beaver Dam Lake (Dodge Co.), Lake Butte Des Mortes (Winnebago Co.), Lake Koshkonong (Jefferson Co.), Big Muskego Lake (Waukesha Co.), Lake Poygan (Winnebago Co.), and Lake Puckaway (Green Lake County). Values shown represent annual mean estimates from all values reported during the months of May through September.

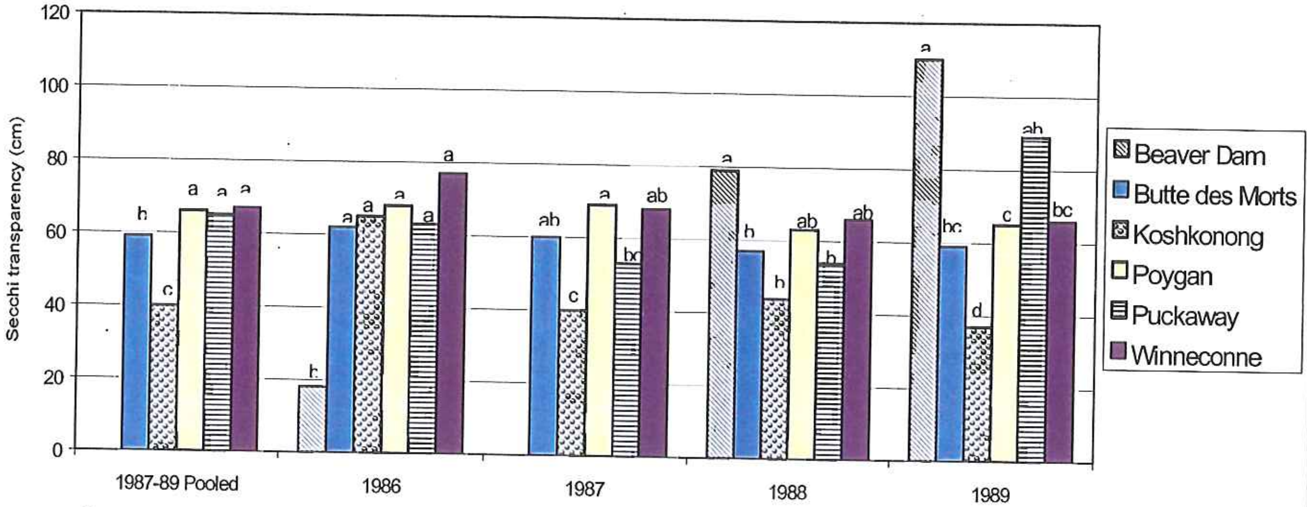


Eutrophication diminishes water quality by promoting the excessive growth of algae, and increasing suspended organic material. When degraded, unpleasant odors and tastes can result from the excessive amounts of algae. Furthermore, microorganisms associated with eutrophication may pose health risks to consumers. Increases in water quality parameters such as chlorophyll *a*, turbidity, total suspended solids (TSS), and nutrients are symptomatic of eutrophic conditions. Concentrations of these parameters can provide insight on the extent of eutrophication and the potential impact on aquatic biota and overall water quality.

Secchi Depth- Water clarity has two main components: true color (materials *dissolved* in the water) and turbidity (materials *suspended* in the water such as algae and silt). The algae population is usually the largest and most variable component. Water clarity often indicates a lake's overall water quality, especially the amount of algae present. Algae are natural and essential, but too much of the wrong kind can cause problems. Secchi disc (Secchi disk) readings are taken using an 8-inch diameter weighted disc painted black and white. The disc is lowered over the downwind, shaded side of the boat until it just disappears from sight, then raised until it is just visible. The average of the two depths is recorded. Secchi disc values vary throughout the summer as algal populations increase and decrease. Measuring several sites may be useful in some lakes, depending upon the uniformity of the lake. Year to year changes result from weather and nutrient accumulation. Weekly or biweekly Secchi records (April-November) over a number of years provide an excellent and inexpensive way to document long-term changes in water clarity.

Secchi depths reported for Lake Koshkonong average 40 cm (1.3 ft.; Figure 26 and 27) and are significantly less than values reported for other large shallow lakes of Wisconsin's Southeast Glacial Plains (Figure 27).

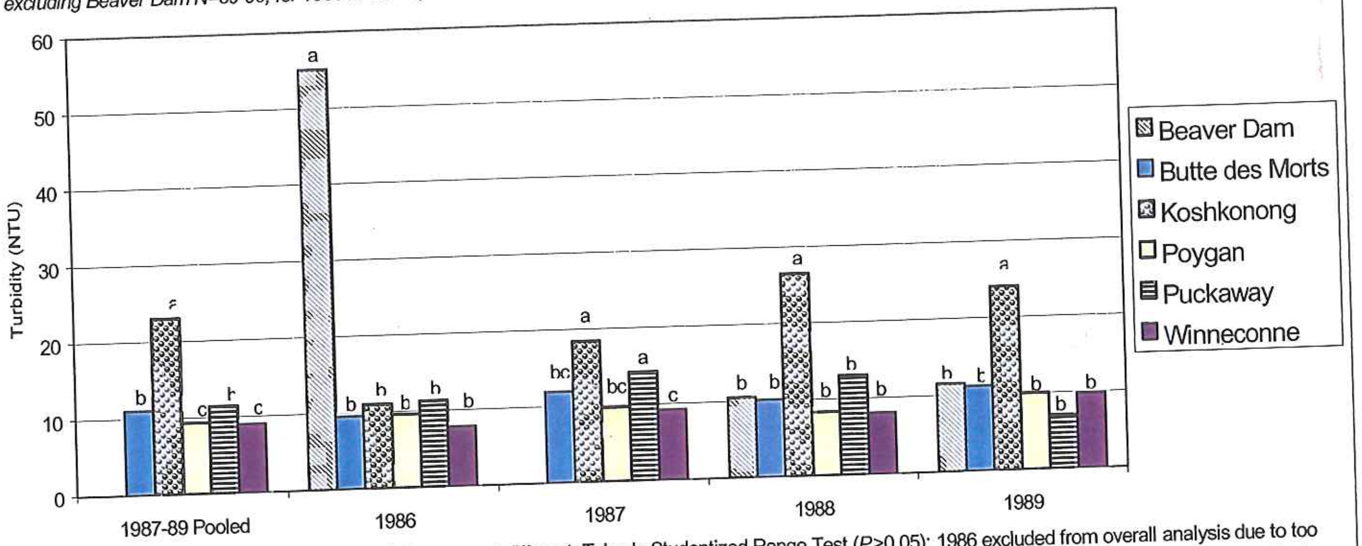
Figure 26 *Mean Secchi transparency depth for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=87-90; for 1986 N=22-27; for 1987 excluding Beaver Dam N=27-30; for 1988-89 N=30).**



*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test (P>0.05); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Turbidity is a measure of the cloudiness of water- the cloudier the water, the greater the turbidity. Turbidity is the result of suspended solids in the water, rather than dissolved organic compounds. Suspended particles dissipate light, which affects the depth at which plants can grow. Suspended solids are variable, ranging from clay, silt, and plankton, to industrial wastes and sewage. Lakes receiving runoff from silt or clay soils often possess high turbidities. These values vary widely with the nature of the seasonal runoff. Suspended plants and animals also produce turbidity. Many small organisms have a greater effect than a few large ones. A rough measure of turbidity can be made with a Secchi Disk, but more accurate measurements need to be taken with a turbidimeter, Turbidity is measured in **NTUs**, the abbreviation for nephelometric turbidity unit. A normal range for turbidity in river water has not been established. High turbidity water will appear to be murky or muddy. Turbidity in excess of five NTUs can be easily detected. Lake Koshkonong is significantly more turbid than other large shallow lakes of the Southeast Glacial Plains. Turbidity values for Lake Koshkonong average 23 NTU's, which is 2 fold higher than other shallow lakes (Figure 28).

Figure 28 *Mean turbidity for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=89-90; for 1986 N=22-27; for 1987 excluding Beaver Dam N=29-30; for 1988 N=29-30; for 1989 N=30).**



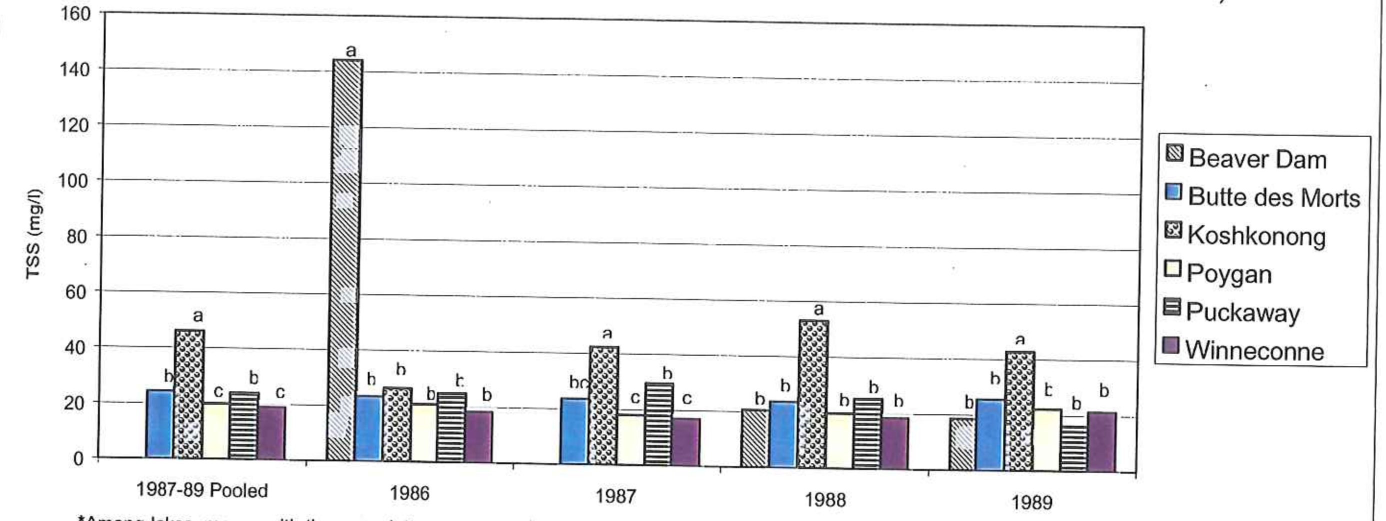
*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test (*P*>0.05); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Total suspended solids (TSS) consist of an inorganic fraction (ISS-silts, clays, etc.) and an organic fraction (OSS-algae, zooplankton, bacteria, and detritus) that are carried along by water as it runs off the land. The inorganic portion is usually considerably higher than the organic. Both contribute to turbidity, or cloudiness of the water. Waters with high sediment loads are very obvious because of their "muddy" appearance. This is especially evident in rivers, where the force of moving water keeps the sediment particles suspended.

The geology and vegetation of a watershed affect the amount of suspended solids. If the watershed has steep slopes and is rocky with little plant life, top soil will wash into the waterway with every rain. On the other hand, if the watershed has lots of firmly rooted vegetation, it will act as a sponge to trap water and soil and thereby eliminate most erosion. Most suspended solids come from accelerated erosion from agricultural land, logging operations (especially where clear-cutting is practiced), surface mining, and construction sites.

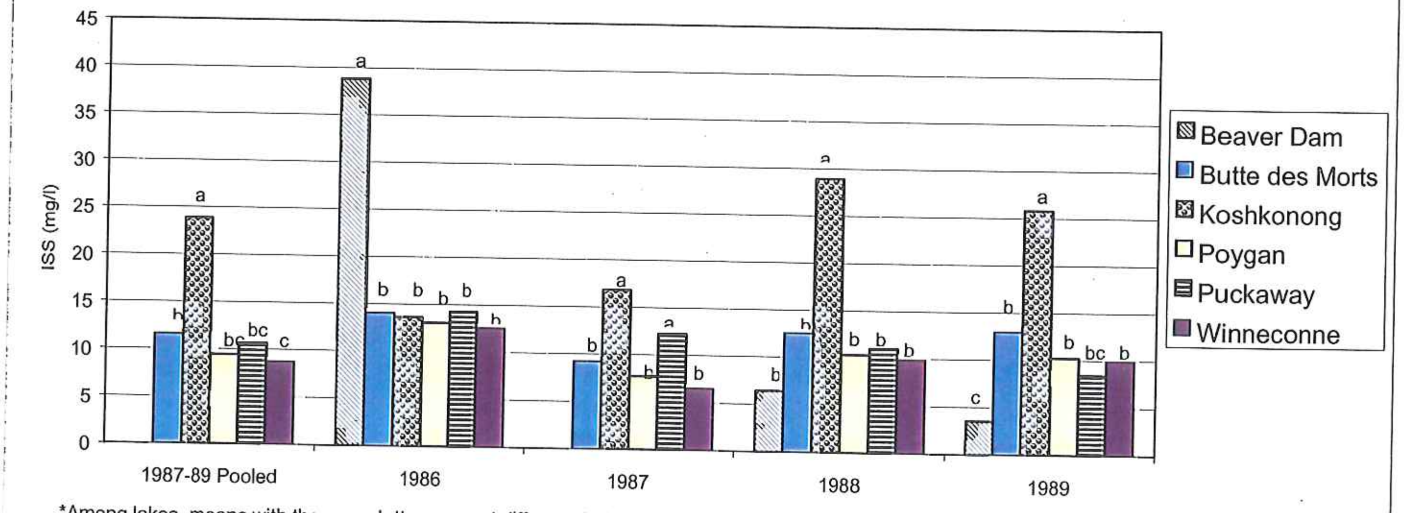
Suspended solids can clog fish gills, either killing them or reducing their growth rate. They also reduce light penetration. This reduces the ability of algae to produce food and oxygen. When the water slows down, as when it enters a reservoir, the suspended sediment settles out and drops to the bottom, a process called siltation. This causes the water to clear, but as the silt or sediment settles it may change the bottom. The silt may smother bottom-dwelling organisms, cover breeding areas, and smother eggs. Indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilize the stratification (layering) in stream pools, embayments, and reservoirs. This, in turn, interferes with mixing, decreasing the dispersion of oxygen and nutrients to deeper layers. Mean total suspended solids (TSS) average 46 mg/l and are approximately two-fold higher than other large shallow lakes (Figure 29). Approximately equal fractions derived from organic and organic origins (inorganic fraction=24mg/l and organic fraction=22 mg/l) comprise Lake Koshkonong's TSS (Figs. 30 and 31).

Figure 29 *Mean total suspended solids (TSS) for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=87-90; for 1986 N=22-27; for 1987 excluding Beaver Dam N=30; for 1988 N=30; for 1989 N=27-30).**



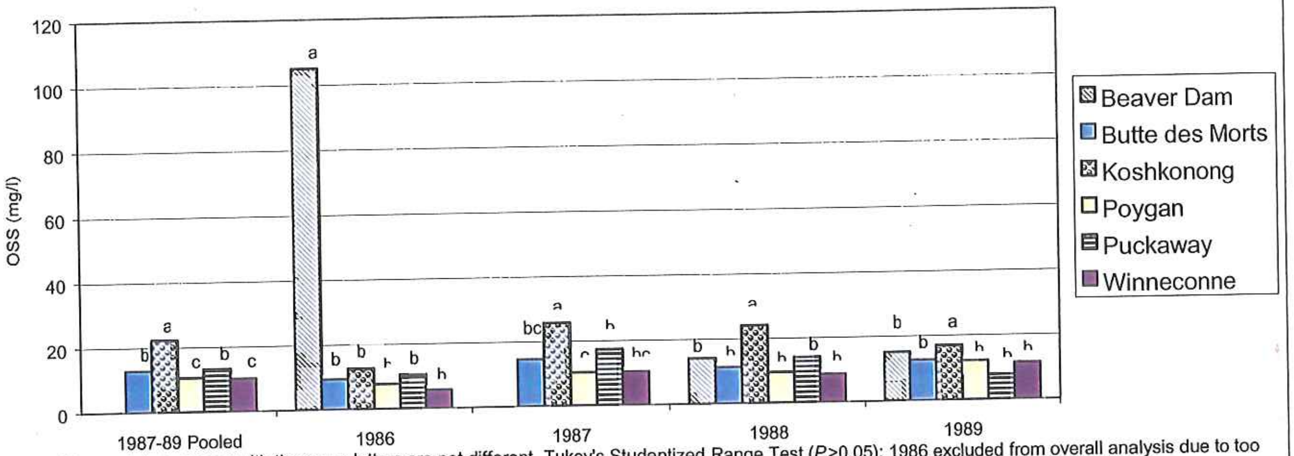
*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test ($P>0.05$); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Figure 30 *Mean inorganic suspended solids (ISS) for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=87-90; for 1986 N=22-27; for 1987 excluding Beaver Dam N=30; for 1988 N=30; for 1989 N=27-30).**



*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test ($P>0.05$); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Figure 31. *Mean organic suspended solids (OSS) for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=87-90; for 1986 N=22-27; for 1987 excluding Beaver Dam N=30; for 1988 N=30; for 1989 N=27-30).**



*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test (*P*>0.05); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Chorophyll A. One adverse effect of nutrient enrichment in surface water bodies is the occurrence of nuisance "algal" blooms (see example; Figure 32). Chlorophyll *a* (Chl *a*) is often used as an estimate of algal biomass, with blooms being estimated to occur when Chl *a* concentrations exceed 30-40 µg L -1. Investigators have shown that there is often a strong correlation between total phosphorus (TP) and algal biomass. Mean chlorophyll a (chla) concentrations for Lake Koshkonong average 180 ug/l and are more than 3-fold greater than other large shallow lakes (Figure 33).

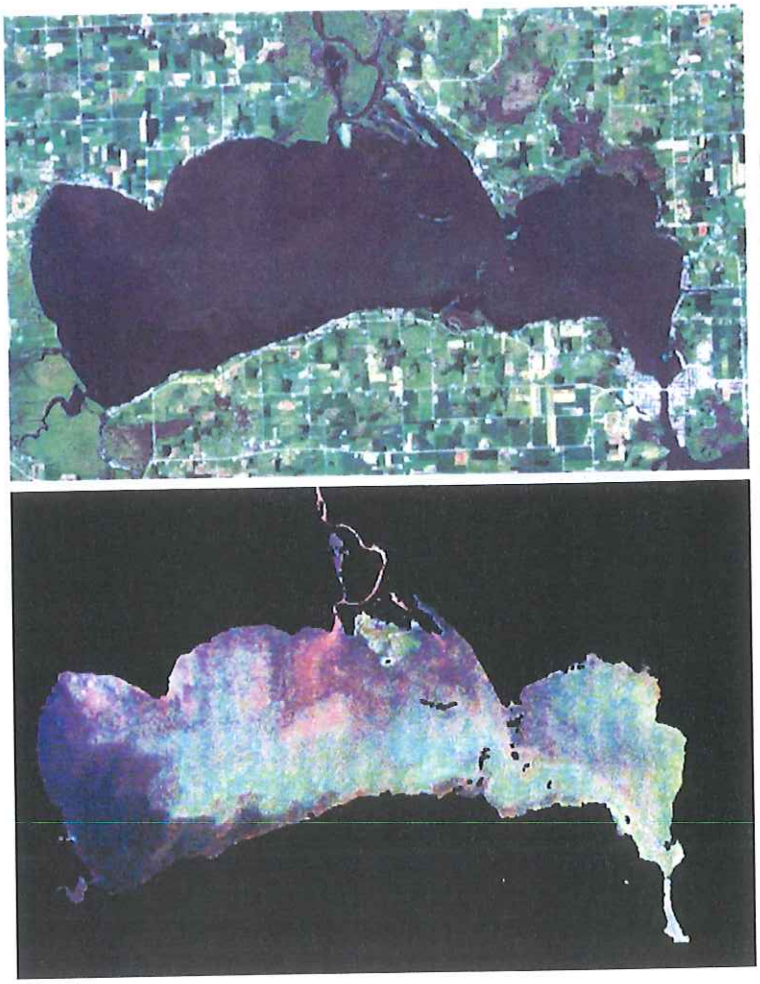
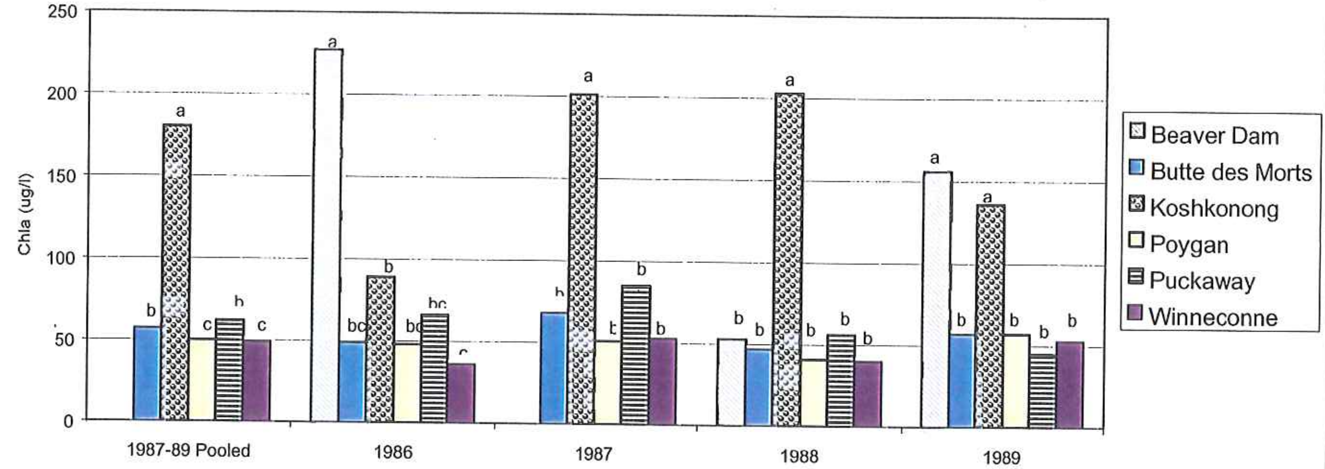


Figure 32. This Landsat-7 image, acquired on July 27, 1999, shows Lakes Poygan and Winneconne. Two versions of the satellite imagery are compared. The first, "raw," image shows the lake in the context of its surrounding landscape. Extensive wetlands can be seen at the western and northern edges of Lake Poygan. In the second image, digital image processing techniques have been used to "mask out" all land areas, and to enhance the variability within the lakes. The results clearly show even the most subtle variations in lake color, with green colors representing the effects of chlorophyll-rich algae and red-brown colors representing suspended materials stirred up by wave action or carried into the lake from sources upstream.

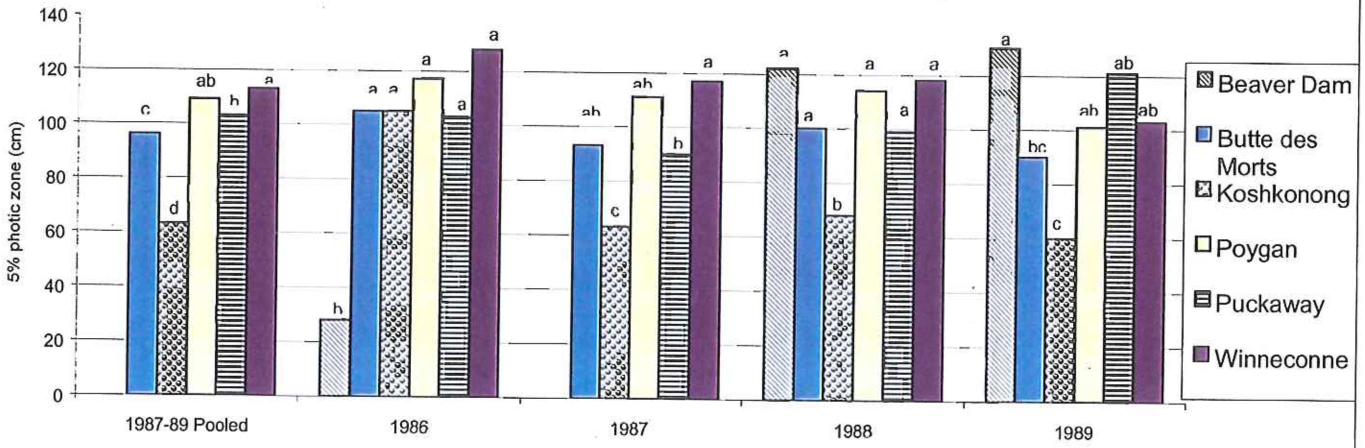
Figure 33 *Mean chlorophyll a (chla) concentrations for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=89-90; for 1986 N=22-27; for 1987 excluding Beaver Dam N=29-30; for 1988-89 N=30).**



*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test ($P>0.05$); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Photic Zone Depth (5%). The photic zone is the uppermost part of the water column, where the intensity of solar radiation is sufficient for net photosynthetic production to occur. Photic Zone depth is often defined as the depth where the irradiance is reduced to 1% of its value in the surface. Effective management and restoration of submerged macrophyte communities often depends on an accurate and meaningful estimate of water clarity. Most studies report water clarity as light attenuation coefficients (AC's) derived from measuring light availability at a single depth or as Secchi transparencies. A few studies use these parameters to indirectly estimate the 1% photic zone based on previously documented relationships between these parameters. Yet submerged macrophytes may require 5-10% of surface light (i.e., the 5% or 10% photic zone). Photic zone depth (5%) for Lake Koshkonong averaged 63 cm (2.1 ft.) for years 1987-1989, while lakes Butte des Morts, Puckaway, Poygan, and Winneconne, averaged 96, 103, 109, and 113 cm., respectively (Figure 34).

Figure 34 *Mean 5% photic zone depth for 3 mid-lake sampling sites in each of 6 lakes in south and east central Wisconsin, late April-late August, 1986-89 (for 1987-89 pooled excluding Beaver Dam N=87-90; for 1986 N=22-25; for 1987 excluding Beaver Dam N=27-30; for 1988-89 N=30).**



*Among lakes, means with the same letters are not different, Tukey's Studentized Range Test ($P>0.05$); 1986 excluded from overall analysis due to too many missing observations, and Beaver Dam excluded from overall and 1987 analyses due to a drawdown in 1987 for a rough fish eradication project.

Phosphorus Loading- One of the major factors influencing the trophic state of Lake Koshkonong is the annual nutrient load to the Lake. Of particular concern is the phosphorus, which is the limited nutrient for plant growth within the Lake. In 2000, the Rock River Watershed Partnership (RRWP) finished its report, culminating two years of modeling and monitoring of the Rock River Basin. That report predicted an average annual load of just over 1 million pounds of phosphorus to the lake. Of that load 56 % (574,725) was estimated from non-point runoff and 44% (456,434 lbs) was estimated from point source loads. Table 7 shows the total phosphorus load by basin.

Table 7. **Phosphorus Load to Lake Koshkonong**

Basin	Non-Point Total P (lb/yr)	Point Source Total P (lb/yr)			
	Non-Point	Point	% of Non-point Watershed load	% of point Watershed load	% of point loads
Lower Koshkonong Creek (LR11)	19,293	48,206	1.87%	4.67%	11%
Upper Koshkonong Creek (LR12)	41,940	31,412	4.07%	3.05%	7%
Bark River (LR13)	19,596	17,497	1.90%	1.70%	4%
Whitewater Creek (LR14)	10,496	14,816	1.02%	1.44%	3%
Scuppernong River (LR15)	13,166	2,905	1.28%	0.28%	1%
Middle Rock River (UR01)	21,545	81,767	2.09%	7.93%	18%
Lower Crawfish River (UR02)	27,543	63,616	2.67%	6.17%	14%
Beaver Dam River (UR03)	42,920	67,944	4.16%	6.59%	15%
Calamus Creek (UR04)	3,868	0	0.38%	0.00%	0%
Maunesha River (UR05)	54,798	8,189	5.31%	0.79%	2%
Upper Crawfish River (UR06)	35,234	848	3.42%	0.08%	0%
Johnson Creek (UR07)	6,188	3,673	0.60%	0.36%	1%
Sinissippi Lake Watershed (UR08)	66,899	45,279	6.49%	4.39%	10%
Oconomowoc River (UR09)	27,986	16,599	2.71%	1.61%	4%
Ashippun River (UR10)	28,368	1,096	2.75%	0.11%	0%
Rubicon River (UR11)	46,960	14,884	4.55%	1.44%	3%
Upper Rock River (UR12)	26,516	17,105	2.57%	1.66%	4%
East Branch Rock River (UR13)	81,410	20,598	7.90%	2.00%	5%
Total	574,725	456,434	55.74%	44.26%	100%

Implementation of NR 217 (point source phosphorus limits) and NR 151 (non-point performance standards) will have some affect on both point and non-point loads to the Lake. The RRWP study indicated that full implementation of NR 217 would reduce P loads by almost 24% basin wide. The RRWP further concluded that fully implementing NR 217 and shifting to agricultural best management practices would result in a P load reduction of about 40%. While this reduction is significant it is unlikely to have a significant affect on the water clarity of the Lake.

During non-runoff times we estimate that STP contribute about 26 MGD (40 CFS) to the base flow. It is possible that NR 217 reductions could cause significant reductions in P levels during low flow, however, it is not possible to predict improved water clarity during these low flow periods. There have been several recent winter fish kills on the Lake that are thought to be related to super saturation of oxygen. These conditions appear to be the result of photo synthesis caused by clear ice conditions and nutrient loads. While it is possible that reduced low flow P levels caused by the implementation of NR 217 could relieve this situation it is not possible to predict through conventional modeling.

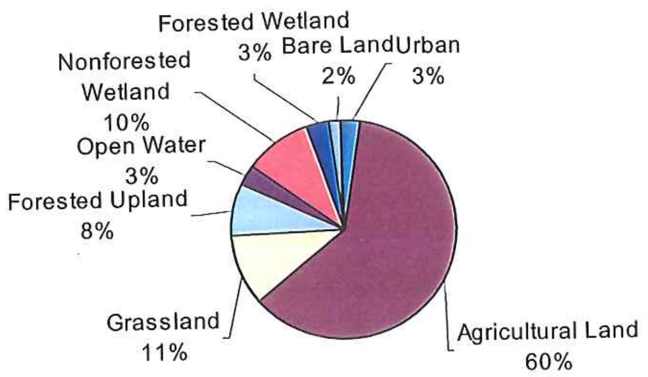
Forested Wetlands

Lake Koshkonong lies within the Ecological Subsection known as the Southern Green Bay Lobe Subsection. Its landforms are glacial till plains, drumlins, moraines, and localized outwash and lake plains. Soil conditions in the Southern Green Bay Lobe Subsection have been summarized as follows (David Hvizdak, NRCS, personal communication):

> Most moraine uplands and drumlins have soils formed in brown calcareous sandy loam to loam till (Udalfs and Udolls). They range from well drained to somewhat poorly drained and generally have silt loam surface textures, moderate to very slow permeability, and moderate to high available water capacity. The outwash plains have upland soils formed in loamy alluvium or loess over calcareous outwash sand and gravel (Udalfs and Udolls). They range from well drained to somewhat poorly drained and generally have silt loam to loam surface textures, moderately rapid to moderate permeability, and moderate available water capacity. The lake plains have soils formed in calcareous loamy to silty lacustrine (Udalfs and Udolls). They range from well drained to somewhat poorly drained and generally have silty loam surface textures, moderate to slow permeability, and moderate to very high available water capacity. Most lowland soils are very poorly drained non-acid muck (Saprists), but includes silty and clayey lacustrine (Aquolls) and loamy till (Aquolls). The major river valleys have soils formed in loamy to silty alluvium (Fluvents, Aquolls, Aqualfs, and Udepts) or non-acid muck (Saprists), range from moderately well drained to very poorly drained, and have areas subjected to periodic flooding. A modern soil survey is available for the area.

The WISCLAND consortium developed broad-scale data on land use/land cover based on satellite imagery collected in 1992. Land use of the Southern Green Bay Lobe Subsection is dominantly agricultural (Figure 35). Forests make up a total of 11% of the area, and forested wetlands represent 3%. This shows that lowland forest is a relatively scarce feature in the landscape. For further discussion of the Southern Green Bay Lobe Subsection and Ecological Land Classification as related to Lake Koshkonong refer to Attachment 9.

Figure 35 Land Use within the Southern Green Bay Lobe Subsection



The lowland forest along Lake Koshkonong is classed as a Floodplain Forest according to the Wisconsin Natural Heritage Inventory Program classification, Wisconsin Department of Natural Resources. The classification replaces in part the Southern Wet and Southern Wet-Mesic Forests of Curtis (1959). This lowland forest community occurs along large rivers that flood periodically. The best development occurs along large rivers in southern Wisconsin.

In the floodplain forest along Lake Koshkonong, the dominant tree species are silver maple (*Acer saccharinum)* and green ash (*Fraxinus pennsylvanica*). Other important tree species include swamp white oak (*Quercus bicolor*), black ash (*Fraxinus nigra*), American elm (*Ulmus americana*), red elm (*Ulmus rubra*), basswood (*Tilia americana*). Box elder (*Acer negundo*), willow (*Salix* spp.), hackberry (*Celtis occidentalis*), and cottonwood (*Populus deltiodes*) are present as minor components. This information is supported through forest survey data of properties within the forested floodplain areas around Lake Koshkonong in Jefferson and Rock Counties.

Common understory plants of lowland hardwood forests often occur in patchy distribution. They include wood nettle (*Laportea canadensis*), sedges (*Carex spp.*), grasses, touch-me-not (*Impatiens biflora*), cardinal flower (*Lobelia cardinalis*), green dragon (*Arisaema dracontium*), green-headed coneflower (*Rudbeckia laciniata*), and button brush (*Cephalanthus occidentalis*). Vines are often prominent in floodplain forests, particularly wild grape (*Vitis riparia*), woodbine (*Parthenocissus vitacea*), poison ivy (*Rhus radicans*), moonseed ((*Menispermum canadense*), and wild cucumber (*Echinocystis lobata*) (Curtis 1959).

Floodplain forests are subject to periodic episodes of flooding of various lengths both during the dormant season and growing season. These floodplain forests are subject to scouring effects (water, ice, and debris), sediment deposition, and periods of saturation or inundation interspersed with very dry conditions. Vegetative composition, including successional patterns, can vary depending on the timing and severity of flooding.

Numerous studies have been conducted to understand the impact of flooding on trees. A state-of-the-art method has not developed sufficiently to warrant a precise statement on the adaptability of a species to a specific flooding condition. Tolerance to flooding depends on many different environmental conditions and tree species. A brief review of soil, tree, and flood characteristics indicates the complexity of these interactions (Attachment 10).

The following soil-related points are important in understanding flooding effects on trees.

Soil Aeration- Flooding results in poor soil aeration because the supply of oxygen to flooded soil is severely limited. Oxygen deficiency is likely the most important environmental factor that triggers growth inhibition and injury in flooded plants.

pH- Flooding of soil increases the pH of acid soils and decreases the pH of alkaline soils.

Texture- Clay and silt soils remain waterlogged for a longer period of time after flooding, because the surface tension of water restricts its movement out of the smaller soil pore spaces. Sandy soils drain more rapidly.

Organic Matter- The rate of decomposition of organic matter in flooded soil tends to be only half that in an unflooded soil. The major end products of decomposition of organic matter in flooded soils are carbon dioxide, methane, and humic materials. In addition, high concentrations of methanol and hydrogen sulfide are produced in waterlogged soils, which can be damaging to root systems.

Sedimentation- Deposits of silt, or sand as shallow as three inches may seal over and smother tree roots by limiting the supply of oxygen. Species vary in tolerance to sedimentation, but all seedlings are susceptible to root injury.

Scouring- Strong currents, waves, or suspended particulates may cause soil around the base of the tree to be washed away, exposing tree roots. Exposed roots can lead to not only tree stress but can make the tree more vulnerable to windthrow.

Various characteristics of a tree affect its flood tolerance with the most prominent presented below.

Height- Tree injury increases in proportion to the percent of crown covered by water. Species that can survive standing in several feet of water for months may die in less than one month when their foliage is completely covered. Few species can tolerate more than one month of complete submersion during the growing season.

Crown Class- Trees in the dominant crown class survive flooding much better than trees in lower crown classes.

Age- Adult trees tolerate flooding better than over mature trees or seedlings of the same species. Therefore, some species rated as flood tolerant may be quite sensitive in the seedling stage. Seedlings often die because they are pushed over, buried in the mud, or uprooted.

Vigor- Tree vigor at the time of flooding influences tolerance. Healthy trees with adequate starch reserves in their roots that are not already under stress, can withstand flooding better than less vigorous trees. Tree vigor may be irrelevant, however, if the tree is totally submersed in water.

Roots- Long-term flooding leads to death and decay of large portions of a tree's root system. During flooding, some species can maintain normal roots in an active or dormant condition; others rely upon new secondary and adventitious roots that may form from the root collar or on the trunk near the water surface. Species unable to either maintain normal roots or grow new ones can quickly die.

Species Variations- Flood tolerance variations within a species are not well understood. Flood tolerance may be an inherited trait and this may explain some of the discrepancies in reports on survival. It is generally accepted that some species have a greater tolerance for flooding than others.

The following points are important in understanding flooding effects on trees

Season- Flooding during the growing season is usually more harmful to woody plants than flooding during the dormant season. Specifically trees are most susceptible to flooding in late spring just after the first flush of growth. The timing of a spring flood influences species differentiation. For example, since silver maple flushes earlier than green ash, an early flood might be more damaging to silver maple while a later flood more injurious to green ash.

Duration-The longer trees are exposed to flooding, the greater the potential for injury. Most trees can stand only 1-4 months with water being continuously over the soil surface. Most trees can tolerate short periods of flooding during the growing season. However, if flooding is recurrent and keeps the soil saturated or prevents recovery from previous flooding, injuries will accumulate and serious damage may occur.

Water Level- The depth of water influences flood tolerance. The mortality rate is less for trees in saturated soil than for trees with water covering the soil. After water covers the soil, the depth may have little significance until the lower foliage is covered; research results, however, differ on this point. Tolerance to complete submersion is much lower than tolerance to shallower depths of water.

Temperature and Oxygen- Cold water is less injurious than warm water due to cold water's capacity to hold more dissolved oxygen. Rapidly flowing water (with higher oxygen content) is less harmful than stagnant water.

Mechanical Injuries- An often overlooked aspect of flood damage is mechanical injury caused by current, wave action, ice, and floating debris. Young trees may be especially damaged by current and wave action. Floating debris can injure both small and large trees. Because the proposed increase in water level will lead to year round flooding, damage due to ice movement will also be significant.

Stress- Permanent and prolonged flooding subject trees to stress. Flood stressed trees exhibit a range of symptoms including leaf chlorosis, defoliation, reduced leaf size and shoot growth, sprouting, and crown dieback. Early fall coloration and leaf drop often occur. It is also common for stressed trees to produce large seed crops in the years following the stressing event. Flood stressed trees are also prime targets for attack by secondary organisms. Secondary organisms include a wide variety of opportunistic fungi and insects that selectively invade hosts after they are weakened or predisposed by stress. Certain root and collar rot diseases are favored by waterlogged, oxygen deficient soil conditions, most notably those caused by the water mold fungi, *Phytophthora* spp. and *Pythium* spp. Flooded soil conditions not only promote reproduction and dispersal of these fungi, but also promote the susceptibility of plant roots to infection.

Table 8 and much of the above information comes directly from the publication Flooding and its Effect on Trees, USDA Forest Service, State and Private Forestry, Northeastern Area, State and Private Forestry, St. Paul, Minnesota, authored by Stephen Bratkovich, Lisa Burban, Steven Katovich, Craig Locey, Jill Pokorny, and Richard Wiest, September 1993 and Wisconsin Ecological Landscapes Handbook (HB 18051), Wisconsin Department of Natural Resources.

Table 8

Relative tolerance of Illinois trees to flooding during the growing season. (Source: Bell and Johnson 1974). **NOTE:** *Flood tolerance categories in Table 2 differ from Table 1 in both name and definition.*

Species	Common Name	Tolerant[1]	Somewhat Tolerant[2]	Slightly Tolerant[3]	Intolerant[4]
Acer negundo	Boxelder	■			
Acer saccharinum	Silver maple	■			
Carya ovata	Shagbark hickory		■		
Carya tomentosa	Mockernut hickory			■	
Celtis occidentalis	Hackberry		■		
Cercis canadensis	Redbud		■		
Crataegus mollis	Downy hawthorn	■			
Diospyros virginiana	Persimmon	■			
Juglans nigra	Black walnut		■		
Fraxinus pennsylvanica	Green ash		■		
Gleditsia triacanthos	Honeylocust	■			
Platanus occidentalis	Sycamore	■			
Populus deltoides	Eastern cottonwood	■			
Prunus serotina	Black cherry				■
Quercus alba	White oak			■	
Quercus bicolor	Swamp white oak	■			
Quercus imbricaria	Shingle oak		■		
Quercus macrocarpa	Bur oak	■			
Quercus palustris	Pin oak	■			
Quercus rubra	Red oak			■	
Quercus velutina	Black oak				■
Salix nigra	Black willow	■			
Sassafras albidum	Sassafras				■
Ulmus americana	American elm		■		

[1] Tolerant: most individuals survived more than 150 days of flooding during the growing season.

[2] Somewhat Tolerant: some individuals killed by less than 90 days of flooding and some individuals survived greater than 150 days of flooding.

[3] Slightly Tolerant: most individuals survived more than 50 days but less than 100 days of flooding.

[4] Intolerant: severe effects with less than 50 days of flooding.

Importance of Wetlands

The federal Clean Water Act requires that wetlands be protected from degradation because of their multiple, important ecological roles including maintenance of high water quality and provision of habitat for fish and wildlife.

Since 1980, this protection has slowed the precipitous decline in wetland acreage observed in the United States since European settlement.

Restoration of riparian functions is a goal. Over the last several decades, federal and state programs have increasingly focused on the need for maintaining or improving water quality, ensuring the sustainability of fish and wildlife species, protecting wetlands, and reducing the impacts of flood events. Because riparian areas perform a disproportionate number of biological and physical functions on a unit area basis, their restoration can have a major influence on achieving the goals of the Clean Water Act, the Endangered Species Act, and flood damage control programs.

Protection should be the goal for riparian areas in the best ecological condition, while restoration is needed for degraded riparian areas. Management of riparian areas should give first priority to protecting those areas in natural or nearly natural condition from future alterations. The restoration of altered or degraded areas could then be prioritized in terms of their relative potential value for providing environmental services and/or the cost effectiveness and likelihood that restoration efforts would succeed. Where degradation has occurred—as it has in many riparian areas throughout the United States—there are vast opportunities for restoring functioning to these areas.

Patience and persistence in riparian management is needed. The current degraded status of many riparian areas throughout the country represents the cumulative, long-term effects of numerous, persistent, and often incremental impacts from a wide variety of land uses and human alterations. Substantial time (years to decades) will be required for improving and restoring the functions of many degraded riparian areas. Commensurate with restoration must be efforts to improve society's understanding of what riparian functions have been lost and what can be recovered.

General Physical Description of Wetlands

The wetlands of Lake Koshkonong are riverine/lake fringe wetlands associated with several navigable bodies of water: Lake Koshkonong, the Rock River and several tributary streams. Many of the tributaries in the upper watershed are ditched to facilitate drainage in agricultural areas. The natural hydroperiod of the Lake Koshkonong wetlands vary from seasonally and permanently flooded to groundwater springs and seeps and saturated soils. Since dam installation, the natural hydroperiod has been modified, resulting in increased water levels and more permanently flooded wetlands.

Before the dam was constructed, the shallow and deep marshes were known as a "sea of green" because of the extensive wild rice beds and other emergent vegetation. Increased water levels have resulted in much greater areas of open water. The wetlands currently present around Lake Koshkonong include aquatic beds, deep marsh, shallow marsh, wet meadow, shrub carr and southern lowland forest. Extensive wetlands underlain by mucks and hydric mineral soils exist around the lake. Surrounding land uses include agriculture, urban development and open space/wetland.

Wetland Observations

A list of plant observations made during field investigations is shown in Table 9. Wetland plant communities observed included southern lowland forest (floodplain forest), emergent marsh, wet meadow and aquatic bed types (Figure 36). The forested wetlands were dominated by silver maple and green ash trees. Other species observed included black willow and swamp white oaks. Herbaceous vegetation was particularly scarce due to both timing of field investigations and long-duration flooding which drowned out these plants.

Shrub carr communities occupied drier areas of marsh and are dominated by sandbar willow. Emergent marsh is dominated by cattail, soft-stem bulrush and river bulrush with some invasion by non-native narrow-leaved and hybrid cattails, tall reed grass and purple loosestrife. Wild rice and chair-makers rush are occasionally seen growing in marsh areas. Wet meadows observed along the lake shore were dominated by reed canary grass. White water-lily, yellow pond-lily and water smartweed were the main species observed in aquatic bed wetlands. In addition to these wetlands, many areas of submergent wetlands, mainly occupied by sago pondweed were observed.

The wetlands observed were not unimpacted. Stresses on wetlands included impacts from raised water levels, decreased water quality, human uses and disturbance from carp and non-native plant introductions. High water levels were noted by the lack of herbaceous layers in much of the lakeside wetlands, the presence of adventitious roots, shallow roots, dead and dying trees and the absence of groundwater-dependent plants and plant communities. High water levels have increased erosion and loss of wetlands. Water quality conditions are poor as a result of nutrient and sediment-laden surface water coming into the wetlands from upstream agricultural and urban areas. Wetland filling has occurred along the shoreline and urban uses within the watershed contribute additional pollutants. Recreational boating stirs up sediments in the shallow basin, increasing turbidity levels. Carp, an introduced species, also stir up sediments, which in turn increases turbidity levels and reduces light penetration and submergent plant growth. Non-native plant species present which are invasive include reed canary grass, giant reed grass, narrow-leaved and hybrid cattails and purple loosestrife.

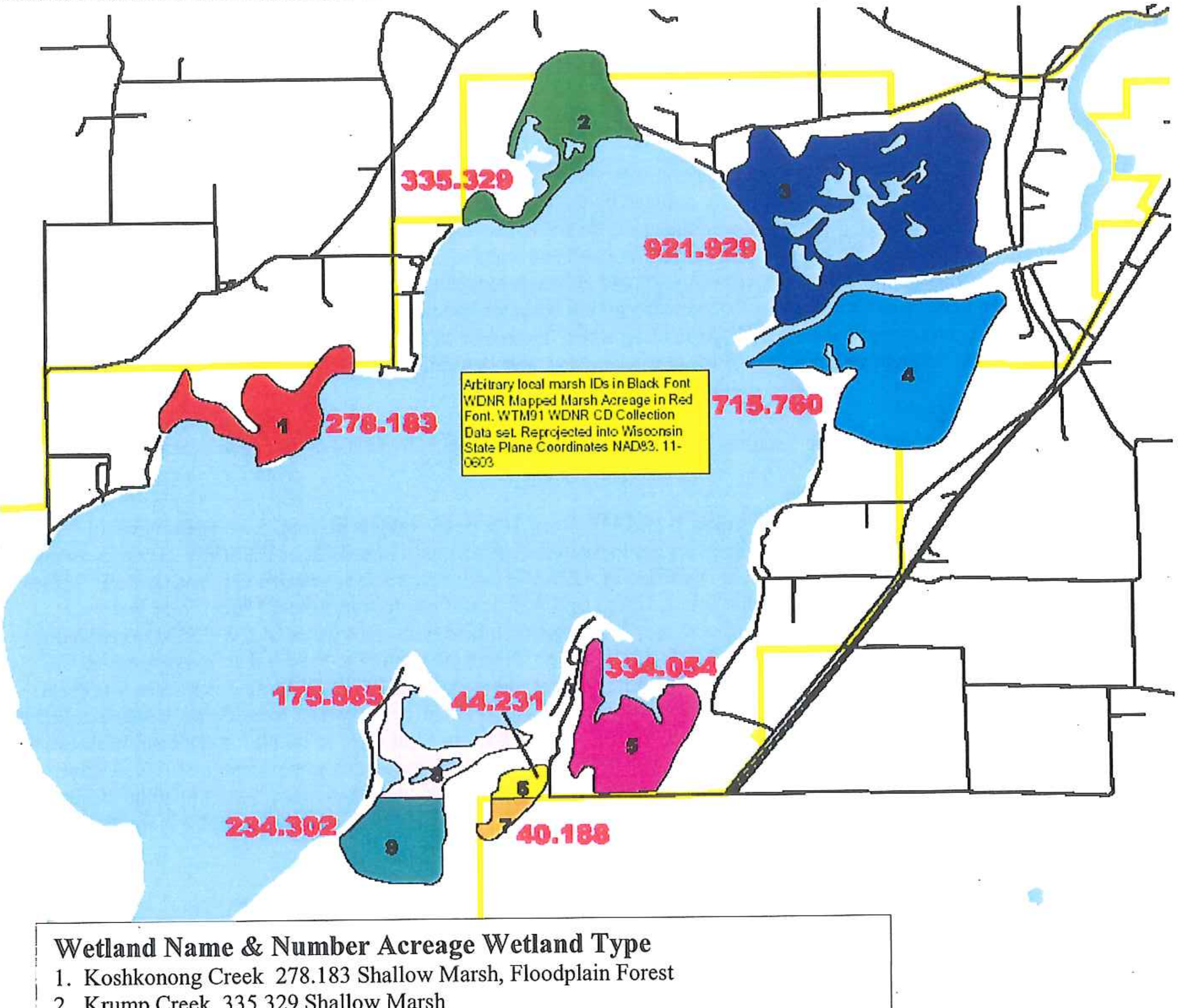
Table 9. Lake Koshkonong Wetland Plant Species Observed

Acer negundo	Box elder
Acer saccharinum	Silver maple
Asclepias incarnata	Marsh milkweed
Bidens cernuus	Nodding beggar-ticks
Bidens sp.	Beggar-ticks
Bolboschoenus fluviatilis	River bulrush
Ceratophyllum demersum	Coon's-tail
Crataegus sp.	Hawthorn
Echinochloa walteri	Water-millet
Eleocharis sp.	Spike-rush
Fraxinus pennsylvanica	Green ash
Glechoma hederacea	Creeping-charlie
Leersia oryzoides	Rice cut-grass
Lemna minor	Common duckweed
Lysimachia nummularia	Moneywort
Lythrum salicaria	Purple loosestrife
Nuphar advena	Yellow pond-lily
Nymphaea sp.	White water lily
Phalaris arundinacea	Reed canary grass
Phragmites australis	Tall reed
Polygonum amphibium	Water smartweed
Quercus bicolor	Swamp white oak
Sagittaria latifolia	Arrowhead
Salix exigua	Sandbar willow
Salix nigra	Black willow
Salix sp.	Willow
Schoenoplectus pungens	Chair-maker's rush
Schoenoplectus tabernaemontani	Soft-stem bulrush
Scutellaria galericulata	Marsh skullcap
Sium suave	Water-parsnip
Solanum dulcamara	Nightshade
Sparganium sp.	Burreed
Spartina pectinata	Prairie cordgrass
Spirodela polyrrhiza	Giant duckweed
Stuckenia pectinata	Sago pondweed
Typha angustifolia	Narrow-leaved cattail
T. latifolia	Broad-leaved cattail
Ulmus americana	American elm
Vitis riparia	Riverbank grape
Zizania aquatica	Wild rice

Wetland Functional Values

Despite the significant stresses to these wetlands, they still provide important functional values. The wetlands support a diverse native plant assemblage. The wetland complexes support aquatic bed, wet meadow, deep and shallow marsh, shrub carr and lowland hardwood forest wetland types. These plant communities support critically important fish and wildlife habitat. The area has been historically noted as one of the most important waterfowl hunting marshes before the dam was installed. It still provides significant migratory waterfowl habitat. Wetlands also support migrating shorebirds and neotropical birds, nesting and year-round resident songbirds, raptors and other bird species and important reptile, amphibian and mammal habitat, particularly for muskrats, mink, white-tail deer and small mammals. During one day's field investigation, we observed over 100 American White Pelicans,

Figure 36. List of riparian wetlands to Lake Koshkonong using Jefferson County GIS data. The green wetland polygons represent shallow marsh areas with the exception of select areas of floodplain forests located along tributaries and the mainstem Rock River at Blackhawk Island.



Arbitrary local marsh IDs in Black Font WDNR Mapped Marsh Acreage in Red Font. WTM91 WDNR CD Collection Data set. Reprojected into Wisconsin State Plane Coordinates NAD83. 11-0603

Wetland Name & Number Acreage Wetland Type

1. Koshkonong Creek 278.183 Shallow Marsh, Floodplain Forest
2. Krump Creek 335.329 Shallow Marsh
3. Mud Lake 921.929 Shallow Marsh
4. State-owned Blackhawk Island 715.760 Shallow Marsh, Shrub/Carr, Wet Meadow
5. Otter Creek 334.054 Shallow Marsh, Floodplain Forest

6,7,8,9. Thiebeau Marsh 494.586 Shallow Marsh, Shrub/Carr, Wet Meadow

Total 3,079.841 Acres

numerous shorebirds, state endangered, threatened and special concern species (Forster's Tern, Great Egret and Black Tern) and large flocks of waterfowl. These wetlands provide habitat for species of aquatic life, which support the Lake Koshkonong fisheries. Although carp have had a major impact upon the fishery of the lake, other native species such as northern pike are present and use adjacent wetlands for most stages of their life cycles.

Wetlands along Lake Koshkonong provide important flood and stormwater attenuation. Evidence of high water levels is observable as high water marks on trees, erosion marks and lack of herbaceous vegetation from long-duration flooding. Long-duration flooding allows settling of sediment, nutrient and pollutant-laden surface water. This water quality protection function is evidenced by historical documentation of alga blooms. Urban development, wastewater discharges and agriculture in the watershed have added additional pollutants to the system over the years. Wetlands can store nutrients, sediments and toxic substances and in some cases remove them, such as through denitrification. Seasonal high water levels, long wind fetch and boat traffic results in shoreline erosion, which can be reduced by shoreline wetlands. Wetland vegetation located along the shore decrease wave energy, hold soil particles and thereby reduce erosion. Although wetland vegetation slows the erosion of shoreline property, wetland erosion and loss has intensified since the dam was installed and continues to be a major problem.

Groundwater functions are not well documented in Lake Koshkonong wetlands, however, springs within the basin feed the lake. Marly soil within the lake basin may be an indication of groundwater seepage. Areas of groundwater springs and seeps may have been drowned by surface water since the dam raised water levels.

Human use values include aesthetics, recreation, education and science. While the aesthetics of the marsh once known as a "sea of green" are significantly reduced by the large expanses of open water, high turbidity levels and algae blooms, the remaining vegetated wetlands provide natural scenic beauty. Wetlands support habitat for important wildlife species that are fished, hunted, trapped and watched. These wetlands were once one of the most significant waterfowl hunting areas in the country and although reduced, they are still locally significant for waterfowl hunters. Also significant is the presence of less common species of birds, which are sought out by bird watchers from throughout the state and surrounding areas. Examples of these species are large flocks of American White Pelicans, state endangered Forster's Terns, waterfowl and shorebirds which have been observed in Mud Lake.

Wetland Recession

Historic aerial photography was interpreted for two wetland complexes of Lake Koshkonong to determine change in wetlands over time.

Mud Lake (Figure 37) Aerial photo dated 7-19-1937: Very little open water is present. The majority of the wetland vegetation consists of persistent emergent vegetation that is classified as E2H or E2/W0H. There is an area of aquatics mixed with open water that is classified as A2/W0H (mix of aquatic vegetation and open water). There are several stands of deciduous trees that are classified as T3K. **Aerial photo dated 5-16-1966:** There is a significant amount of open water (W0L) and aquatic vegetation mixed with open water (A2/W0H) as compared to the 1937 aerial photo. A channel is also visible that connects Lake Koshkonong to Mud Lake. Large areas of persistent emergent vegetation (E2H) are also present. **Aerial photo dated 6-25-1979**: More open water is present as compared to the 1966 aerial photo. Areas are classified as A2/W0L and A2L where more dense stands of aquatic vegetation are present. The channel that connects Koshkonong Lake to Mud Lake is visible. **Aerial photo dated 5-31-1986:** The vegetation, open water and channel appear to be very similar to what was present in 1979. **Aerial photo dated 5-6-1992**: More open water (W0L) is present than in 1986. It appears that a berm or similar structure was built through a wetland and across the mouth of the channel. Other wetland vegetation present includes E2H and T3K.

Carcajou (Figure 38) Aerial photo dated 7-19-1937: A large floodplain forest (T3Kw) is present. Large areas of persistent emergent vegetation are also present (E2H). The E2H wetlands buffer the floodplain forest complex from Lake Koshkonong.**Aerial photo dated 5-16-1966**: The E2H wetlands that buffer the floodplain forest complex have decreased in area. They no longer exist at the southern edge of the floodplain forest surrounding Koshkonong Creek and have decreased in size in the bay to the east. **Aerial photo dated 6-25-1979**: The E2H wetlands in the bay have decreased further. **Aerial photo dated 5-31-1986:** The E2H wetlands appear similar in size as to what was present in 1979. **Aerial photo dated 4-28-1992**: The E2H wetlands appear similar in size as to what was present in 1979.

Figure 37. Aerial Photos of the Mud Lake Wetland Complex.

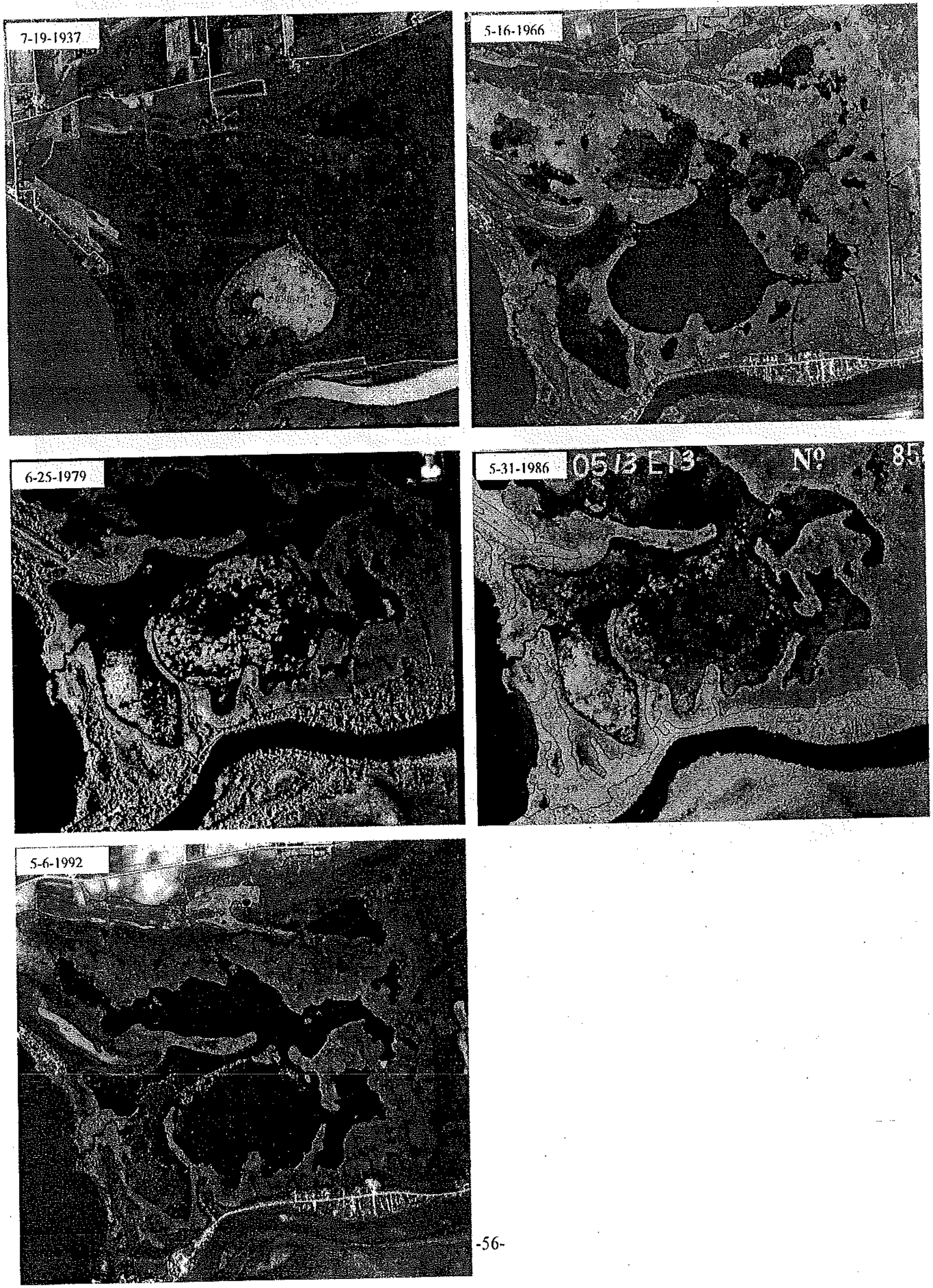
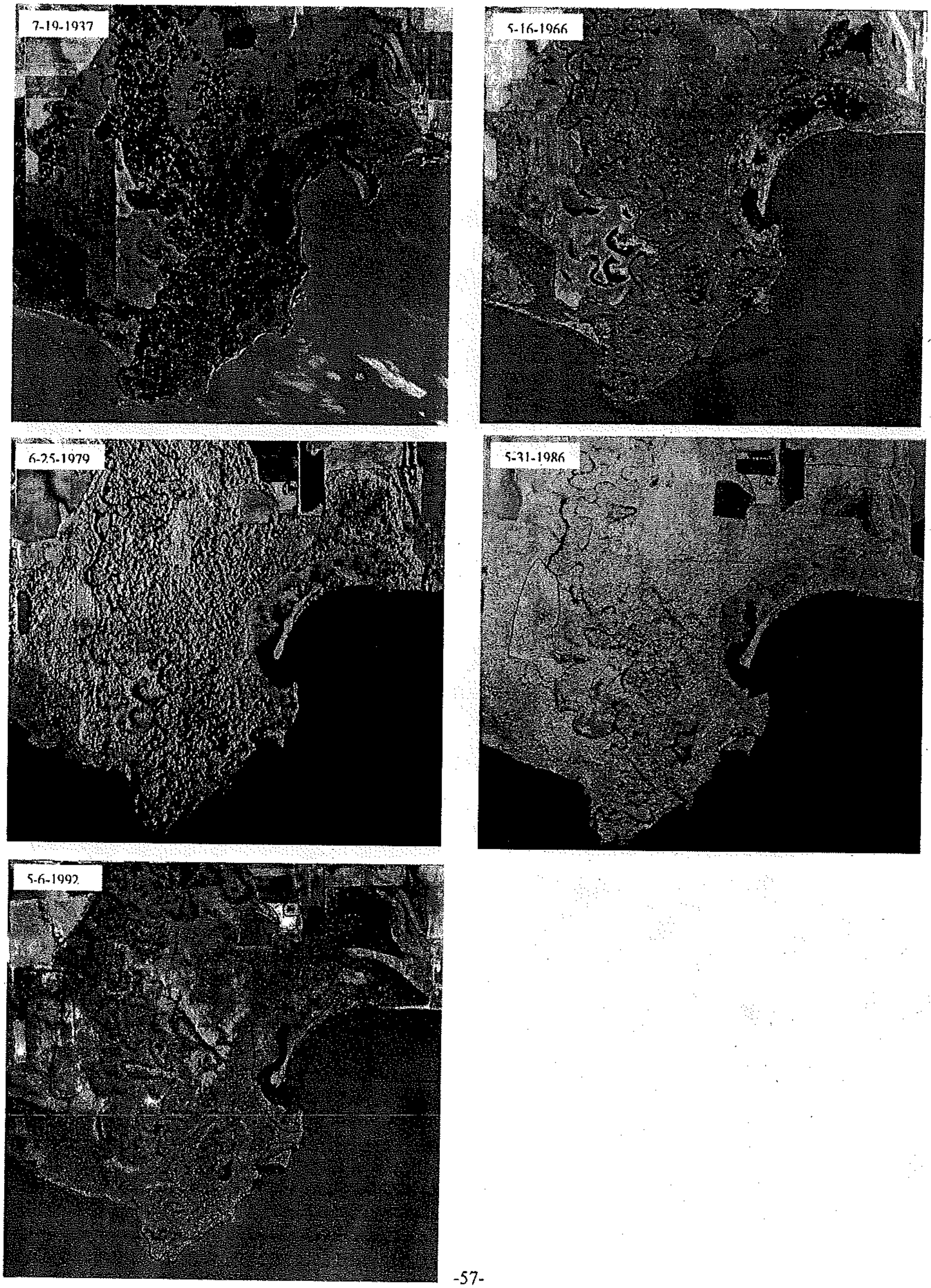


Figure 38. Aerial photos of the Carcajou Wetland Complex



Fish

The fishery of the Rock River is a diverse assemblage of species common to the Mississippi River drainage. As a wide spot of the Rock River, the fishery of Lake Koshkonong reflects the riverine species, pelagic species, and fish of the littoral zone. A changing, dynamic, and prolific fishery is the result of several forces. The earliest comprehensive fishery survey of the lake was conducted in response to concerns and complaints due to the fluctuations in the fishery (Threinen, 1952.).

The species list for fish known to be present in Lake Koshkonong and the Rock River between Indianford and Jefferson is presented in the Table 10. Sixty-seven fish species are represented. (DNR Fisheries Surveys and Distribution *and Relative Abundance of Fishes in Wisconsin 1. Greater Rock River Basin. Technical Bulletin No. 136 WDNR 1982 Don Fago*).

Migrations of fish in and out of the lake constantly reflect conditions above, below and within the system. A commercial harvest of over one million pounds of rough fish each year is the state's single largest biomanipulation. Restocking efforts are a management attempt to develop a fishery to satisfy the public demand for quality fishing while maintaining an ecological balance. Natural changes in the watershed such as drought and floods will enhance or hinder some fish populations. Flood events affect the fishery by enhancing reproduction of fish that spawn during the flood. April floods have produced walleye year classes, while May and June floods help carp. Fish kills have been documented in summer as well as winter, and from low oxygen as well as supersaturation.

Management efforts

One cannot discuss fish management of Lake Koshkonong without discussing carp. The warm, shallow and turbid waters of the lake are perfect habitat for this large benthivore. Additionally, carp have an inherent ability as a species to modify the environment to their advantage with great detriments to other species. They accomplish this by rooting up vegetation and eliminating the habitat for littoral species such as bluegills, bass and perch. Their rooting behavior further

Table 10. Fish Species list: Lake Koshkonong and Rock River (I-ford to Jefferson)

Common Name	Scientific Name	Family
American brook lamprey	*Lampetra appendix*	Petromyzontidae
American eel (uncertain)	*Anguilla rostrata*	Anguillidae
Banded killifish	*Fundulus diaphanus*	Fundulidae
Bigmouth buffalo	*Ictiobus cyprinellus*	Catostomidae
Black bullhead	*Ameiurus melas*	Ictaluridae
Black crappie	*Pomoxis nigromaculatus*	Centrarchidae
Blackchin shiner	*Notropis heterodon*	Cyprinidae
Bluegill	*Lepomis macrochirus*	Centrarchidae
Bluntnose minnow	*Pimephales notatus*	Cyprinidae
Bowfin	*Amia calva*	Amiidae
Brook silverside	*Labidesthes sicculus*	Atherinidae
Brook stickleback	*Culaea inconstans*	Gasterosteidae
Brown bullhead	*Ictalurus nebulosis*	Ictaluridae
Burbot	*Lota lota*	Gadidae
Central mudminnow	*Umbra limi*	Umbridae
Channel catfish	*Ictalurus punctatus*	Ictaluridae
Common carp	*Cyprinus carpio*	Cyprinidae
Common shiner	*Luxilus cornutus*	Cyprinidae
Creek chub	*Semolitus atromaculatus*	Cyprinidae
Emerald shiner	*Notropis atherinoides*	Cyprinidae
European rudd	*Scardinius erythropthalmus*	Cyprinidae
Fathead minnow	*Pimephales promelas*	Cyprinidae
Flathead catfish	*Pylodictis olivaris*	Ictaluridae
Freshwater drum	*Aplodinotus grunniens*	Sciaenidae
Golden redhorse	*Moxostoma erythrurum*	Catostomidae
Golden shiner	*Notemigonus crysoleucas*	Cyprinidae
Goldfish	*Carassius auratus*	Cyprinidae
Greater Redhorse	*Moxostoma valenciennesi*	Catostomidae
Green sunfish	*Lepomis cyanellus*	Centrarchidae
Hornyhead chub	*Nocomis biguttatus*	Cyprinidae
Johnny darter	*Etheostoma nigrum*	Percidae
Largemouth bass	*Micropterus salmoides*	Centrarchidae
Least darter	*Etheostoma microperca*	Percidae
Logperch	*Percina caprodes*	Percidae
Longnose gar	*Lepisosteus osseus*	Lepisosteidae
Mississippi silvery minnow	*Hybognathus nuchalis*	Cyprinidae
Muskellunge	*Esox masquinongy*	Esocidae
Northern hog sucker	*Hypentelium nigricans*	Catostomidae
Northern pike	*Esox lucius*	Esocidae
Northern redbelly dace (uncertain)	*Phoxinus eos*	Cyprinidae.
Orangespotted sunfish	*Lepomis humilis*	Centrarchidae
Pugnose minnow	*Opsopoeodus emiliae*	Cyprinidae
Pugnose shiner	*Notropis anogenus*	Cyprinidae
Pumpkinseed	*Lepomis gibbosus*	Centrarchidae
Rainbow trout	*Oncorhynchus mykiss*	Salmonidae
Redfin shiner	*Lythrurus umbratilis*	Cyprinidae
River Redhorse	*Moxostoma carinatum*	Catostomidae
Rock bass	*Ambloplites rupestris*	Centrarchidae
Sauger	*Sander canadensis*	Percidae
Shorthead redhorse	*Moxostoma macrolepidotum*	Catostomidae
Silver redhorse	*Moxostoma anisurum*	Catostomidae
Slender madtom	*Noturus exilis*	Ictaluridae
Slenderhead darter	*Percina phoxocephala*	Percidae
Smallmouth bass	*Micropterus dolomieu*	Centrarchidae
Spotfin shiner	*Cyprinella spiloptera*	Cyprinidae
Spottail shiner	*Notropis hudsonius*	Cyprinidae
Stonecat	*Noturus flavus*	Ictaluridae
Sturgeon unsp. (extirpated)		Acipenseridae
Tadpole madtom	*Noturus gyrinus*	Ictaluridae
Walleye	*Sander vitreus*	Percidae
Warmouth	*Lepomis gulosus*	Centrarchidae
White bass	*Morone chrysops*	Percichthydiae
White crappie	*Pomoxis annularis*	Centrarchidae
White sucker	*Catostomus commersoni*	Catostomidae
Yellow bass	*Morone mississippiensis*	Percicthyidae
Yellow bullhead	*Ameiurus natalis*	Ictaluridae
Yellow perch	*Perca flavescens*	Percidae

increases siltation, nutrient recycling and algae growths. This results in high biological oxygen demand, lower oxygen levels and a reduction in water quality that favors their survival over species requiring higher oxygen levels. Additionally, the habit of carp eating the eggs of other species can tip the balance in favor of the carp. Left to their own end, carp are capable of dominating an entire fishery.

Controlling carp with seining operations began in the 1920's and was conducted by state crews from 1936 until 1975. Since then, commercial contract fishermen have done all seining. Crews under the state program removed approximately one million pounds per year. Private contractors have increased the harvest to about 1.5 million pounds per year.

The original belief was that a carp population could be eliminated or at least controlled by seining. It was felt that if only carp could be reduced or eliminated, that the desirable species would be able to restore the fishery without further enhancements. Ironically, the process of harvesting carp has benefits to the remaining carp population. The survivors are healthier, more fecund and with less competition and ultimately can grow and survive better. Early criticisms of the state engaging in "carp farming" had merit in that seining alone did not control the population.

In the 1970's with rough fish stations being absorbed into other state operations, hatchery production increased. The state began intensive stocking programs with the intention of controlling carp with a combination of predator stocking and continued seining. The problem with this plan was that carp can grow exceedingly fast, reaching over nine inches in length in just one year. Therefore, only the largest of the pike or walleyes were capable of preying on yearling carp.

Shoreline seining data collected in the late1970's and 1980's indicated that although carp populations were high, the numbers of juvenile carp in the lake were low. Additional data collected in tributary streams, especially below shallow impoundments, suggested that many of the carp in the Koshkonong system were the progeny of upstream carp populations. It became apparent that a high density of panfish notably white bass and crappies were able to help control carp recruitment by preying on carp eggs, fry and fingerling.

The current belief and management philosophy recognizes that carp cannot be eliminated from the system. But with intensive management, a level of control can be achieved to bring the balance back to provide good sport fishing. Efforts are focused on the following objectives:

Reduce standing stocks of carp by mechanical removal.
- issue contracts for carp removal
- support infrastructure to aid removal program
- encourage sport angling for carp

Restore gamefish populations
- maintain strong populations of predators through stocking
- support state stocking with Bark River Hatchery production
- enhance panfish populations through field transfers and stocking

Habitat modifications and enhancements
- remove dams from impoundments known to be "carp hatcheries"
- utilize mechanical barriers to exclude carp
- enhance habitat for panfish, forage fish and predators

Continue to monitor, evaluate and make improvements the management system.

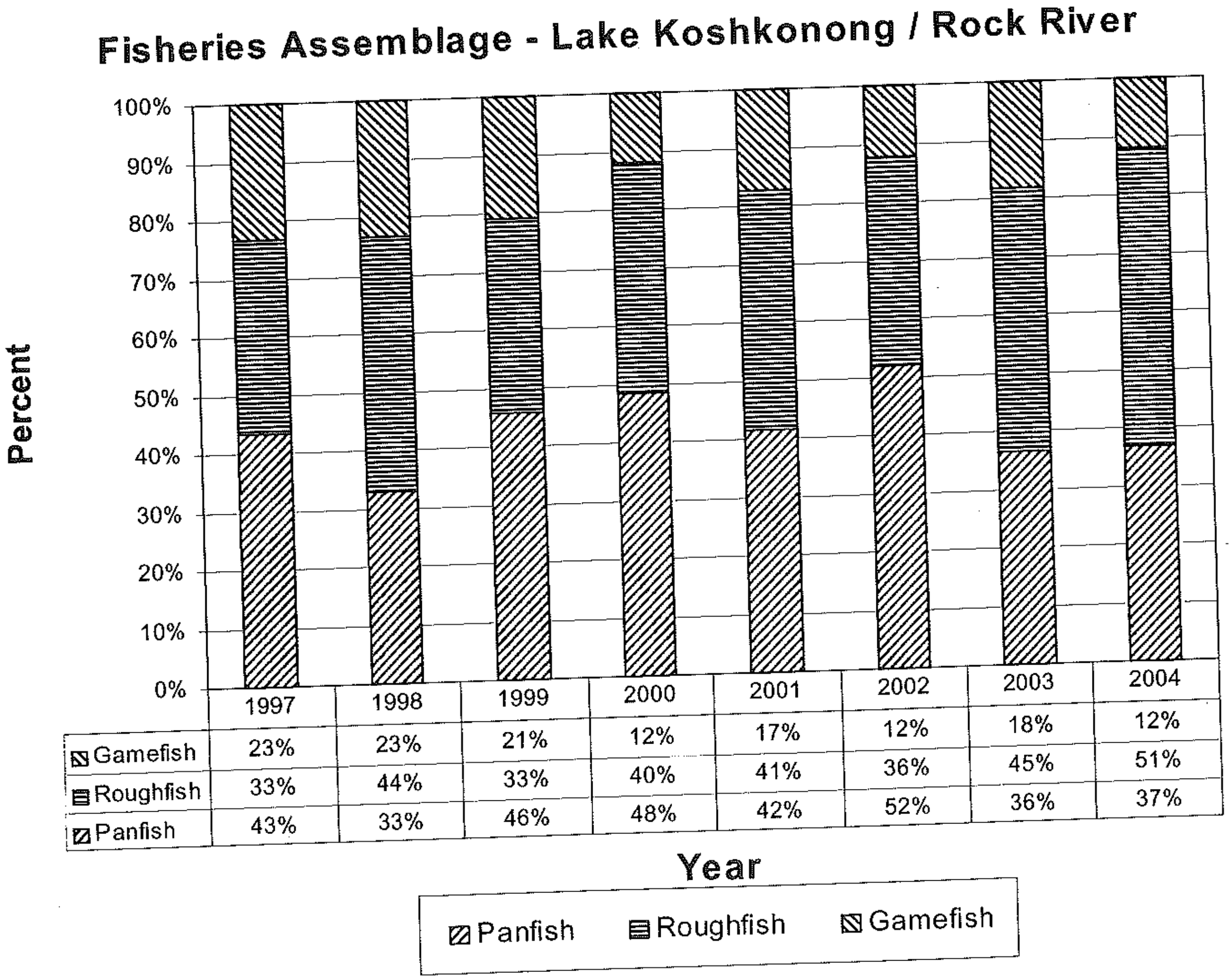
Other rough fish species in the harvest include white suckers, shorthead, silver and golden redhorse, bigmouth buffalo and freshwater drum. Combined catch of these species may exceed one hundred thousand pounds per year. These fish are not as detrimental as carp to the habitat of the lake and the river. A commercial harvest is allowed because anglers generally under utilize the species. High densities of juvenile rough fish are an important forage component of game fish.

Current fishery status:

Continuing evaluation of the Koshkonong fishery falls into several efforts, but the most valuable data is from spring fyke netting and fall electrofishing. Spring fyke netting is a passive capture technique that is most successful when large numbers of fish are moving. Sets are made to capture northern pike as they move into spawning areas at ice out. Nets are then moved to collect walleyes moving up the Rock River as the waters warm. Generally fyke nets are operated continuously from around mid-March to mid-May. Figure 39 indicates the changing nature of the fish community of Lake Koshkonong. In 1984, carp populations were at a low level due to heavy commercial harvest and lack of recruitment. A major fish kill from supersaturated oxygen in the winter of 1989-1990 decimated the panfish community. This was followed by big year classes of channel catfish and carp. Consequently, the 1991 assemblage consists of only 10 percent panfish. Roughfish consisting primarily of carp went to 30 percent of the fishery. While gamefish numbers are 60 percent for 1991, these are nearly all channel catfish. After 1991, catfish recruitment was low in the system, but walleye had a banner year in 1993. By 1997, the gamefish assemblage was down a bit to 34 percent of the fishery, but 75 percent of the gamefish were walleyes and sauger. Panfish had improved to 43 percent of the fishery by 1997 due to good hatches of white bass.

Since 2000 the fishery has enjoyed an unprecedented period of stability. A panfish community, largely consisting of white bass and black crappie comprises around 50 percent of the fyke net catch (Figure 40). The rough fish portion of the catch is around 35 to 40 percent of the catch but is largely comprised of freshwater drum (Figure 41). The gamefish catch primarily consists of northern pike, walleye and sauger. In recent years, walleye are increasing and saugers are declining (Figure 42).

Figure 39



	1997	1998	1999	2000	2001	2002	2003	2004
▧ Gamefish	23%	23%	21%	12%	17%	12%	18%	12%
▤ Roughfish	33%	44%	33%	40%	41%	36%	45%	51%
▨ Panfish	43%	33%	46%	48%	42%	52%	36%	37%

Figure 40. Panfish Composition. BH-Bull heads (black, brown, and yellow), YP-Yellow perch, YB-Yellow bass, WB-White bass, BG-Bluegill,BC-Black crappie

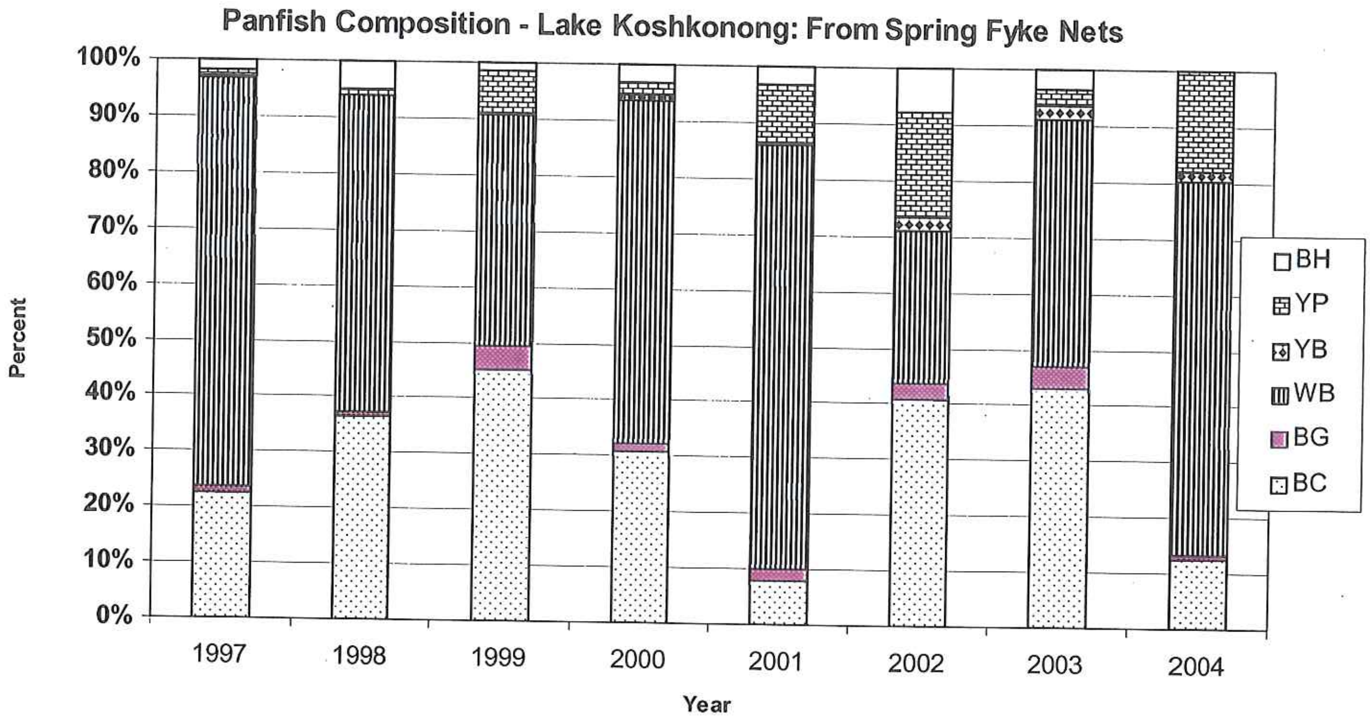


Figure 41. Roughfish Composition. Bowf-Bowfin, Buf-Largemouth buffalo, WS-White sucker, Redh.-Redhorse, Drum-Freshwater drum, Carp-Common Carp.

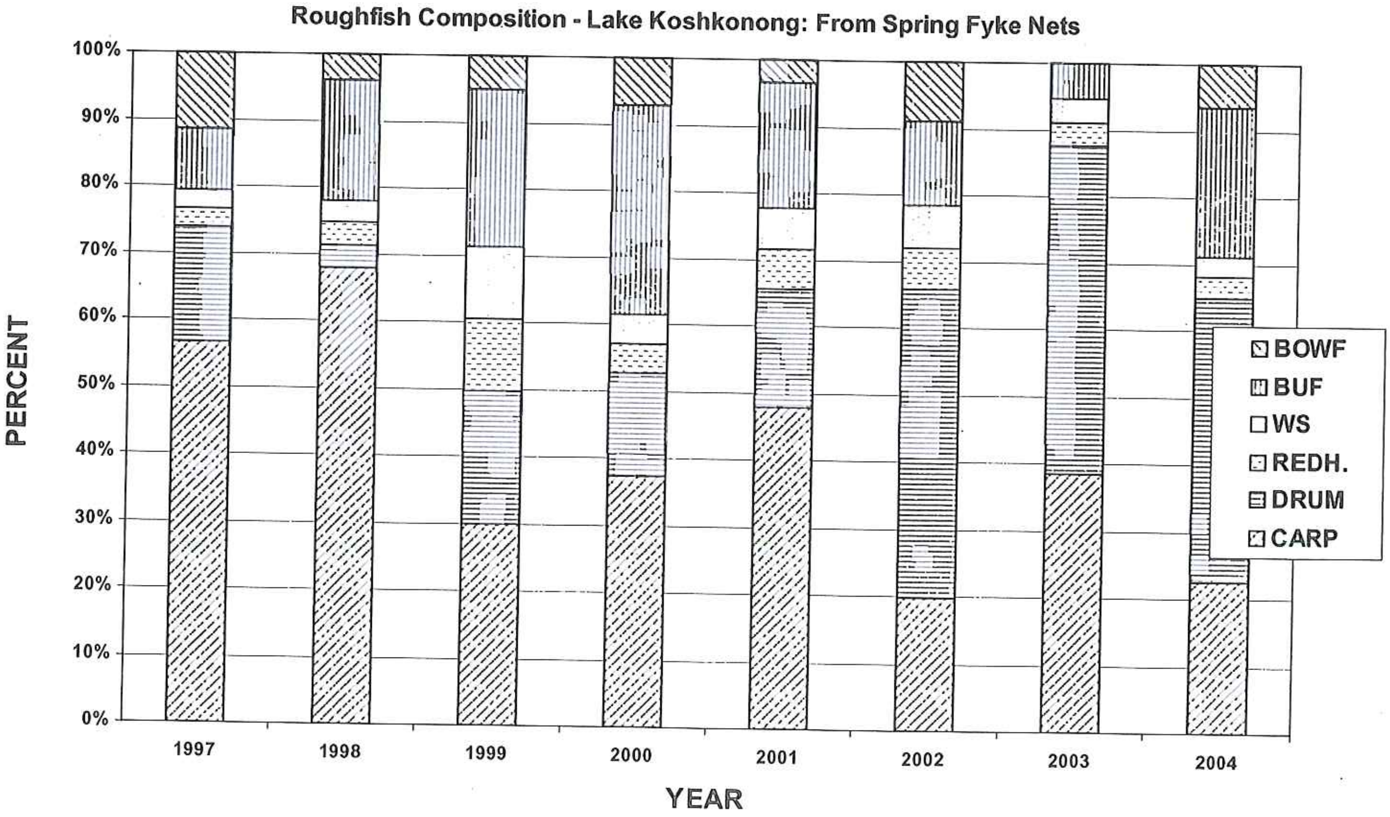
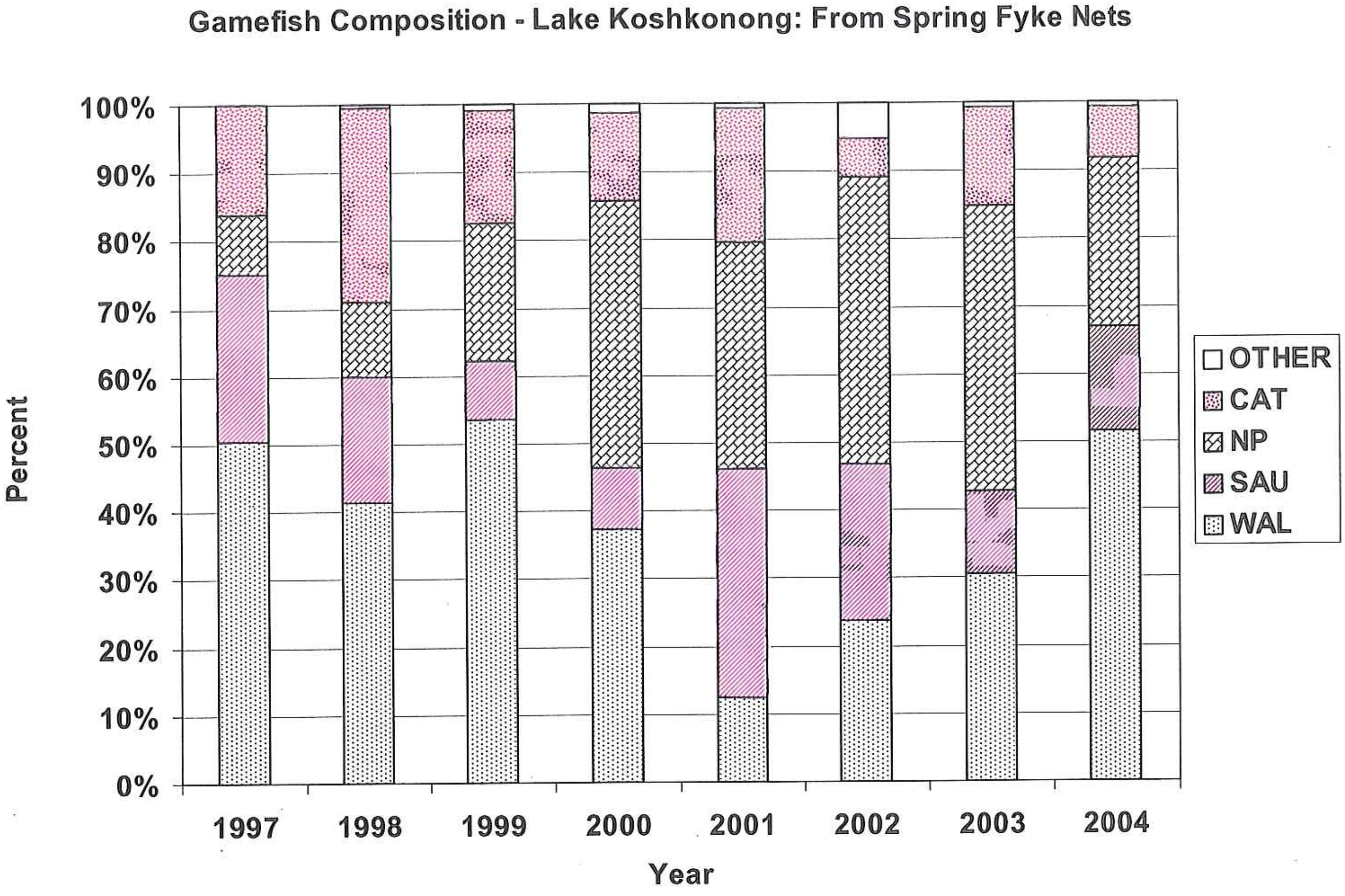


Figure 42. Gamefish Composition. Other-Largemouth & Smallmouth bass, Cat-Channel & Flathead catfish, NP-Northern pike, Sau-Sauger, Wal-Walleye



Fish consumption reports/advisories

As with most of the inland lakes of Wisconsin, the fish of Lake Koshkonong contain harbor contaminants in the form of PCBs (polychlorinated biphenyls) and mercury.

It is advised that children under the age of 15 years, nursing mothers and women of childbearing age should not eat more than 1 meal per week of the following species: white and black crappies, yellow perch, sunfish (bluegill, pumpkinseed, green sunfish etc.), bullheads. It is advised that no more than one meal per month for this group should be ingested of the following fish species: smallmouth and largemouth bass, white bass, rock bass, northern pike, walleye and sauger, channel and flathead catfish, white sucker, sheepshead (freshwater drum), carp or other species.

It is advised that women beyond childbearing years and men may eat unlimited amounts of the following species: white and black crappies, yellow perch, sunfish (bluegill, pumpkinseed, green sunfish etc.), bullheads. It is advised that this group eat no more than one meal per week of the following species: smallmouth and largemouth bass, white bass, rock bass, northern pike, walleye and sauger, channel and flathead catfish, white sucker, sheepshead (freshwater drum), carp or other species.

Amphibians and Reptiles

Of the 54 species of amphibians and reptiles present in Wisconsin, 21 are found in Lake Koshkonong. The more common species are: painted turtle , green frog, northern leopard frog, spring peeper, blue spotted salamander, and various snakes. Forested ephemeral ponds found near the lakeshore are significant habitat for breeding frogs and amphibians

Waterfowl/Birds

Lake Koshkonong proper supports one the state's largest concentrations of Ruddy Ducks during their spring and fall migration and staging periods. During winter of most years, it supports more than 1000 overwintering waterfowl.

See descriptions of following areas in next section:

Koshkonong Creek Floodplain Forest: supports Blue-winged Teal, Hooded Merganser, Wood Thrush and Veery, Black-billed Cuckoo, and Virginia Rail during the breeding season.

North Lake Koshkonong Marshes: Bird surveys found large numbers of Marsh Wren and Yellow-Headed Blackbird, plus Swamp Sparrow, Wood Duck, Great Blue Heron and numerous other marsh birds.

Koshkonong Wetland, Thiebeau Marsh & Fair Meadows Prairie: These areas along the south shore provide migratory or nesting habitat for a large number of waterfowl and other bird species including Blue-Winged Teal, American Black Duck, Bufflehead, Canvasback, Gadwall, Green-Winged Teal, Pie-billed Grebe, Yellow-headed Blackbird, Double-crested Cormorant, cooper's Hawk, Great Blue Heron, Green Heron, Wood Thrush, and many others.

Lake Koshkonong, being a part of the Rock River and resultantly a part the Mississippi River drainage, is an important wetland in the Mississippi Flyway.

Historically, the lake provided a major migration staging location for a wide variety of species and large numbers of waterfowl with the main importance being for Canvasback *(Aythya valisneria)* and Redhead *(Aythya americana)* ducks. Many species of wading birds, double crested cormorant, gulls, pelicans, and other wetland associated species used Koshkonong and its attached marshes for both migration and production.

Important attractions to the migrating flocks of waterfowl were the lush, large beds of both submergent and emergent vegetation. The Koshkonong area provided a large area for the migrating flocks to both rest and feed. Important species of vegetation included smartweeds *(polygonum spp.),* wild celery *(Vallisneria spp.)*, pondweeds *(Potamogeton spp.),* Wild rice *(Zizania aquatica,* and bulrushes *(Schoenoplectus spp.).* These species provided both cover and high energy foods.

Lake Koshkonong and its adjoining marshes also provided valuable cover for local waterfowl production. The main species of waterfowl utilizing these wetlands were Mallard *(Anas platyrhynchos),* Blue winged teal *(Anas discors),* and Wood duck *(Aix sponsa).*

The problems associated with the increased water levels brought about by construction of the Indianford dam and the introduction of carp *(Cyprinus carpio)* both worked to degrade the habitat value of the lake and its adjacent wetlands. Increased water levels decreased areas available to shallow water species of vegetation and increased wave action causing further habitat destruction. Carp activity results in the uprooting and loss of aquatic vegetation.

Presently, Lake Koshkonong and its associated wetlands still provide the same types of opportunities for waterfowl migration and production except to a far lesser degree. This loss in value is due to the long-term degradation of habitat that has occurred and is still in progress.

The WIDNR has acquired and manages Hunting Marsh #4 for habitat protection, waterfowl production, and public recreation (Figure 36). The highest priority management of this wetland is to protect the still existing native wetland vegetation. The higher water levels now present are threatening this marsh through increased wave action on the lake and consequent shoreline erosion into the marsh itself, and the further invasion of carp. These same threats are present to the other privately owned marshes surrounding the lake. The WIDNR has also acquired and planted some adjacent upland sites to native prairie providing valuable nest cover for grassland nesting waterfowl.

Some construction of wave barriers has occurred with varying success. The objective of this management technique is to protect an area of the affected wetland from wave action with the result being improved aquatic vegetative growth. More such management is in the planning stages and awaiting funding.

As discussed in the Fish portion of this report, waterfowl management on Lake Koshkonong must include a strategy for carp reduction and control.

Waterfowl hunting on Lake Koshkonong has a long and famous history. There still exists a number of private hunt clubs surrounding lake which have existed many years and can trace their existence back to time when market hunting was very active on the lake. Most of the Hunting Marshes (Figure 36) are privately owned and are managed for the hunting benefits of their owners.

Threatened, Endangered, and Species of Special Concern

Source: NHI database, DNR staff, and Rock County Natural Area Survey, by Robert Baller, 2002

NOTE: This does not include all old, historical records, nor records for upland species and communities that are more than one mile away from the lake and unlikely to be impacted.

Natural Communities and Rare Species Excluding Fish, by Township:

JEFFERSON COUNTY

Sumner Township (5N13E)

Koshkonong Creek Floodplain Forest: (Secs. 17, 20): Lowland hardwood forest and shrub swamp bordering Koshkonong Creek as it enters Lake Koshkonong. In 1980s, was "undisturbed and rich in wildlife" and supported a Great Blue Heron Rookery near the lake shore. Many old records of rare plants from the area, such as Slenderleaf sundew (Thr.), Pale Green Orchid (Thr.), Swamp pink orchid (Special Concern). Was called "Busseyville Tamarack Swamp" in 1800s.

> Rare Birds: This area supports several pairs of Cerulean Warbler (Threatened) and Acadian Flycatcher (Thr), both species found in larger forest tracts; many Prothonotary Warblers (Spec. Conc.); Yellow-Billed Cuckoo (Spec. Conc.), a Bald Eagle nest (Fed. Thr. And State Special Concern).

North Lake Koshkonong Marshes: (Sec. 10): Rare species include Forster's Tern (End.), Virginia Rail (Spec. Conc.), Least Bittern (Spec. Conc.) and foraging Black Tern (Spec. Conc.)

Koshkonong Marsh: (Secs. 12, 13, 24): A large cattail-reed marsh on the east side of Lake Kosh. And bisected by the Rock River. Pockets of open water with submerged aquatics. Diverse wildlife populations; needs further inspection. Includes Mud Lake (shallow, hard, seepage lake) and Rock River.

> Rare Birds: A nesting pair of Forster's Terns (End.) was observed here in … Three Special Concern birds occur in the emergent marsh and floodplain forest at the east end of the lake: Least Bittern, American Bittern, and large numbers of Black Tern use the area. More than 100 white pelicans were observed here on a single day in August 2004. Bald Eagles were also observed nesting near the lake.

Thiebeau Marsh (Secs. 33, 34) Large wetland complex, mainly cattail-bulrush, along SE shoreline of Lake Koshkonong. Significant portion owned by hunting club, which has planted wild rice. Some areas of wet prairie. Signficant wildlife include Osprey, Sandhill Cranes (probably rails, etc.) and abundant migratory waterfowl.

Koshkonong Township (5N14E)

Koshkonong Marsh (Secs. 7, 18) See description above

ROCK CO.

Milton Township (4N13E)

A very large population of a *Federally listed plant* occurs in wetlands along the south side of Lake Koshkonong It is one of the largest populations of this very rare plant in the state.

Blanding's Turtle (Threatened), Secs. 3, 4 and 13; several have been observed every year since 1992.

Small yellow lady's slipper orchid (Special Concern), Sec. 4, on peat mounds surrounded by lowland hardwood forest

Small white lady's slipper orchid (Thr), Sec. 2

Koshkonong Wetland (Secs. 2, 3) Wet- to wet-mesic prairie, sedge meadow, and wildlife scrapes in area under active restoration.

Fair Meadows Prairie (Sec. 4): Sand prairie with wet and dry elements on active restoration project. Supports State-Threatened kittentails plant.

Thiebeau Marsh (Sec. 4): See description above, extends north into Jeff. Co

The following rare birds and plants have been documented in the three areas described above, Secs. 2, 3 and 4:

Purple milkweed (End.)
Sedge Wren (Spec. Conc.)
Red-shouldered Hawk (Thr.)
Red-headed Woodpecker (Spec. Conc)
Cerulean Warbler (Thr.)
Black Tern (Spec. Conc)
American Bittern (Spec. Conc.)
Least Bittern (Spec. Conc)

An Osprey platform has attracted osprey in 2003and 2004, which constructed a nest but have not yet used it; this species would be expected to begin nesting here any year. This species is listed as Threatened in Wisconsin.

Great Egrets (Thr) have been observed using the marsh during non-nesting periods.

Koshkonong Lake Access (Sec. 6): Very high quality floodplain forest, which includes a small county park, with large swamp white oak and silver maple, mostly native understory. This site rated among the top 9 sites for preservation in the Rock County Natural Area Inventory of 2001.

Newville Carr (Sec. 7): Springy and uncommon wetland type along Lake with very old organic peat deposits (mounds rising at least 10 feet above shoreline) alternating with low, water-filled basins, unusual mosses and lichens, and good native flora in openings among shrub-carr community. There is a high probability of rare plants here.

Otter Creek Springs (Sec. 11) Artesian springs complex, somewhat degraded by invasives, at SW corner of STH 26 and CTH N.

Rare Fish

Slender madtom (*Noturus exilis*) – Found in the Upper Rock River and the Upper Bark River. Endangered.
This fish prefers clear and moderate to swift water (Becker 1983). However remote, there is a chance that an individual might wind up in the vicinity of Lake Koshkonong.

River redhorse (*Moxostoma carinatum*) - Found in the Upper Rock River. Threatened.
Found in fast flowing large rivers over silt-free bottom (Becker 1983). This condition just does not occur in the Lower Rock River basin.

Greater redhorse (*Moxostoma valenciennesi*) - Found in the Upper Bark River. Threatened.
This fish prefers clear and moderate to swift water (Becker 1983). However remote, there is a chance that an individual might wind up in the vicinity of Lake Koshkonong.

Pugnose shiner (*Notropis anogenus*) - Found in the Upper Bark River, Koshkonong Creek and the Crawfish River. Threatened.
Extremely intolerant of turbid water (Becker 1983).

Banded killifish, *(Fundulus diaphanous)* Found in Lake Koshkonong and Rock River. Special Concern.
This species is rare in Lake Koshkonong but several individuals were collected in 2004 with a beach seine.

Pugnose minnow *(Opsopoeodus emiliae)* Sampled from Rock River as enters the lake. Special Concern.
The Lower Rock River may be near the northern most extent of their range (Becker 1983).

Least darter *(Etheostoma microperca)*, Allen Creek. Special Concern.
Once found throughout the state this species numbers have been greatly lowered due to changes in land use (Becker 1983). They prefer clear water at moderate temperatures.

Redfin shiner *(Lythrurus umbratilis)*, Rock River. Threatened
Statewide, this species has been devastated due to toxins employed in rough fish control programs (Becker 1983).

American eel *(Anguilla rostrata)*, Special concern.
This species is in trouble world-wide and the existence of numerous dams and problems with water quality contribute to the decline in numbers.

Historical records exist for redfin shiner (Threatened), American eel (Spec. Concern) in Lake Koshkonong system.

Cultural Environment

Recreational Boating and Navigation

Boating on Lake Koshkonong is described in the publication *"Boating on the Rock River. Results of the 1989-1990 Wisconsin Recreational Boating Survey.* " In the study, the Rock River ranked 13th statewide in boating popularity, following behind the Mississippi River, Lake Winnebago, Wisconsin River, Lake Geneva, Lake Mendota, Wolf River, Pewaukee Lake, Fox River, Lake Monona, Shawano Lake, Green Lake and Lake Wisconsin. Residents of Rock and Jefferson Counties accounted for 75 percent of the boating use. The survey period of the study included the seven traditional months of April through October, but it should be noted that a significant amount of boating occurs in February, March in mild winters from walleye fishermen, and November from anglers and duck hunters. Like all Wisconsin waters, there has been a trend for horsepower of boats to increase, boat size to increase and for more time to be spent on personal watercraft since the 1889-90 study. Ninety-eight percent of the boats were motorized, and the average rating was 58 horsepower

The boating effort was estimated at 49,480 boating days during the seven-month period Wisconsin Recreational Boating Survey from . Effort was fairly well balanced through the seven months. May was the busiest month with 19 percent, and October was the slowest with 11 percent. The most popular activity that boaters engaged in was fishing which accounted for about half of the boating. The rest was divided into cruising, sailing, water skiing, swimming, and "other."

Sixty-two percent of the respondents said the waters were "not at all crowded," while 18 percent said it was slightly crowded, 19 percent said it was moderately crowded. Only one percent said it was extremely crowded. Only four percent of the boaters reported an experience that was poor to fair. Ninety-six percent described their experience as good to perfect.

Lake Koshkonong's large expanse of open water and the shallowness make the lake prone to rough conditions. Changing winds and sudden storms have lead to disasters for unprepared boaters. The stability and the large deck area make the pontoon boat the boat of choice for most shoreline residents. Flat bottom "john boats" are popular as they can launch at the shallow landings and travel into the shallow bays. Most fishing boats are open hull; outboard propelled boats between 16 and 18 feet in length. The size and number of "cruising" type boats has increased in recent years despite their requirements for deeper launches and deeper draft.

Boat launching access is available at three private marinas, several taverns, and a few unimproved township road ends. Public access with some improvements include: Newville Public Access Site; Royce Dallman County Park; Vinne Ha Ha Public Access Site; Groeler Road Public Access Site; Kuehn Road Access; Amacher's Landing (Bingham Road;) and two access sites in Fort Atkinson. In addition, there are numerous private launches that provide access for neighborhoods and individuals.

The marinas and a few of the private tavern sites on the Rock River are capable of launching large boats (23 feet or larger.) Private launches on the lake as well as the public access sites cannot provide launching for boats requiring over 2 feet of water. Yet many boaters have purchased roller trailers that can launch in very shallow water.

Many of the complaints on navigation stem from the fact that boats need to be moored long distances from the shore. In many cases this means from 100 to 200 feet offshore. Unless boaters build extremely long piers, they must wade out to get to their boats. Holding the water higher would provide some relief, but in some cases boats would have to be moored offshore even if the lake was higher.

Public access sites on Lake Koshkonong are several years behind the sites on neighboring lakes such as the Madison Lakes. There is a definite need for a well-developed site with a dredged harbor, breakwater and modern facilities.

The 1989-1990 boating survey did not address the months of November through March. The winter drawdown begins on November 1st. As water levels fall during the waterfowl season, navigation in marshes for duck hunting becomes extremely difficult. In the case of Mud Lake, the marsh goes completely dry.

A study was conducted by RKLD in March of 2004 to estimate the additional acreage of water that would be added by modifying the operating orders of the dam. Shorelines were examined in residential areas of the lake. Water depths were measured and the areas were mapped using g.p.s. It was determined that an additional 50 acres of water would become navigable for most boats by raising the water level 0.5 feet.

> The following summarize a WDNR recreational boating survey performed from May 1989 to April 1990 titled, Boating on the Rock River.

- Boating on the Rock River was fairly evenly spread out from April through October.
- Boats on the Rock River were largely either open-hulled or pontoon, most with outboard. The percentage of boats with open hulls was 81%.
- The average horsepower of the boats on the river was 58hp.
- The average length of boat on the river was 16.2 feet.
- Inquiries of local marine dealers in the area indicates that the average draft of open-hulled boats with outboard motors is 23 inches and with inboard motors is 28 inches.

RKLD prepared and distributed a survey questionnaire to determine the consensus of opinion about many of the lake-related issues. The survey responses were summarized in a Lake Planning Grant Report submitted to the Department in 2001. The survey yielded the following:

- Spring and summer are the seasons that respondents spent the most time on the lake. The most popular watercraft usage was boat with >25 hp motor.
- The overall rating of quality of fishing was poor. Water quality was described the as murky or pea soup by 68% of the respondents and 59% reported that summer was when water quality was worst.
- Aquatic plant growth was described as too little by 49%.
- In response to negative impacts regarding the use of the lake, poor water quality, algae, low water ranked as "very much." High water was ranked as "very little", and weeds as none.
- The top three factors contributing to the problems on the lake were lake level changes, boat/Personal Water Craft (PWC) traffic and fertilizers/pesticides.
- The most negative aspect of the lake was worsening water quality.
- The most positive aspect was RKLD being active and concerned.
- With respect to water levels, 55% responded that there was too much variation and 43% responded that water levels were too low.
- The survey response to lake management priorities was water levels followed by water quality.

Mail surveys have been a preferred off-site survey method for many resource management agencies because they are relatively simple and cost-effective. Mail surveys can be affordably conducted. The utility of the survey results is in question, due to improper sample selection and nonresponse bias.The RKLD mail survey targeted solely RKLD members and achieved an 8% response rate. demonstrates a failed survey instrument. The survey as conducted, cannot measure preferences of Lake Koshkonong recreationalists and interested general public by sampling targeted at RKLD members. Moreover, due to the large potential non-response bias, the survey cannot measure preferences and issues of the RKLD membership. With 92% non-responding the likelihood of large nonresponse bias is great. Nonresponse to mail surveys is not a problem in itself; the problem is that nonresponse induces a nonresponse bias in the estimates. This happens because nonrespondents usually differ in important characteristics from respondents. Nonresponse bias in mail surveys can be a major problem because nonresponse can be substantial. Even when a survey and its instrument have been well designed and three mailings have been made (Dillman Method 1978); the response rate may only reach 50-75%. Response rates >60% for statewide surveys are commonly deemed reasonable. Note: The Statewide Boating Mail Survey (Boating on the Rock River) included in the appendix of the EIR achieved a 74% response rate. Surveys achieving <50% response rate are typified as low (Pollock et. al 1994.) There are primarily two ways of dealing with the problem of nonresponse bias; reducing nonresponse by good survey design (multiple mailings, use of rewards) and estimating the remaining bias with a follow-up telephone survey. The two approaches are not mutually exclusive and both can be used in the same survey. The RKLD survey used neither approach, hence the extremely low response rate.

Based on the survey results, in part, RKLD at their 2002 annual meeting overwhelming passed a proposal to request a change in the Operating Order. Nonetheless, shortly thereafter (2003), the Lake Koshkonong Wetland Association (LKWA) was formed in response to the threat of RKLD's proposal. The formation of the LKWA was primarily prompted by this proposed increase in water levels due to local concern about the potential adverse impacts to the more than 4000 acres of wetlands adjacent to the lake. LKWA describes their mission as an effort to protect the existing wetlands on Lake Koshkonong and the Rock River and to promote the health of natural plants, fish, birds, and other forms of wildlife in the basin.

Environmental Consequences

Physical

Erosion

Due to the combined effects of ever-increasing water levels and the loss of aquatic plants, erosion of the wetlands and some adjacent uplands has been a problem for at least the last 50 years. RKLD and other citizens have recognized this problem and have attempted to deal with this by "armoring" part of the shoreline. The majority of these projects have included riprap armor (Figures 43 and 44) of wetland shoreland areas that have been eroded and lost over time.

Figure 43. 6/13/03; USGS Gage - 776.31 msl; top of riprap protection at Carcajou Shallow Marsh at outside corner of riprap lakeward from opening behind Carcajou Shallow Marsh. Elevation near top of rock is 777.48 msl.

Figure 44. Carcajou Shallow Marsh Date: 5/13/2003 Water Elevation: 777.30 msl.

During 2002 and 2003, the RKLD worked cooperatively with wetland owners to protect approximately 38% or 4.7 miles of the 12.5 miles of wetland shoreline. In 2001 Act 16, the Legislature granted authorization to the District for a Lake Koshkonong Comprehensive Project (Table 2). Act 16 recognized the placement of breakwater structures was another suitable management approach to prevent wetland losses resulting from wind and seasonal flood conditions.

RKLD is also currently involved with the U.S. Army Corps of Engineers (ACOE) in an Ecosystem Restoration Program (under Section 206 of the Water Resources Act) to further restore and protect wetlands and near-shore shallow water areas. The ACOE has identified several places in Lake Koshkonong where off shore breakwaters could provide protected habitat for plants and aquatic life. This project has a focus of not only arresting waves but also excluding carp from shallow near shore areas. On the Lake Winnebago pool this concept has been effective in reestablishment of submergent vegetation, but not emergent vegetation. The status of this program is tenuous at this point. In Federal FY 04 a $112,000 congressional addition was placed within the Water Resources Development Act specifically allotting money to the ACOE to work on the Lake Koshkonong 206 project for planning and design of the Lake Koshkonong breakwater project. There is currently $160,000 of congressional additions within the House vision of the Water Resources Development Act for FY 05, which if enacted would allow for continued funding of the Lake Koshkonong 206 project at the Feasibility level. ACOE officials have estimated that the report is approximately 40% to 50 % complete. However, the project manager has expressed great concern about moving forward with a project design until they are certain of the water level regime that will be established and further that the new water level regime will yield the same environmental benefits from off shore breakwaters. Accordingly, the ACOE project management team has decided to suspend all work on this project until the District's petition to raise water level is resolved.

RKLD concludes in the EIR that one of the negative impacts of raising the summer water level to a target of 776.8 would be:

> "Reduced diversity of emergent macrophyte community, potentially an increase in wave erosion on unprotected wetland shorelines, potentially more access to shallow marshes by roughfish, higher water levels may cause shallow marshes to proceed to lake phase resulting in reduced emergent macrophytes and aquatic insect populations."

They propose to counteract wetland losses by installing additional rock rip rap similar to what has been placed in front of the Carajou marsh (Figures 43 and 44). While this rock may be effective in the short term, based upon similar low elevation installations in the Upper Winnebago pool lakes (UWPL) riprap alone is unlikely to prevent long term erosion of these wetlands. In the UWPL rock and even old cars were placed in front of a cattail marsh over a number of years to prevent erosion. In all cases, erosion continued (R. Kahl, WI Dept of Natural Resources, personal communication). The rock material that has been placed in Lake Koshkonong is smaller than that used in UWPL and would be expected to be less effective over time. Figure 44 shows that this material will largely be flooded at water levels only slightly higher than the maximum proposed target level of 777.0 msl. With the higher level, even minor flood events will overtop these structures and may result in the deterioration of this armoring. While high water levels and waves during storm events are partially responsible for the failure of these structures, even more detrimental to the riprap structures in UWPL was ice jacking. If winter drawdown is eliminated as proposed, the rock riprap would degrade more quickly. The destructive capability of ice shoves is evident during the current water levels with past problems with some boat landings on Lake Koshkonong.

In order for the armoring to have any chance of long term success it must be much larger than shown in Figure 43. In the UWPL (Terrell Island) much larger material was used. The large rocks used extend roughly 4 feet above the water and this type of structure seems to be effective and long lasting in the UWPL but is very expensive to build. In Lake Koshkonong it is important that large rocks to be used and they must extend above the OHWM. If these large rocks are not used, the armoring will be short-lived as the rock dikes will quickly deteriorate during flood events and as a consequence of ice jacking.

If the winter drawdown is eliminated, there will be an increase in erosion as the result of ice jacking. The larger surface area of ice will increase the potential damage from ice. In addition, the higher water levels will enable ice jacking to more readily damage shoreland structures such as armoring, boat ramps and piers. Ice-jacking and the formation of ice ridges is most dramatic during winters with extreme temperature fluctuations and little snow cover. A dense layer of snow on top of the ice not only reduces the freezing rate, but also forms an insulation blanket that reduces temperature changes in the ice, and subsequent frequency of ice-jacking events. In conclusion, it appears that the effects of the "jacking" action of ice are most severe during those periods when there is little or no snow-cover, and temperatures fluctuate greatly. One intent of winter drawdown is to purposely move the zone of ice-jacking offshore; in the interest of minimizing shoreline alterations and the formation of ices ridges at the bank.

Figure 45

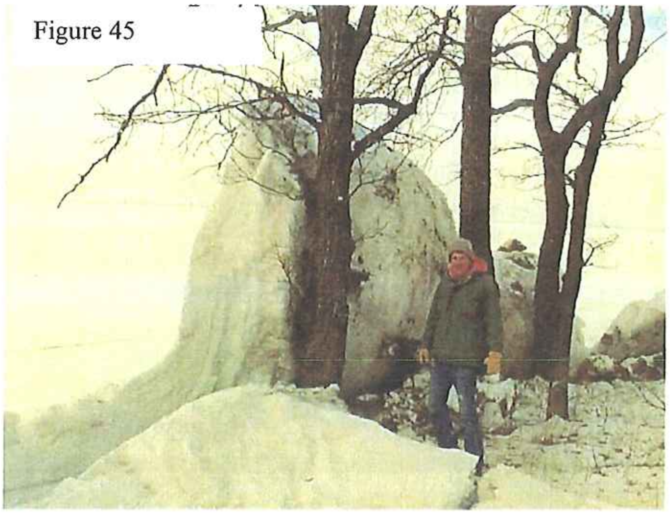


Figure 46

Floods

A change in normal operating pools will not have an effect on flood levels. There have been two studies to address this issue. ***Evaluation of Alternative Reservoir Management Practices In The Rock River Basin, Wisconsin*** *by* USGS and ***Hydraulic Analysis of Indianford Dam and Lake Koshkonong*** *by* Montgomery Association Resource Solutions, LLC. Both studies came to similar conclusions, that normal pool elevations or changes in normal pool level had little to no affect on flood level elevations.

Affects on the OHWM

Due to the limitations and lack of data, the Montgomery analysis is not a sufficient prediction tool to assure that the OHWM will not change do to the increase in water levels. There is no known relationship between recurrence interval (the presence and action of water) and the OHWM. While we do not know how often water has to be present to influence the OHWM we do know the presence of water on the shoreline is a function of three elements: 1) still water level, 2) wave action generated from wind or boats, and 3) shoreline configuration. In taking into account wind set-up and wave run-up under conservative conditions (20 and 24 mph winds) it appears that the presence and action of water will be changed to the point that the OHWM could be affected by the proposal.

Water Level Affects Beyond Lake Koshkonong

The full extent of the area that will be affected by the RKLD's proposal to raise the water levels held by the Indianford Dam is not fully known. The extent of the impact was requested of RKLD but was not provided. Evidence shows that the effects go well beyond Lake Koshkonong. Raising water levels in a waterway can affect the water levels on tributaries to that waterway as well as groundwater, wetlands and other low-lying areas. The OHWM study and portions of the Montgomery report only address Lake Koshkonong and do not speak to OHWMs in the upstream and downstream river channels affected by the dam.

The Jefferson County Flood Insurance Study (FIS) and the City of Jefferson FIS are dated 1984. These FISs contain floodplain studies for the Rock River, the Crawfish River and the Bark River. The five floodplain study panels showing the channel elevations are in Attachment 8. The floodplain studies contain channel bed survey information taken on these waterways. The Rock River channel profile is on Panels 01P and 02P of the county FIS and panel 01P of the City FIS. The elevation profiles show that raising water levels at the Indianford Dam affect water levels as far upstream as the Jefferson Dam in the City of Jefferson.

The Bark River study's survey (shown on Panel 13P) extends from the mouth of the Bark River at the Rock River to County Highway D, a total of 12.3 miles. RKLD's proposed increase will affect the entire 12.3 miles within the study but the full extent of the water level effect can't be determined since the survey ends before the increased water level effect ends.

The Crawfish River study's survey (shown on Panel 14P) starts at the mouth of the Crawfish River at the Rock River extending upstream. The survey shows that RKLD's proposed increase would affect 5 miles upstream of the mouth including a small tributary to the Crawfish River at 4.1 miles upstream of the mouth.

Other tributaries to the Lake Koshkonong and the Rock River will be affected but the full extent is not known. Again, raising water levels in a waterway can affect the water levels on tributaries to that waterway as well as groundwater, wetlands and other low-lying areas. These tributaries can be found on the US Geological Survey quadrangle maps and include:

Rock County

- Saunders Creek which outlets 1.7 miles upstream of the Indianford Dam in section 15, T4N, R12E
- an unnamed tributary which outlets 3.3 miles upstream of the dam in section 14, T4N, R12E

Dane County

- A small tributary enters Lake Koshkonong in section 36, T5N, R12E.

Jefferson County

Several tributaries enter Lake Koshkonong in T5N, R13E, Jefferson County. They include:

- an unnamed tributary in section 10
- an unnamed tributary in section 15
- Koshkonong Creek in section 20
- an unnamed tributary in section 24
- an unnamed tributary in section 33
- Otter Creek
- 2 unnamed tributaries in section 34

Rock River Upstream of the Lake

- an unnamed tributary in section 5, T5N, R14E
- an unnamed tributary in section 8, T5N, R14E
- Allen Creek in section 17, T5N, R14E
- Deer Creek in section 35, T6N, R14E
- three unnamed tributaries in section 23, T6N, R14 E
- an unnamed tributary in section 14, T6N, R14E
- an unnamed tributary in section 11, T6N, R14E

Crawfish River

- two unnamed tributaries in section 4, T6N, R14E
- an unnamed tributary in section 33, T7N, R14 E

Bark River

- an unnamed tributary in section 12, T5N, R14E
- an unnamed tributary in section 7, T5N, R15E
- Whitewater Creek in section 7, T5N, R15E
- two unnamed tributaries in section 9, T5N, R15E
- an unnamed tributary in section 10, T5N, R15E

Drainage Board

A common agricultural practice to drain wetlands and other large tracts of land that were too wet to cultivate was to dig ditches or deepen and widen adjacent streams to improve the surface and subsurface drainage. The ditching would dry out the associated fields and allow the fields to be put into crop production. To assure that a downstream ditch wouldn't adversely affect the drainage of an upstream area, and to share the cost of the planning, design, ditch construction and maintenance, drainage districts were formed. Drainage Districts' authority is under ch. 88, Wis. Stats., and numerous earlier state laws.

The Jefferson County Farm Drainage Board is granted powers under ch. 88.90 and 88.91, Wis. Stats., to contest actions that would adversely affect water flow in the drainage districts in Jefferson County. The Board has provided survey evidence that raising the water level of Lake Koshkonong will adversely affect Drain 39. Raising water levels in an agricultural drainage ditch will lessen the drainage of the associated cultivated land and can reduce crop production. In a letter dated May 5, 2004, the attorney for the Jefferson Board registered objection to increasing Lake Koshkonong water levels.

Drain 39 outlets into the Bark River, tributary to the Rock River, in the NW1/4 of Section 9, T5 N, R15 E. Survey provided by the Board shows that the downstream 1850 feet of the main ditch and outlet of lateral 4 will be affected by the RKLD's proposed water levels and dam operation.

Low flow

RKLD's petition does not propose a change in low flows release from the dam. The current low flow release requirement of 64 cubic feet per second (CFS) is similar to the drought level flow conditions within the Rock River. The requirement to release a minimum low flow is intended to protect downstream aquatic life. A change in water levels is not expected to have any significant effect on the occurrence of low flow conditions. While it has been the routine practice of the Department and the state to require a minimum release, it would be far more protective for downstream resource to tie the dam release to the amount of flow that is in the system, commonly referred to as run of river (ROR) flow. The Department has requested ROR restrictions on power dams regulated by the Federal Energy Regulator Commission routinely. Revising the order to require ROR releases from the dam would be more protective of downstream resources but would come at the expense of more lake fluctuations.

Groundwater

The Indianford Dam and Lake Koshkonong water levels impact the groundwater levels in the SE corner of Dane County, the SW corner of Jefferson County and north central Rock County. Lake Koshkonong is an area of groundwater discharge, meaning that the precipitation that infiltrates into the soil in the area move through the soil towards the lake. Groundwater can be exposed at the land's surface in the form of wetlands, springs, ponds and stream flow. Historical accounts of Lake Koshkonong often refer to the area as replete with springs. Lake Koshkonong's lake level and associated groundwater level affect these water features and the soil moisture which can ultimately affect vegetation and land use. The effects are not only adjacent to the lake but can be a considerable distance away from the lake. The lateral effect to groundwater depends on a number of factors including topography, groundwater recharge, other water features such as streams, and soil characteristics.

The soils in nearshore area the impoundment that includes the lake are saturated to the same level as the Lake Koshkonong water level. Additionally, there are extensive wetlands, numerous ponds, springs and drained agricultural land in the general area of the lake that extends long distances from lakeshore.

The RKLD proposes to increase the normal lake elevation from a normal of 776.2 msl and a maximum of 776.33 msl at which all gates must be opened on the dam, to a normal of 776.8 and a maximum of 777.0 msl. Raising the water levels by 0.6 feet (7.2 inches) will result in the nearshore groundwater raising 7.2 inches. The nearshore saturation zone will extend landward but the distance is not known. It can be reasonably expected that the long term effects will be to expand areas of soil saturation around the lake, raise water levels in some ponds and soil moisture in some areas. It is possible that some marginal septic fields could be negatively affected in the near shore area. The extent of exact horizontal and vertical increase has not been determined.

Biological

Riparian emergent and forested wetlands

Lake Koshkonong possesses riverine/lake fringe wetlands associated with the Rock River and its tributaries. Wetland plant communities present include southern lowland forest (floodplain forest), emergent marsh, wet meadow and aquatic bed types. Stresses on wetlands include impacts from raised water level, decreased water quality, human uses and disturbance from carp and non-native plant introductions. High water levels were noted by the lack of herbaceous layers in much of the lakeside wetlands, the presence of adventitious roots, shallow roots, (Figures 47 and 48) dead and dying trees and the absence of groundwater-dependent plants and plant communities. High water levels have increased erosion and loss of wetlands. Water quality conditions are poor as a result of

Figure 47 Location: Carcajou Floodplain Forest Date: 5/28/02 WL: 776.81 msl. Evidence of erosional sediment loss in root systems along shore.

Figure 48. Carajou floodplain forest Jan 02

nutrient and sediment-laden surface water coming into the wetlands from upstream agricultural and urban areas. Wetland filling has occurred along the shoreline and urban uses within the watershed contribute additional pollutants. Recreational boating activity stirs up sediments in the shallow basin, likely increasing turbidity levels.

Lake Koshkonong has experienced significant riparian wetland loss since the lake was dammed. Originally the lake was described as a deep-water marsh with most of the surface covered with emergent vegetation, e.g. wild rice, cattails, reeds, bulrushes (Kumlien, 1877; Main, 1945). Much of the current lake area became an open water environment after the water level was increased with the construction of the original dam soon after 1851, which raised the lake level, by 6 feet. Although it is very likely the area of riparian emergent wetlands declined during the period from dam construction until the first available aerial photographs in 1937, there were considerable acreage of these wetlands. The next available aerial photographs in 1966 indicated that a large amount of these wetlands had been destroyed. It is highly likely this was the consequence of increasing lake levels that occurred during the time period as documented in the Affected Environment Section. Mean summer water levels increased on average 0.5 feet from 1937-1966. Perhaps more important than the increase in the average water level was abnormally high water levels as a result of floods. Such an event occurred during the spring of 1959. Interestingly, a similar event occurred in 1929, yet there were large areas of wetlands remaining after this event. It is likely that the lower water levels in the 1930s allowed the wetlands to recover. While it is possible that the 1959 flood resulted in the loss of wetlands, it is also possible the loss was the result of abnormally high water levels during the period 1956-59. Mean summer water levels during this period were about 776.2 msl, which is the current summer target value.

The EIR indicated that there was a loss of 57 acres of shallow water wetlands between 1950 and 1969. There was a further loss of 76 acres between the 1969 and 2000. During the first time period, the mean summer water level increased 0.4 feet and there was a further increase in water level of 0.5 ft during the second time period.

Additional aerial photographs from 1979, 1986, and 1992 document the continued loss of the riparian wetlands. Since 1966, the lake levels have continued to increase and there has continued to be a loss of riparian emergent wetlands. The history of wetland loss in conjunction with rising water levels indicates that if the summer target water level is raised to the requested level of 776.80 msl there will be a further loss of riparian emergent wetlands.

Numerous other studies support the loss of wetlands as the result of high water levels. Large shallow lakes in Wisconsin, such as Puckaway, Upper Winnebago pool lakes (Butte des Morts, Winneconne, Poygan) have historically lost significant amounts of emergent vegetation as the result of elevated water levels, usually as a consequence of dam construction (Kahl, 1991). A small lake in northwestern Wisconsin, Rice Lake, was converted from a clear water, wild rice dominated system to a turbid algal dominated system as a result of high water (Engel and Nichols, 1994).

In lakes, wetland plants have been reestablished as a result of lowering water levels, usually as a consequence of drought. One example, Delta Marsh on the shore of Lake Manitoba, experienced a large increase in the growth of *Scirpus* as a result of lower water levels in response to a drought (Goldsborough and Wrubleski, 2004). In Lake Saint-Pierre near the St. Lawrence River, low water levels result in a large marshland, while during high water levels the lake shifts to an open-water body (Hudon, 1997). In a study conducted in Pool 8 of the Upper Mississippi River, manually lowering the water level by 18 inches resulted in a large increase in emergent vegetation. As a result of the increased vegetation, there was a large increase in the presence of shorebirds and the usage of this area by migratory waterfowl (Benjamin and Kenow, 2004).

Increased water levels will result in continued loss of emergent and forested wetlands along the shoreline due to erosion and increase areas of open water. Groundwater dominated wetlands such as sedge meadows will be converted to marshes. Based on observations of permanently flooded black willow (tolerant to flooding) on Horicon Marsh Wildlife Area by DNR staff, all trees in areas flooded (to the surface of the soil or above) by the permanent increase in water level will die. Most trees in the areas that will now have continuously saturated soil will be overthrown by the wind or die as a result of the combined stresses of growing in permanently saturated soil. Because areas which are currently not forested that remain dry enough to support floodplain forest are currently in other uses, the losses from the increased water level will not be offset by floodplain forest restoration.

A water level increase will adversely affect the functional values of wetlands associated with Lake Koshkonong. The wetland complex has already been affected by high sustained water levels since the dam was installed.

Increasing the level and duration of water will add to those impacts. Because of higher precipitation during the spring and summer of 2004, water levels were higher in the wetlands and the Department was able to observe how the proposed increased water levels may affect these wetlands. In terms of floral diversity, there was a loss of much of the herbaceous vegetation in forested wetlands. Established plant survey points showed a significant reduction in diversity due to species loss from high water levels. It is well documented in the literature that marshes have cyclical drought and flood cycles and are often manipulated to simulate the drought cycles. This management regime has historically been used to increase wetland emergent growth and provide enhanced habitat for waterfowl and other species of wildlife. Sustained high water levels reduce the ability of the marsh species to regenerate and revegetate. This is evident in the recent past and the continuing loss of emergent and forested wetlands.

Another adverse impact to floral diversity resulting from increased water levels is the drowning of groundwater dominated wetland communities. Groundwater dominated wetlands are generally more diverse floristically. Increased surface water, especially if carrying nutrients and sediments, can adversely impact these wetlands. Wetlands such as sedge meadows, low prairies and lowland hardwood swamps are highly susceptible to surface water inundation. Marshes are considered moderately susceptible and floodplain forests are slightly susceptible. Even for wetlands in the "slightly susceptible" category, regular inundation for longer than an additional two days may result in significant adverse impacts to the wetland.

Water Quality

If the lake level is raised to the summer proposed target of 776.8 MSL there will be no change in water clarity or turbidity. There will also be no change in dissolved oxygen (DO) or temperature during the summer. If winter drawdown is eliminated as proposed, there may be a nominal increase in DO during winters with heavy snowcover since there will be more water volume above the sediment. There will not be a change in winter temperatures.

It was estimated in the EIR that increasing the summer water levels would improve water clarity. A graph showing Secchi depths at various water levels was used to support this argument (Figure 49). In fact, when summer (June-mid September) Secchi depth is regressed against water levels within the range of the proposed target (maximum of 777.0), there is no significant relationship (Figure 50). This is not surprising since a model run using WILMS (Panuksa and Kreider, 2002) was performed (Attachment 9), which indicated there would not be a significant reduction in total phosphorus with the increased water level. The model run used the period from October through September 1999 as the baseline data since the U.S. Geological Survey had collected relevant data during this time. The surface area and volume used in the analysis were calculated at a point located half way between the proposed target level of 776.8 MSL and the maximum level of 777.0 MSL. The modeling effort indicated that the greater water volume that would result from higher water levels would only increase the water residence time by 1.9 days. This increased residence time would reduce the total phosphorus concentration from 312 µg L^{-1} to 310 µg L^{-1} which would have no effect upon water clarity or the frequency of algal blooms.

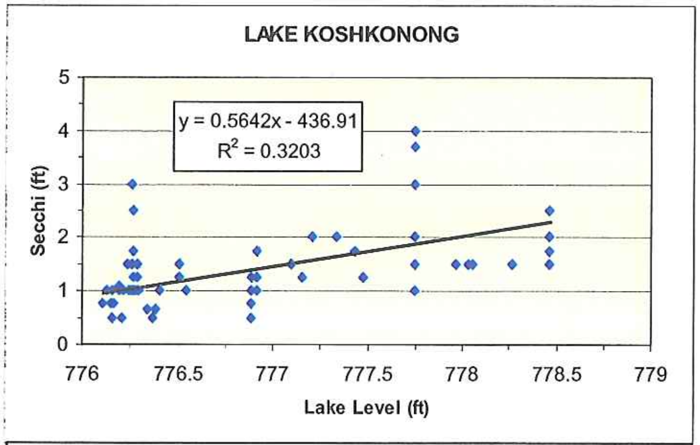


Figure 49 Regression of water level vs summer Secchi depth for years 2001-2003.

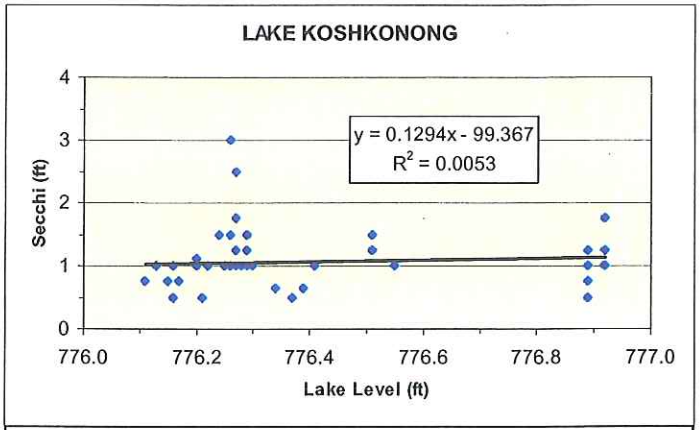


Figure 50 Regression of water levels vs summer Secchi depth for years 2001-2003 at levels below the proposed summer maximum (777.0 msl).

The suggested improvement in water clarity with higher water levels presented in the EIR is the result of flooding events when the water levels exceeded the proposed maximum target level (777.0 msl). A plethora of studies conducted worldwide clearly show that algal levels are strongly correlated with phosphorus loading /concentration (Sakamoto 1966, Dillon and Rigler 1974, Jones and Bachman 1976, Vollenweider 1976. Shindler 1978, Oglesby and Schaffner 1978, Rast and Lee 1978, Canfield and Bachman 1981). The regression between phosphorus loading and average annual chlorophyll (algal) concentrations is approximated by (Wetzel 2001):

$$[\text{chl. a}] = 0.55\{[P]_i/(1+\sqrt{t_w})\}^{0.76}$$

where:

chl a = mean summer chlorophyll concentration
P = total phosphorus loading
t_w = average residence time of water

The improvement in water clarity during the higher water levels is the result of additional runoff from precipitation and does not accurately reflect typical water clarity with higher water levels. During these events the higher water volume from overland runoff diluted the density of the algal community and did not reflect conditions that would occur under normal operating conditions with the proposed order.

Numerous studies in North America and Europe have shown that to improve water clarity it is necessary to REDUCE water levels, not increase them (Wallsten and Forsgren 1989, Bengtsson and Hellström 1992, Beklioglu 2002a, Beklioglu and Tan 2002b, Coops and Hosper 2002, Steinman et al. 2002). These studies have shown that reducing water levels increases the amount of light that reaches the upper plant canopy, which facilitates their growth. Timms and Moss (1984) report that the establishment of plants improved water clarity. This is further supported by regional studies in the Netherlands (Scheffer 1998), Danish lakes (Jeppesen et al. (1990) and Florida lakes (Canfield et al. (1984). From these studies it is clear that increasing the water levels will not increase water clarity. Instead, reducing the water levels may enhance growth of submerged aquatic plants which could improve water clarity.

Oxygen Depletion Rates-Winter

A general assumption is that lower water levels cause an oxygen deficit leading to a greater possibility for winterkill. In order to evaluate the potential for winterkill, the following analysis was made.

Mathias and Barica (1980) found that the winter oxygen depletion rate of Canadian lakes was predictable according to two parameters. Namely, the ratio of surface area of sediments to lake volume, and secondly whether the lake was eutrophic or oligotrophic. Water depth in itself was not significant as the water of both oligotrophic and eutrophic lakes had an oxygen consumption rate of 0.01 $(g)(m^{-3})(d^{-1})$. Thus it would take 100 days to reduce the water by 1 ppm if dependent upon the water volume alone.

Sediments were found to be responsible for most of the oxygen consumption, and fell into two rates depending upon primary productivity. Oligotrophic lakes had a mean oxygen depletion rate of 0.075 $(g)(m^{-2})(d^{-1})$, and the value for eutrophic lakes was about three times higher at 0.23 $(g)(m^{-2})(d^{-1})$. Therefore, a formula incorporating the ratio of sediment area to lake volume and trophic status will predict the winter oxygen depletion rate of the lake. This is described as follows:

$$A/V\,(D) = R$$

Where A = Area of sediment m2
V = Water Volume m3
D = $0.23(g)(m^{-2})(d^{-1})$ for eutrophic lakes or
$0.75\,(g)(m^{-2})(d^{-1})$ for oligotrophic lakes
R = the oxygen depletion rate in $(g)(m^{-3})(d^{-1})$
Or the loss of Oxygen in ppm/day

In order to estimate the amount of time that oxygen would be available to prevent winterkill, it was assumed those oxygen levels would be at least 12.0 ppm at the time that oxygen production ceased. It was also assumed that winterkill would not begin until oxygen levels had fallen to 2.0 ppm. Therefore, the formula was used to predict the number of days necessary to consume 10 ppm of oxygen, or simply 10/R.

In computing the probability of winterkill at various winter water levels, area and volume ratios were computed for various levels from 776.2msl, to 772.6msl which represents an 18-inch drawdown with 18 inches of ice (Table 11).

Since flushing rates increase at the volume of the lake decreases, the flushing rates at various levels were also computed.

Table 11. Model of winter oxygen depletion rates based on various water levels for Lake Koshkonong.

MSL	776.2	774.7	773.2
Flushing time @ 1223 cfs	23 days	21.4 days	15.7 days
Area (acres0/Volume (acre feet)	10460/55793	10042/52000	9522/3800
A (m^2)/V(m^3)	42,363,000/68,775,784	40,670,100/64,100,400	38,454,100/46,842,600
Area (m^2)/Volume(m^3)	.6160	.6344	.8201
Sed. Depl. Constantg/m$_2$d	0.23	0.23	0.23
O_2 Depletion Rate(R) AD/V = g/m^{3}d or ppm/d	.1417	.1459	.1886
Time to consume 10 ppm (days to fish kill)	70.57	68.54	53.02
Number of times lake flushes within Oxygen supply	3.07	3.20	303

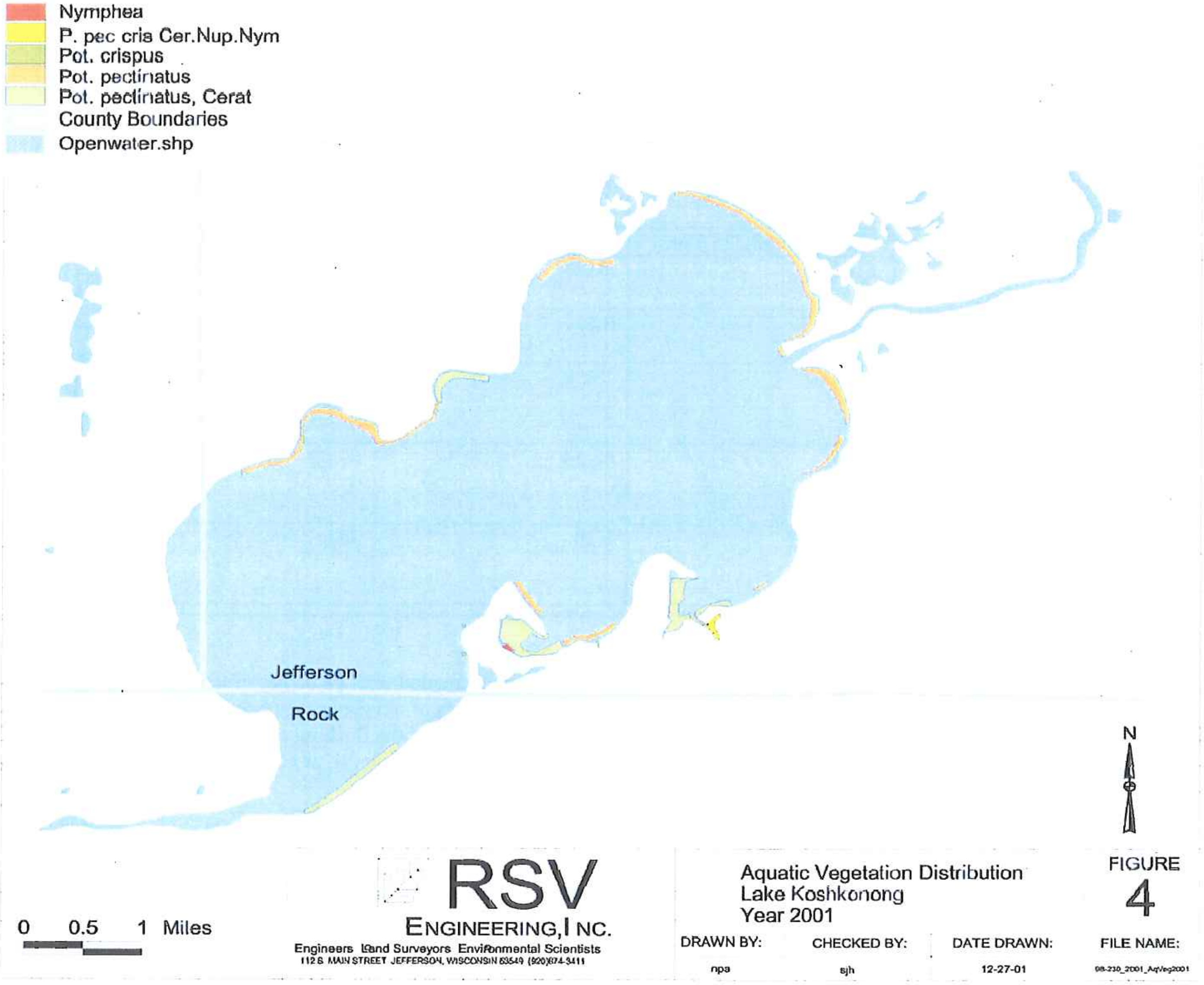
Summary--In the extreme example of an 18-inch over winter drawdown coupled with 18 inches of ice, the oxygen supply will drop from 70.57 days to 53.02 days. This loss of seventeen days of oxygen would become a problem if flushing rates were not an issue. At such a low level, the volume decreases and the flushing rate or turnover rate for the lake speeds up to once every 15.7 days over once every 23 days. At any water level, at normal flows, the lake will change its water three times within the predicted oxygen supply time.

Complicating factors are that some of the lake may not be cycling its water with the river flows, the river flows may fall to levels below 200 c.f.s., and photosynthesis will likely be adding oxygen to the system. The bottom line is that the winter water quality of the lake is extremely dependent upon the water quality and quantity of the incoming Rock River. There are times when oxygen levels in the river are low. If combined with low flows and a lack of flow, a fish kill may occur regardless of what level the lake is a

Submerged Aquatic Vegetation (SAV)

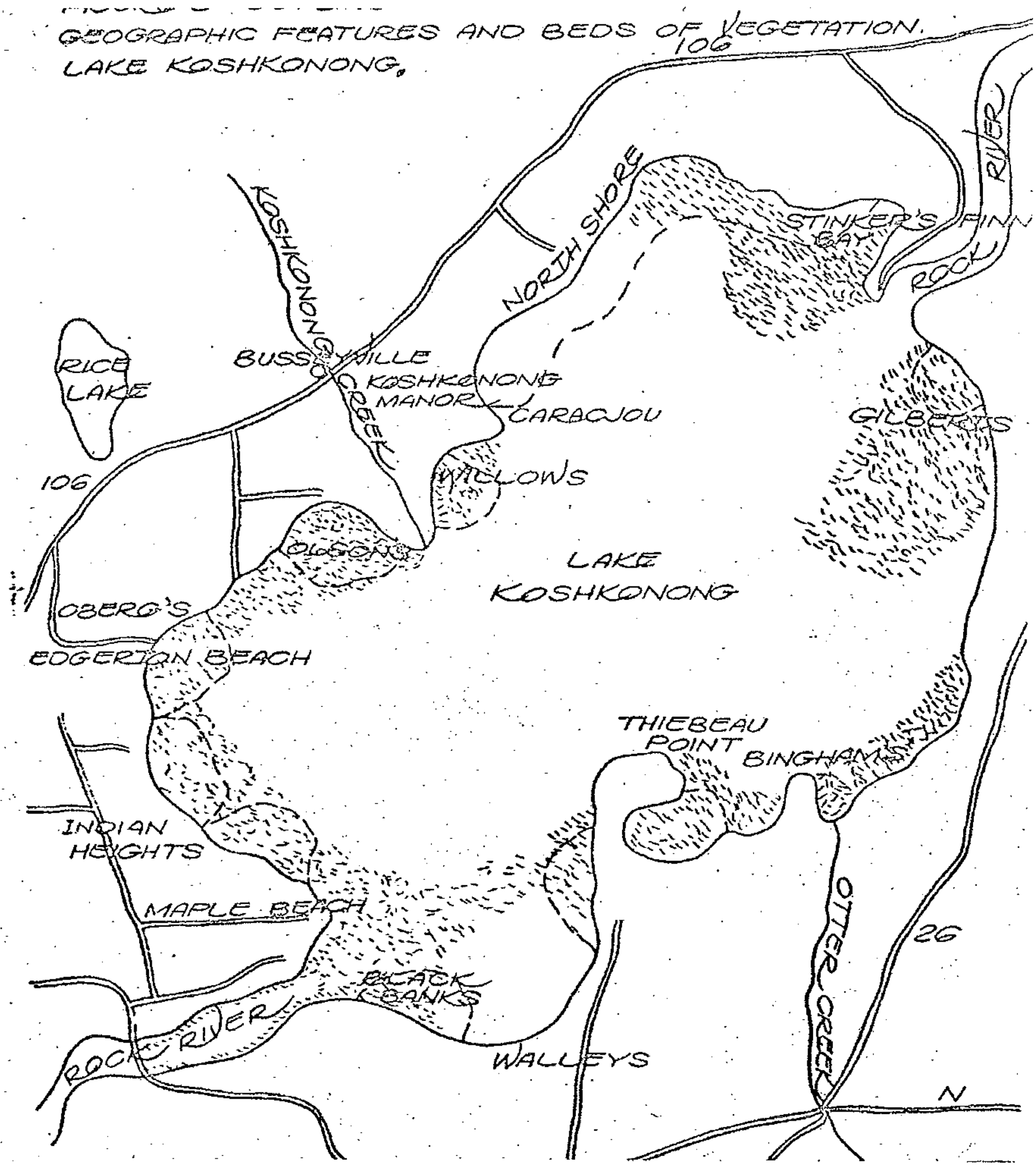
At the current time the area of the Lake Koshkonong that contains SAV is relatively small (Figure 51). It is much reduced from coverage reported by Threinen (1952) (Figure 52). The community is also relatively simple, being dominated by sago pondweed (*Potomageton pectinatus*). The loss of plant cover is most likely the result of increased nutrients and sediment delivered from the watershed via the Rock River as well as rough fish (carp) activity. It was stated in the EIR that the amount of SAV would increase since water clarity would improve. Modeling using the WILMS model (water quality section above) indicates there would be no discernable decrease in total phosphorus concentrations with the higher water level, thus there would be no improvement in water clarity. Because there will not be an improvement in water clarity if the summer water level is raised to a target of 776.8 MSL, there will not be an expansion of the submergent plant beds. If the water level is raised, the maximum depth of growth will remain at about 4 feet as it is now. Increasing the water level will only displace the plant beds towards the present shoreline such that the SAV is found growing closer to the present shoreline and to a maximum depth of 4 feet.

Figure 51. Map of submerged aquatic vegetation in 2001.



Elimination of the winter drawdown would have no effect upon the SAV. Typically, the SAV does not grow in water depths less than 0.5-1.0 feet. The failure of plants to grow in this shallow depth is probably related more to erosion as a result of wave action during the ice free period than to winter drawdown. It is expected the minimum depth of plant growth will be unaffected whether the winter drawdown occurs or not.

Figure 52. Submergent Aquatic Vegetation map reported by Threinen (1952).



Amphibians and Reptiles

Of the 54 species of herptiles present in Wisconsin, 21 are found in and adjacent to Lake Koshkonong. Many of these inhabit riparian marshy habitats that support emergent, and in some cases, submergent vegetation. These species are dependent upon emergent and submergent vegetation for cover, food or egg deposition and will likely be negatively affected by higher summer water levels, as they have been as a result actual dam operations in the past. The history of emergent habitat loss in this lake is clear. Higher water means eventual loss of emergent shoreline habitat caused by the instability of inundated emergent vegetation. The process that has resulted in the historic loss of habitat caused by high water in the past will guarantee additional habitat loss if water levels are increased. As habitat is lost, the carrying capacity for herptiles and many other wildlife species dependent on this habitat within the Lake Koshkonong landscape will decrease.

Several amphibians are dependent on fishless habitats in order to sustain their populations over time. As water levels increase, and as additional shoreline habitat is lost, shallow habitats now isolated from fish will become available to fish and amphibian reproduction is likely to be reduced.

The EIR states that elimination of the winter drawdown would be beneficial to hibernating herptiles. This statement is especially accurate for turtles, which are slow growing and take many years to reach maturity. Drawdowns conducted after aquatic herptile hibernation has started often results in mortality related to stranding and freezing. To avoid mortality, the department recommends that drawdowns be completed prior to October 1, although once completed, can be maintained for months or even years. Drawdowns can be very effective for restoring or enhancing emergent vegetation, for compacting bottom sediments, and for other purposes, most of which benefit herptiles associated with these habitats. As such, periodic drawdowns are recommended to enhance or restore habitats in Lake Koshkonong.

Macroinvertebrates

Many macroinvertebrate species are strongly dependent upon adequate substrate, e.g. submergent plants. As stated above, higher water levels are expected to cause additional losses of these habitat types. This will result in further impact to macroinvertebrates associated with the plants. Emergent vegetation also serves as habitat for numerous macroinvertebrate species. Since it is expected these marshes will be reduced in aerial coverage, there will be a decline in the amount of macroinvertebrates associated with these marshes. Some macroinvertebrates also inhabit sediments, e.g. chironomids. If the winter drawdown does not occur the numbers of these insect larvae may increase, as a larger amount of sediment will be flooded. However, it is important to note that none of the studies have documented the size of the macroinvertebrate community in the drawdown zone, so it is impossible to know how much of the community is affected. Unlike turtles, most lacustrine macroinvertebrates reproduce rather rapidly, allowing populations to rebound quickly following drawdowns.

Freshwater mussels are one macroinvertebrate group that would potentially benefit from the elimination of winter drawdowns since they mature much slower than most other invertebrates, and therefore do not have the same recovery potential. These organisms do not readily move, especially once water temperatures drop below 40^0F, and are readily stranded in late fall or winter drawdowns. The EIR reported stranded mussels on dry land following the winter drawdown. However, it is important to note that freshwater mussel diversity is typically low in flowage habitat, as is the case in Lake Koshkonong, because most mussel species require higher flows and more stable substrates. The species present in areas other than the main channel of the lake are species tolerant of poor water quality and slow flows. They seldom make up a significant portion of the macroinvertebrate community due to low densities. As a result, this group of organisms should receive less consideration when determining how and when to use drawdowns as a management tool in Lake Koshkonong. Because the freshwater mussels indicative of the lake occur in low densities, it s reasonable to conclude that, while increased water levels may benefit these mussels, their contribution to the system is expected to be negligible.

Fishery

As noted by Threinen, (1952), the fishery of Lake Koshkonong is noted for fluctuations of strong year classes of a wide variety of fish species. This is typical for all river systems. Periodic flooding and drought will enhance environmental conditions for the benefit of some species to the detriment of others. Adding to this potential for variability, the commercial removal of over one million pounds of carp from the system leaves a biological void to be filled by other species. In addition, the Department's aggressive gamefish stocking program has the opportunity to establish year classes which vary from minimal to enormous.

No water level manipulation (high or low) is capable of replacing or duplicating the natural conditions that enhance fish spawning during periodic flooding. Timing of flood events will benefit one species over another. During 1993 high waters caused one of the best hatches of walleyes on record. The same flood conditions on the Mississippi River washed many of the walleye fry downstream to unfavorable habitat. The flood events on the Rock River in 2004 were too late to enhance walleye spawning, but the high water enhanced forage fish populations which in turn resulted in exceptional growth and survival for young of the year walleyes and northern pike. It must be kept in mind that such flood events are not an occurrence on Lake Koshkonong by itself. The floods will cover fields and marshes throughout the Rock, Crawfish and Bark River systems. As the waters recede, the fry move downstream and eventually get down to Lake Koshkonong.

Flooded marshes are critical spawning habitat for northern pike, and can be used by walleye. The proposed raise in water levels will not be enough to cover marshes to enhance northern pike spawning in any way. Erosion from high water, wave and ice action has already destroyed most of the peripheral floating wetland habitat useful for pike spawning. If higher water levels result in the loss of more wetland vegetation, it equates to a reduction of pike spawning habitat.

Of the sixty or so species of fish found in the Rock River and Lake Koshkonong, many of them are river spawners, or are species that will utilize both lotic and lentic systems. River spawners such as sauger, white bass, suckers, redhorse and catfish will be unaffected, as they will still seek out the same habitats. Lake spawning fish may have some enhancements to spawning success during low river flows. The most abundant species such as carp and buffalo will still deposit millions of eggs along the shoreline. If water levels are stable and the eggs are deposited in vegetation, there may be a higher hatching rate. Nest building fish such as the Centrachidae or Sunfish will be largely unaffected. They may be able to move their nests somewhat inland, but it is doubtful that there will be any change in hatching success or numbers of nests.

The removal of the winter drawdown order may have consequences to the fishery. These observations are based upon the single season of 2002-2003 where the overwinter drawdown was successfully implemented. Under the current order, when water levels start dropping in marshes adjacent to the lake, the fish need to move out. Most of the fish in question are carp. With the marshes drying up and the lake being drawn down, the fish are concentrated and are therefore more susceptible to commercial seining. Moving carp out of marshes also allows for the operation of mechanical barriers to inhibit carp movements back into the marshes in the spring. Without a winter drawdown the carp barriers at the Thiebeau and Mud Lake marshes will be ineffective.

Dropping water levels will also concentrate gamefish. This may lead to higher angling success, but also can lead to heavy exploitation of the resource. To offset those issues, it is apparent that during low water conditions, many gamefish move upstream into the river where angling success is not as great. Fish appear to be skittish in very shallow water under ice. Ice angling is apparently less effective during low water conditions.

Under the current water level order, the drawdown persists until May 1st. This means that under normal or low flows, the bays around the marshes on the lake are dry during the spawning periods for northern pike and walleye. With the vegetation eroded back so far into the marshes, there is very little if any spawning habitat for northern pike in the lake. During the spring of 2003 northern pike which were marked in marshes in the spring of 2002 moved up the Rock River as the marshes were inaccessible. While higher water levels may seem like the quick fix to this situation, a more preferable alternative is to extend the wetland vegetation back to its former extent in the lake.

In summary, fish populations fluctuate in response to floods and droughts. These fluctuations are augmented by management efforts to remove rough fish, and stock gamefish. While it is tempting to draw a conclusion that more water in the lake will equate to more fishery habitat, the reality is that because of the extensive nature of the Rock River basin as a whole, there will be an insignificant gain in fish habitat from raising water levels. The potential loss of wetlands from higher water will result in a loss of northern pike spawning habitat. Elimination of the winter drawdown will make carp barriers ineffective, but will make current marshes somewhat more accessible to pike. Higher and more stable water levels may enhance spawning success for carp and buffalo.

Waterfowl
Presently, Lake Koshkonong and its associated wetlands still provide the same types of opportunities for waterfowl migration and production except to a far lesser degree. This loss in value is due to the long-term degradation of habitat that has occurred and is still in progress. The accelerated wetland loss due to the proposal will make the lake less attractive to waterfowl for staging and local production.

Furbearers
The lake and adjacent wetlands have a typical complement of furbearers, which include muskrat, mink, raccoon, river otter, some beaver, red fox, and coyote. These are the most "important" or valuable species from a trapping view point. All these species would be negatively impacted by artificially raised water levels due to the degradation and loss of wetland habitat types. Obviously, the species most injured would be the muskrat, beaver, mink, and river otter. The survival of these species is almost entirely tied to quality wetland habitat. The wetlands adjacent to the lake itself will see the largest vegetative change (negative) from higher water levels and consequently, this is where the furbearers would be most impacted. These species are present in significant numbers. Muskrats, the number one trapped fur in Wisconsin, will likely be the species sustaining the highest negative impact of all.

Endangered Resources
As discussed above, high water levels in riparian wetlands have been correlated with lack of herbaceous vegetation, tree mortality, drowning of groundwater-dependent wetland types, and adverse water quality impacts from sediment and nutrient deposition. Adverse impacts would be expected to the rare natural wetland communities and the rare species they support

The Koshkonong Creek Floodplain Forest is a high-quality natural community and habitat for a number of rare birds, and historically a number of rare plants. This area could suffer significant degradation due to tree mortality and loss of groundlayer plant species, impacting habitat for rare species such as Cerulean Warbler and Acadian Flycatcher. It is unknown whether the historical populations of several rare plants still exist in the area today; further surveys are needed. Likewise, the very high-quality floodplain forest documented at Koshkonong Lake Access could experience tree mortality, and negative impacts to the largely native ground flora. This site ranked among the top 9 for protection by Rock County in their Natural Area Inventory.

Other wetlands and marshes around the lake that support numerous rare nesting and migratory birds such as North Lake Koshkonong Marshes, Koshkonong Marsh/Mud Lake, and Thiebeau Marsh would be affected. Rising water levels in these marshes and increased siltation would diminish vegetative nesting habitat for birds such as Black Tern, Forster's Tern, American and Least Bittern, Virginia Rail, and others.

Along the south side of the lake, there is substantial risk that the wet and wet-mesic prairies and sedge meadows found in Koshkonong Wetland, Fair Meadows Prairie and Thiebeau Marsh would be permanently altered by long-term surface water inundation and higher water tables.

Newville Carr, along the south shoreline of Lake Koshkonong, is characterized by the Rock County Natural Area Inventory report as a significant and uncommon wetland with an exceptional number of spring seepages running through the very old organic peat mounds. The report states that it has a high probability of supporting rare species, and features unusual mosses and lichens. More surveys are needed here. Increased water levels would be expected to impact the peat mound hydrology and morphology, the water quality, and plant composition.

The degree to which the rare plants found in the lake's riparian wetlands would be impacted by increased water levels cannot be determined with certainty without further studies and surveys. There is strong risk of impacting one of the best populations of a plant that is listed at both the state and federal levels. If inundated, these plants would perish. During the high water levels of May 2004, some of these plants were submerged and by July had disappeared. Inundation would affect seed germination and survival, cause siltation, and create competition due to the deposition and establishment of invasive species. Inundation could also affect the mycorrhizal fungi that these species rely on, and the moth species that pollinate them (including the moths' larval foodplants). Another population of this plant in Wisconsin that had apparently disappeared responded dramatically to a water level reduction of 1.5 feet along with burning and invasives management. After these activities, that population numbers over 500 plants. The 1999 federal recovery plan for this species states that if a site is disturbed by flooding, it should be left undisturbed for at least five years once flooding receded, so the seeds can germinate.

Other significant rare plant populations may exist in surrounding forested wetlands, as they did historically, but further surveys are needed.

Nesting habitat for Blanding's Turtle could also be affected.

Rare Fish: All of the nine rare and endangered fish species referenced in Chapter 7 of this analysis are rare in the Rock River. Their appearance in Lake Koshkonong is attributed to the diversity of habitat within the Rock River Basin. It is unclear if implementing the petitioner's proposal will benefit or detract from the abundance or continued successful spawning of these species.

Relevant Studies -- Three studies critical to a more quantitative assessment of impacts to these resources have been funded and are currently underway or to begin in 2005. Natural Resources Consulting, Inc., on behalf of the Lake Koshkonong Wetland Association, has received DNR River Protection Grant funding for three projects:

1. A Comprehensive Wetland Community Assessment: This project will include floristic quality assessment of five major wetland areas around the lake, classification and mapping of wetland communities, and development of a preliminary management strategy. Further rare plant species may be found in this study.
2. A Floodplain Forest Study: This project will describe correlations between lake water levels and growth rates of trees.
3. A Rare Plant Study: This project will study correlations between water elevations and populations of the federally listed plant found along the south shore. Five water-level monitoring wells were installed this year and monitoring will continue in 2005.

Cultural

Outdoor Recreation

An overall loss of recreational opportunity for wildlife observation, hunting, fishing, and trapping is anticipated; primarily due to accelerated wetland loss.

Angling--Ice fishing is an important cultural activity on Lake Koshkonong. Angler hours are measurable in the tens of thousands, and the catch and harvest of fish is in the thousands. During periods of good ice fishing, the local bait shops, sporting goods stores, restaurants and bars all profit from ice fishing.

Ice fishing activity on Lake Koshkonong is a function of safe ice and strong fish populations. In many years ice fishing is poor despite good fish populations because ice conditions are bad. Conversely, if ice conditions are good, and the fishery is not there, the fishing activity will not develop. It is apparent that during periods of low winter water levels many fish will leave the lake. Fish that do not leave the lake are often skittish and are not easily caught in the shallow water below the ice.

Biologically it makes no difference if the fish are harvested during the winter or the open water months. Open water anglers appreciate "saving" the fish until the warmer months, but to the angers that prefer to venture onto the ice, the sport is diminished.

Eliminating the winter drawdown would provide an overall enhancement to ice fishing. Improving the harvest rates of ice anglers will diminish the success rates of the open water anglers.

Recreational Boating and Navigation

RKLD's EIR estimates an increase of approximately 50 acres of boating surface area as a result of the proposed action. This increase in boating area is minimal as it represents less than 0.5% of the total surface area of Lake Koshkonong

However, one of the largest benefits to raising the pool 7 to 8 inches is thought to be improved access to the Lake both by riparians who need shorter piers and better access at boat landings. In order to better quantify this benefit DNR staff conducted a survey during the winter of 2004 using ice augers and hand held GPS units. The intend of this survey was not to address every access issue on the lake, but rather to try to better understand these issues at some of the more extreme access areas along with the public boat landings. A total of 17 cross sections were taken. Figures 54 -60 are included as representative x-sections of that survey. Figure 53 shows the location of these cross sections.

A review of the Figures 58-60 (non-boat landing x-sections) gives one an idea of how access may be changed as a result of this proposal. In Wisconsin, a riparian may place a pier out to the line of navigation without a permit (generally 3 feet of water). However many piers are placed at more moderate depths especially when the piers have to be very long as they are on Lake Koshkonong. From a review of the North Shore X- Section 4-C, which is fairly typical of cross sections on the North Shore, it would appear that RKLD's proposal would reduce pier lengths 85 to 100 feet depending upon the desired depth at the end of the pier (2-3 feet). Piers would also be substantially shorter on the southeast shore of the lake. The Highwood at Cherokee Road cross would suggest that pier lengths could be reduced by 160 feet. However, the Mallwood cross section would predict much less of a reduced pier, perhaps 10 feet.

The cross sections at the boat landings are much more dubious. While RKLD's proposal would improve depths at all of the boat landings, the improved depth is probably not going to make these landings substantially more usable. The usability of these landings is probably much more effected by the type of equipment being used rather than a change in depth. Boater launching from tilt up boat trailers with boats on rollers will be much more affective than boaters launching from trailers using friction skid pads. Small maintenance dredging projects at these landings would make the landings much more dependable for a variety of boats/trailers.

Figure 53 Location of Navigation x-sections

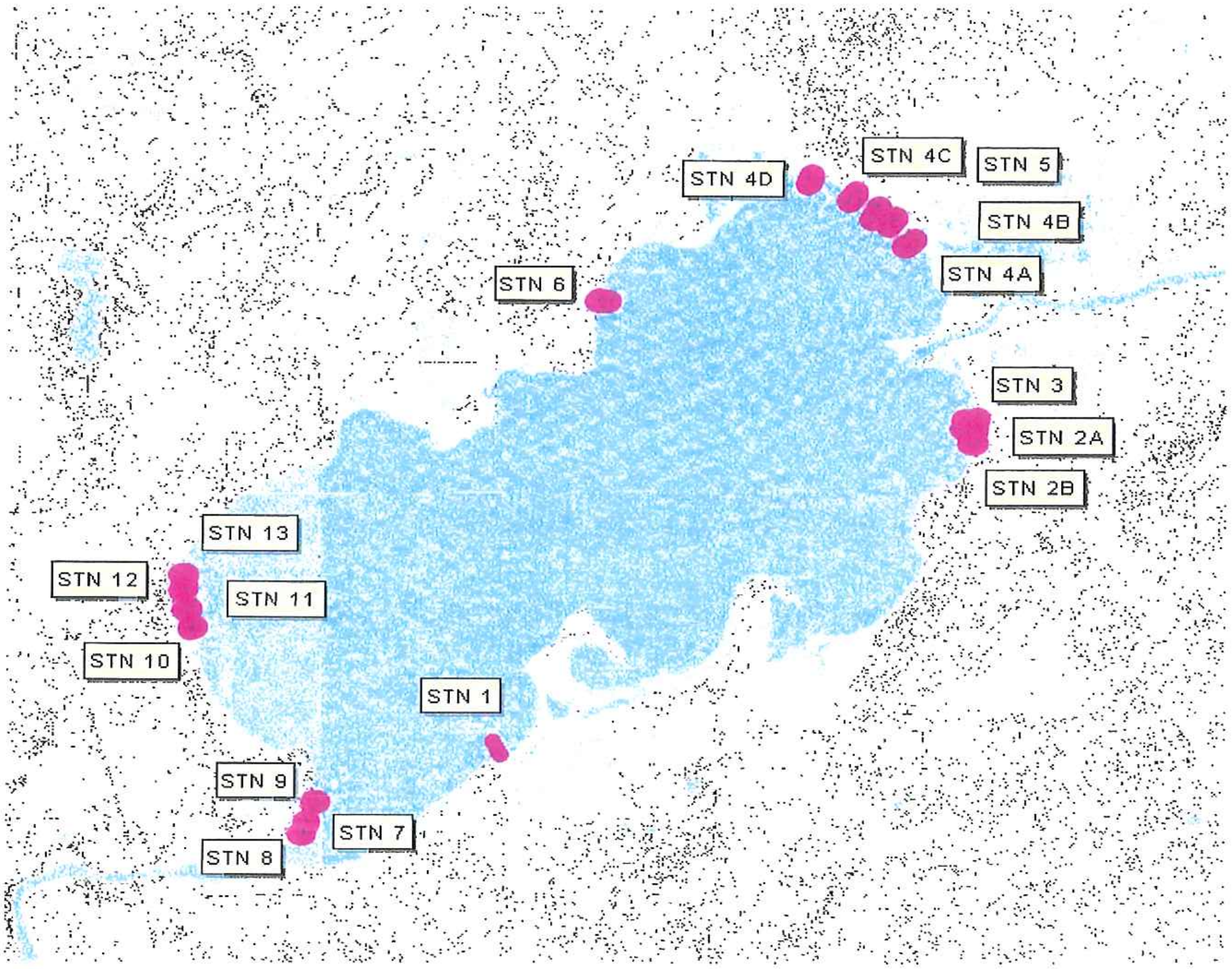


Figure 54. Keuhn Boat Landing is shown as STN 6 in Figure 53.

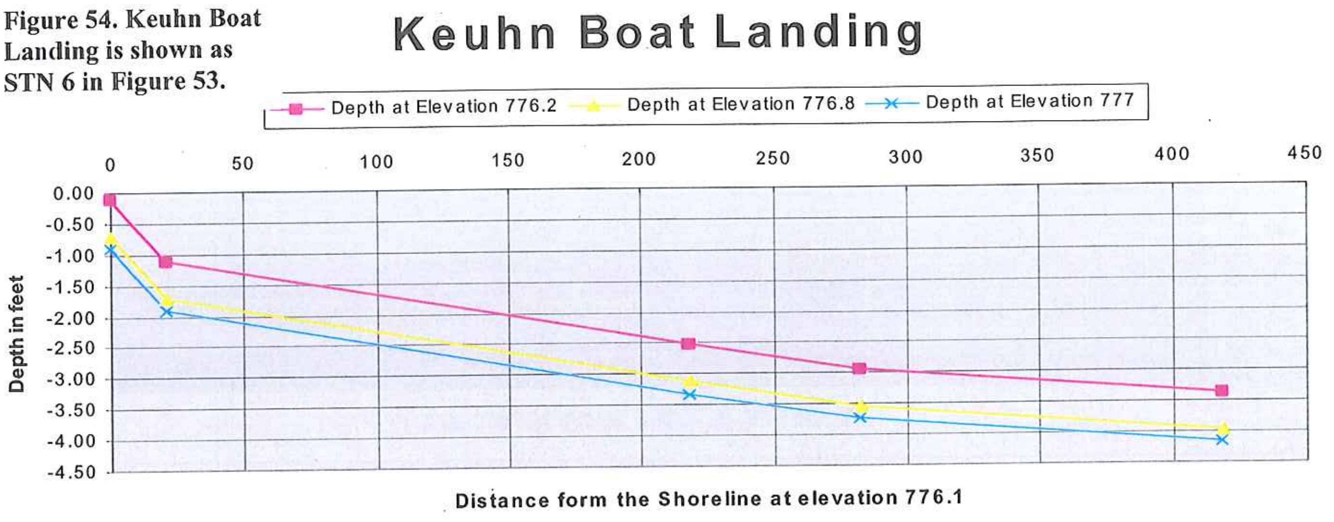


Figure 55. North Shore is shown as STN 5 in Figure 53.

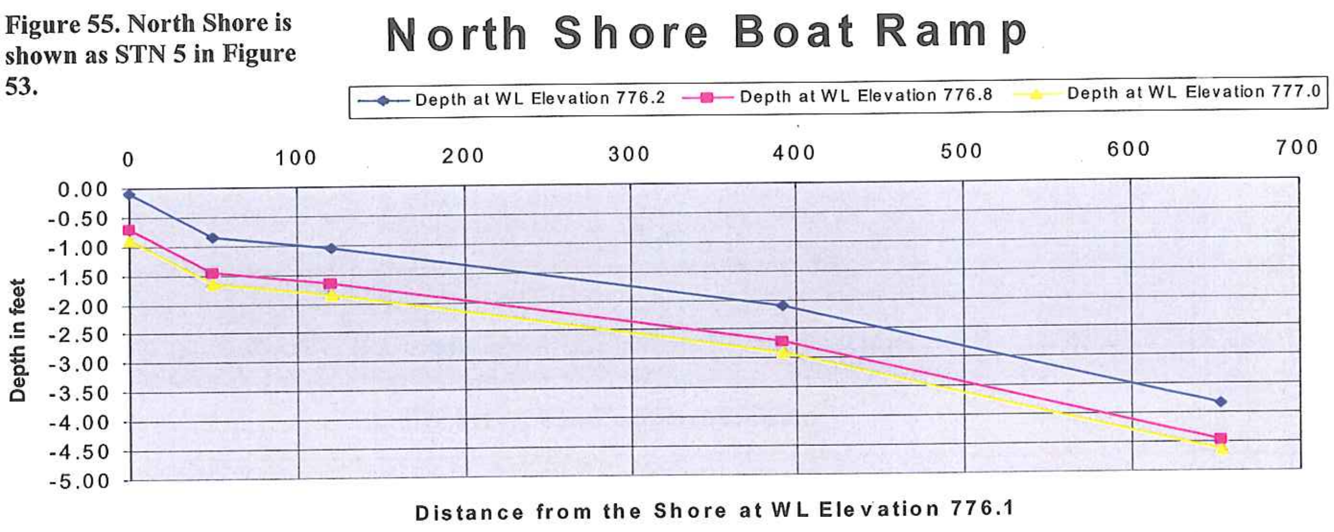


Figure 56. Dallmans is shown as STN 1 in Figure 53.

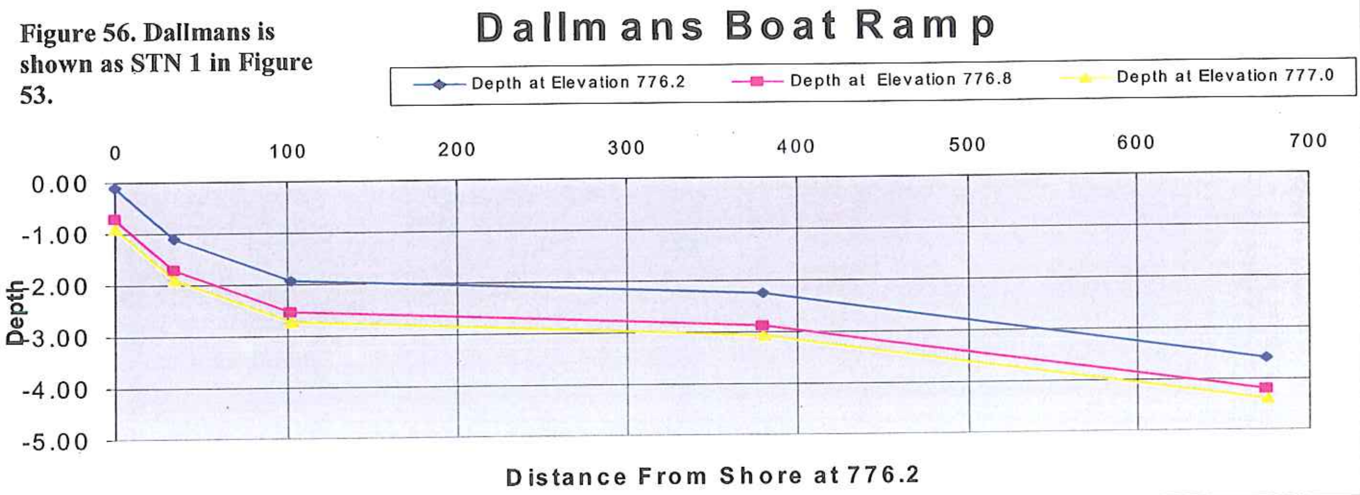


Figure 57. Vinnie Ha Ha is shown as STN 3 in Figure 53.

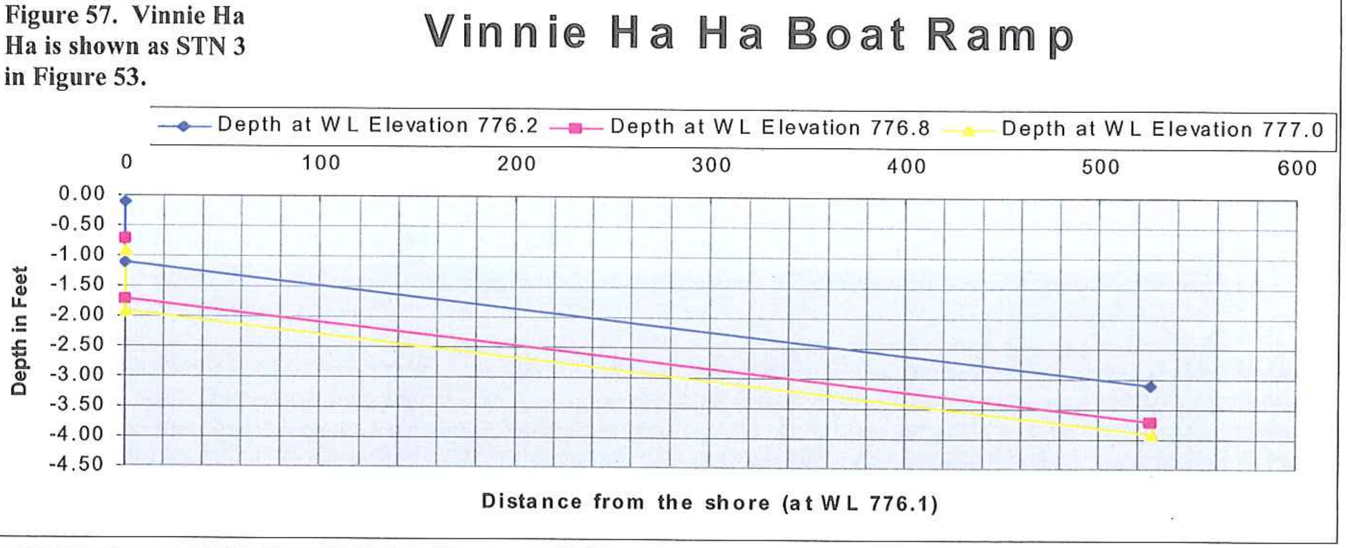


Figure 58. Highwood is shown as STN 13 in Figure 53.

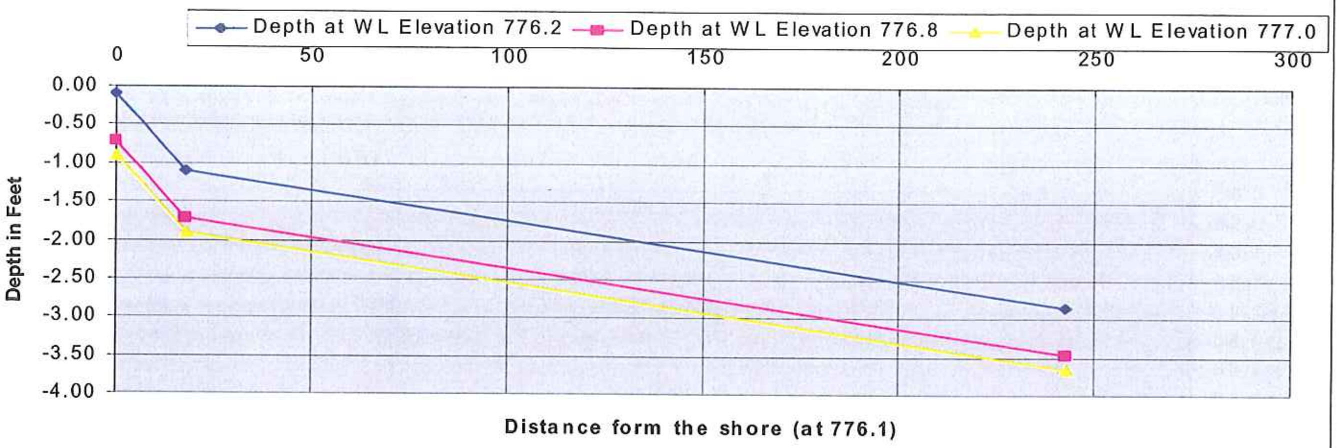


Figure 59. North Shore is shown as STN 4C in Figure 53.

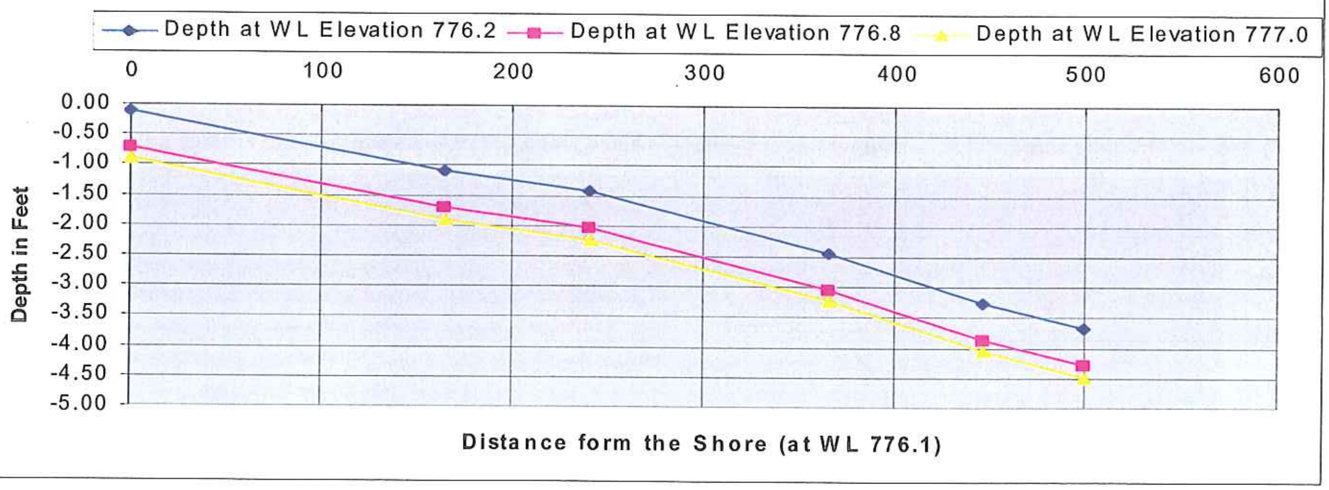
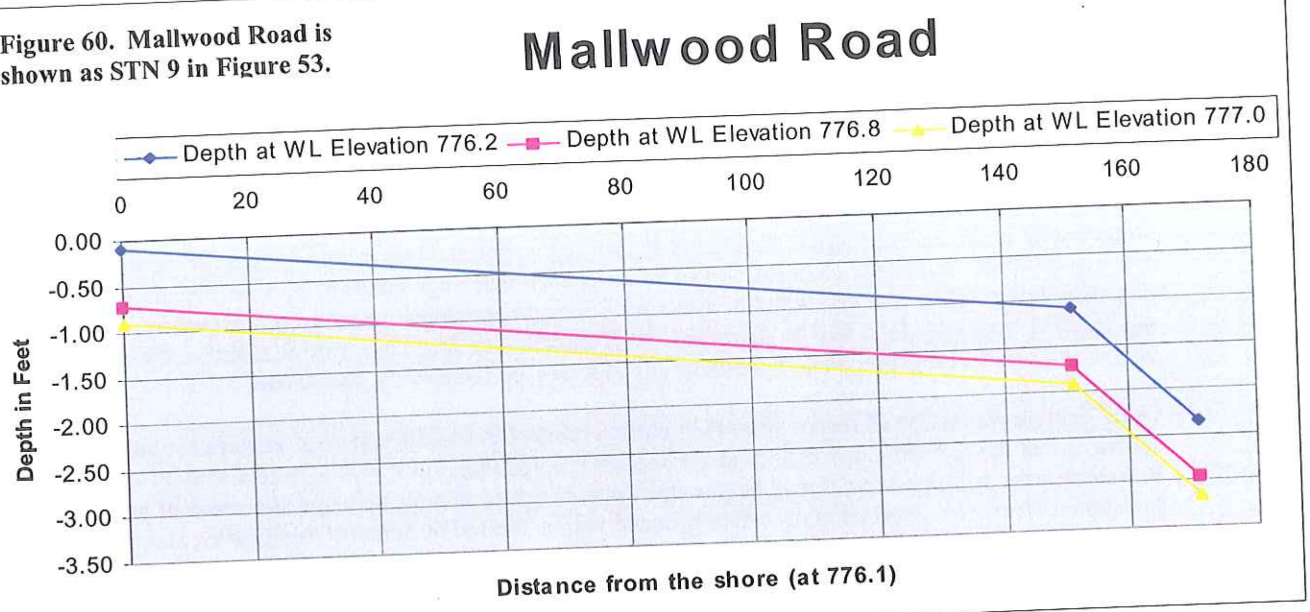


Figure 60. Mallwood Road is shown as STN 9 in Figure 53.



Shoreland Zoning
With higher water level the OHWM may migrate shoreward. This could mean that marginal structures may become nonconforming since they will be closer than 75 feet to the lake. In order to be legal, these structure will have to be moved or removed over time.

Archaeological
There are 27 archaeological sites recorded on the shores of Lake Koshkonong. One located on Carcajou Point is listed in the National Register of Historic Places. Many of the lakeshore sites are at least partially low lying and extend to the water's edge. The raising of the lake level could lead to substantial erosion of significant archaeological deposits.

State law (s.44.40 Wis. Stats.) requires state agencies, including the Wisconsin Department of Natural Resources, to determine if their actions may impact historic properties that are listed in their inventories, and to consult the Wisconsin Historical Society if impact is likely to occur. The Environmental Assessment is such an action. Therefore, any change in raising the water level cannot be accomplished until the Historical Society has had a chance to review a proposal and make a determination as to the disposition of affected sites. The State Historical Society has not been contacted at this point due to workload considerations. If the water level is not raised, there is no need to have the Historical Society take a look at possible impacts.

DNR EVALUATION OF PROJECT SIGNIFICANCE

Primary and Secondary Environmental Effects and Their Significance

Discuss which of the primary and secondary environmental effects listed in the environmental consequences section are long-term or short-term.

The primary negative effect of this proposal will be the continued and accelerated loss of riparian wetlands. Of particular immediate concern is the change in forested wetlands. This relatively rare habitat in Southern Wisconsin will be drastically changed. It can be anticipated that large stands of trees will be affected by permanently saturating root zones and in some cases outright permanent inundation. Ultimately, much of this forested wetland habitat will be destroyed. It is unlikely that new land-ward forested wetlands will evolve as a result of this proposal. Forested wetland losses are likely to be permanent.

Other riparian wetlands will recede from their current borders as water levels rise. Historical evidence has shown us that the recession of wetlands at the borders is continuing but it will be accelerated by an increase in water levels. In some cases it may be possible for wetlands to migrate up slope as a result of increased inundation. However, expansion of wetlands inland will be limited by adjacent topography, current land use and the availability of suitable soils. Wetland losses are likely to be permanent.

Permanent, increased, water levels on Lake Koshkonong wetlands is a systemic problem with long-term negative consequences. The described impacts of increased water levels cannot be justly compensated by remedial site-level "fixes", such as the construction of stone dikes and wetland armoring. To recover and protect Lake Koshkonong wetlands, management agencies must continue to address the underlying causes of wetland loss. For Lake Koshkonong the underlying primary causes are the combined effects of increased water levels, excessive nutrient inputs, and dominance of exotic common carp.

Discuss which of the primary and secondary environmental effects listed in the environmental consequences section are effects on geographically scarce resources (e.g. historic or cultural resources, scenic and recreational resources, prime agricultural lands, threatened or endangered resources or ecologically sensitive areas).

Several rare wetland community types occur along the shores of Lake Koshkonong, as identified in the Natural Heritage Inventory and the Rock County Natural Area Inventory. The high-quality floodplain forest communities and the rare species they support could be significantly degraded. An unusual peat mound wetland, and wet prairie and sedge meadow habitats also could experience serious adverse impacts. One of the best known populations of a Federally Threatened and State Endangered plant found on wet to wet-mesic prairie near the lakeshore could be seriously impacted. A Federal Recovery Plan for this plant was approved by the U.S. Fish & Wildlife Service in 1999. Recovery goals established for this species, which would allow ultimate de-listing, could be more difficult to meet if this large population is lost. The population is among very few in the state that are large enough to be considered viable in the long-term, but needs further habitat protection to meet recovery goals in this ecological region for high viability.

The wetlands surrounding Lake Koshkonong support a large number of rare bird species, including the Endangered Forster's Tern, large numbers of Special Concern Black Terns, and the Threatened Cerulean Warbler and Acadian Flycatcher. Nesting and foraging habitat impacts from higher water levels would further impact these species. Impacts to other rare plants, including the small yellow lady's slipper orchid (Special Concern) and kittentails (State-Threatened) are unknown without further study.

Comprehensive rare plant, bird, insect and herptile surveys have not been conducted across the affected area. It is highly likely that other rare species occur in these habitats. Many plants now listed as endangered or threatened were documented historically in the wetlands north of Lake Koshkonong.

Discuss the extent to which the primary and secondary environmental effects listed in the environmental consequences section are reversible.

As discussed above, this proposal will likely result in permanent wetland loss at an accelerated rate. It may be possible to reverse some of the wetland losses with a concerted long term summer draw down or periodic summer draw downs. The reestablishment of submerged plants and riparian wetlands have been successfully accomplished at other shallow lakes by implementing summer drawdowns, and could be instituted at Lake Koshkonong. However , the hydrology of Lake Koshkonong would dictate the appropriate time to implement a draw down. For example, the high water of the summer of 2004 was driven by early spring runoff, a bad time to try to implement a summer draw down on the Lake. Conversely the prior two year period had relatively low spring runoff and would have been good years to implement a summer draw down. In the absence of a plan to revitalize the new shore vegetation, wetland losses will be permanent. Even with periodic summer draw downs the losses of forested wetlands as a result if raising water levels will be permanent.

Significance of Cumulative Effects

Discuss the significance of reasonably anticipated cumulative effects on the environment (and energy usage, if applicable). Consider cumulative effects from repeated projects of the same type. Would the cumulative effects be more severe or substantially change the quality of the environment? Include other activities planned or proposed in the area that would compound effects on the environment.

There are many shallow water lakes in Wisconsin of larger and smaller scales. Lake Winnebago, Lake Puckaway, Beaver Dam Lake, Big Muskego Lake, and Lake Poygan are just a few that have similar management issues to Lake Koshkonong. Human perturbations, primarily, non-point and point source nutrient loading, introduction of exotic species, and water-level changes have caused changes in the ecosystem function of these shallow lakes. Many larger shallow lakes in Southern Wisconsin have shifted to an alternative stable state characterized by high turbidity, phytoplankton blooms, loss of submersed macrophytes and recession of emergent plants, low waterfowl use, and altered fish communities (benthivores/planktivores like carp tend to dominate). Lake Koshkonong is among them. Management and restoration planning efforts to date universally seek to recover their earlier attributes that these lakes provided (clearer water conditions, abundant macrophytes, and improved fisheries and wildlife). Examples of success are found among some of them (Puckaway, Big Muskego, Miss. R. Pool 8) and typically involve aggressive management approaches including emulating natural disturbance events like drought through drawdowns, and drastic fish stock reductions of rough fish populations. Drought is a disturbance event and a natural component of ecosystems that promotes diversity and renewal processes. The wetland drought/renewal process is often eliminated with the establishment of dams and water level orders.

These lakes are also managed for multiple uses. Some of these uses are in direct opposition to the welfare of other uses. For example, the deeper recreational pools are often times desired by the boating public but those deeper pools come at the loss of riparian habitat. Likewise, we know that shallower pools and allowing for more routine drought like conditions (deep summer draw downs) will further riparian wetlands and submergent plants. However, these regimes come at the expense of decreased or more difficult navigation and navigational access. These ecosystems are inherently shallow in nature, and because of their shallow nature contain highly valuable fish and wildlife habitat. Because of their shallow nature power boating aspects of navigation has been historically limited to their deeper open pool areas. Establishing operating rules is often a balancing act between the competing public trust interest within the water body. While, weighing public trust issues is always done, it is never done to the exclusive benefit of one aspect of the public trust. Approving this proposal would establish a precedent that navigation and navigation access issues far outweigh the negative aspects associated with loss of riparian habitat. Accordingly, approving this proposal would likely result in justification of higher water levels on other shallow water lakes at the expense of loss of habitat.

Likewise, the winter draw down on Lake Koshkonong has been established as a balance of issues. Ideally, the winter draw down would have been set for early October but was delayed until November 1 to accommodate the navigational interest of duck hunters. To minimize shore land damage from ice it is probably advantageous to have very deep winter draw downs. However, deep winter draw downs can affect ice fishing access and fish movements. It is likely that approval of this proposal would result in other winter draw downs being challenged for the exclusive benefit of one aspect of the public interest.

Significance of Risk

Explain the significance of any unknowns that create substantial uncertainty in predicting effects on the quality of the environment. What additional studies or analysis would eliminate or reduce these unknowns?

Groundwater impacts

The proposal will increase groundwater levels near the lake. The extent of the area affected is unknown. In order to better understand this issue it would be necessary to have near lake soil surveys and groundwater monitoring. A ground water model coupled with near shore monitoring may give a better idea concerning the extent of the effect on increased groundwater levels. This information would help to establish whether or not there are private septic fields that may be impacted and to further quantify the extent of impact to the adjacent forested wetland.

Inundation

The actual increased inundation at higher pools is not known. RKLD has provided near shore surveys that give some insight to the area that may be affected. While the survey does show the extent of the 777.0 msl contour at many points around the lake it does not indicate the extent of the land that will be affected by raising the pool to 777.0 msl. For, example the survey does not reach into the Mud Lake area but rather stops along the North Shore. From reviewing the survey it would appear that the Mud Lake area would be unaffected which we know is not true. The survey also did not include the river upstream of the lake or the river below the lake to the Indianford Dam. A survey conducted while the pool is at 777.0 msl would be a better indication of the effect of raising the pool. Aerial photographs taken at 777.0 msl and 776.2 msl would also better describe the inundation area.

OWHM: From the information assembled within this document it would appear that the OHWM may have been artificially raised by operation of the dam. Whether or not this is the case can only be established by long term proper operation of the dam and monitoring the location of the OHWM.

Winter Draw Down Effects

There are several competing theories concerning the effect of the current winter draw down. Much of the discussion centers around the impact on submergent plant beds and adjacent riparian wetlands. One theory suggests that freezing and desiccation are negatively affecting plants. The second theory suggests that plants are being benefited by the draw down by moving ice action away form wetland boundaries. To address these questions RKLD and DNR began a survey program two years ago to assess the change in plant communities at several transects. Unfortunately due to an in-operable dam we have not been able to institute the draw down required by the 1992 order until two years ago. Not enough data exist from the transect survey to assess the affects from the winter draw down. In order to properly assess the effects from the winter draw down on plant communities at least 5 to 10 years of data would be desirable.

Rare, Threatened and Endangered Species

As discussed above there are three ongoing studies funded by Department grants that will shed more light on the impact of higher water levels on wetlands rare, threatened and endangered species. None of these studies are progressed enough to be useful for this analyses, however the forestry study is likely to be completed before any final action on the Districts petition. The results of the remaining two studies, although relevant, will likely not be available on a time frame consistent with the timeline for the Department's action.

Archaeological

State law (s.44.40 Wis. Stats.) requires state agencies, including the Wisconsin Department of Natural Resources, to determine if their actions may impact historic properties that are listed in their inventories, and to consult the Wisconsin Historical Society if impact is likely to occur. The Environmental Assessment is such an action. Therefore, any change in raising the water level cannot be accomplished until the Historical Society has had a chance to review a proposal and make a determination as to the disposition of affected sites. The State Historical Society has not been contacted at this point due to workload considerations. If the water level is not raised, there is no need to have the Historical Society take a look at possible impacts.

Explain the environmental significance of reasonably anticipated operating problems such as malfunctions, spills, fires or other hazards (particularly those relating to health or safety). Consider reasonable detection and emergency response, and discuss the potential for these hazards.

It is apparent that the trash racks and wicket gates have not been properly maintained or operated for at least the last 10 years and probably much longer. Failure to operate and maintain the powerhouse as part of the spillway works is likely to result in higher water levels on a more routine basis. It would appear that failure to operate and maintain the powerhouse has had an effect on the OHWM. In addition it is likely that failure to operate the powerhouse could accelerate wetland loss due to higher water levels.

Significance of Precedent

Would a decision on this proposal influence future decisions or foreclose options that may additionally affect the quality of the environment? Describe any conflicts the proposal has with plans or policy of local, state or federal agencies. Explain the significance of each.

Most of the original (condition at statehood) aesthetic character and biologic character of the lake has changed as a result of loss of wetlands and submerged plant beds. These changes have resulted from the maintenance of higher water levels and the introduction of carp into the system. This proposal will further change the character of the lake and move one more step away from any possible hopes of restoring the past biology, water quality or natural scenic beauty of the lake.

Significance of Controversy Over Environmental Effects

Discuss the effects on the quality of the environment, including socio-economic effects, that are (or are likely to be) highly controversial, and summarize the controversy.

Lake Koshkonong is listed on the federal 303d list as an impaired waterbody. The listed impairments are eutrophication, sedimentation, and habitat. This proposal is likely to cause more sedimentation into the lake from accelerated erosion and habitat loss from the destruction of riparian wetlands. Water quality will not be improved as a result of this proposal and will likely be negatively affected. Accordingly, this proposal will make removal from the 303d list more difficult.

As stated earlier, forested wetlands and riparian wetlands will be lost as a result of this project. Wisconsin has lost almost half of the wetlands present at time of statehood. Recognizing this historic loss and the importance of wetlands for fish and wildlife habitat, it has been the policy of the State to preserve wetlands whenever possible (see NR 1.95 and NR 103 Wisconsin Administrative Code). This proposal would be inconsistent with existing department policy on wetlands.

Boating access may be slightly improved and it is possible that Lake Koshkonong could see some additional boating as a result. Lake Koshkonong is also notorious for submerged obstructions. A slightly higher water level may reduce these obstructions but it is also just as likely that we will experience navigation closer to the shore with increased depth resulting in boaters finding new obstructions.

ALTERNATIVES

Briefly describe the impacts of no action and of alternatives that would decrease or eliminate adverse environmental effects. (Refer to any appropriate alternatives from the applicant or anyone else.)

No Change
Lake Koshkonong's environmental condition is not expected to make marked measurable improvements without aggressive: 1) water level management to emulate drought; 2) reductions in nutrient inputs; 3) increased stock suppression of common carp; and 4) commensurate enhancement of the sport fishery through stocking and fishing regulations. Lake Koshkonong is extremely productive, in fact too productive. The combined effects of stable high water levels, excessive nutrients, and impacts of common carp have severely decreased the ecological value of Lake Koshkonong. The stable regulation of Lake Koshkonong water levels is at odds with the natural fluctuation of lake levels, which are critical to the ecological health of Lake Koshkonong's wetlands, and closely tied to its waterfowl and sport fishery. Lake Koshkonong's marshes require periodic fluctuation of inflow to survive. Prior to regulated water levels, the lake level typically dropped during summer months, allowing sediments along the water's edge to dry out and firm up, in some years much more so than others. This drying effect encouraged emergent aquatic plants such as bulrush, arrowhead, and cattail to grow. With the more stable water levels created by the Indianford dam, this low-water effect and drying of sediments no longer occurs. Plant beds that depend on this drying process have decreased in extent or disappeared entirely. Stands of perennial emergent aquatic plants are important to fish and wildlife populations because they provide food, shelter, spawning habitat, and dissolved oxygen. Without these fluctuations, marshes are threatened, essentially the marshes are receding and will continue to decline in the absence of these fluctuations, albeit, much of this recession has already occurred. This habitat loss has adversely affected fish and wildlife and has reduced overall desirable productivity of Lake Koshkonong.

Without change in water levels the Lake Koshkonong fishery will remain cyclic. Without significant improvements in habitat, the walleye population and other sport fish will cycle up and down, as will common carp. Walleye are fairly tolerant of turbid water conditions, and will continue to provide a fishery, as long as there is significant investment in walleye stocking and carp removal.

Elimination of winter drawdown alone
Elimination of the winter drawdown alone is not expected to improve the sport fish populations. Elimination of the winter drawdown would improve winter ice angling, however, at the cost of the summer fishery. This action would also provide improved water level conditions for spawning fish species that are dependent on access to inundated wetlands in the very early spring, particularly northern pike. Even though pike will face more suitable spawning habitats the population may not respond as expected due to the fact that Lake Koshkonong is extremely stable in its turbid condition. The biomass of pike that Lake Koshkonong can support is positively related to aerial coverage of submergent aquatic vegetation (SAV), and elimination of the winter drawdown is not anticipated to improve SAV.

Without a winter drawdown the carp barriers at the Thiebeau and Mud Lake marshes will be less effective, as carp presently move out of the marshes during the fall drawdown.

Shoreline with armored revetments, predominantly riprap will likely be subject to increased damage due to ice/bank interactions like ice-jacking, particularly in snowless, cold winters.

Maintain the current levels and implement successive summer drawdowns
"A Matter of Will--All of these principles come back to the key question of how to balance diverse values and incorporate them into the principles. In looking for balance, we need to be mindful of the fact that both ecosystems and economies are subject to constant change. Related to this, we must resist simply taking a "midpoint" and calling that balance; if, on the ecosystems side, we always take such a compromise position, we end up with incremental, negative cumulative impacts."
(Anonymous)

Summer drawdowns combined with reductions in nutrient inputs; increased stock suppression of common carp; and enhancement of the sport fishery through stocking and fishing regulations hold the most promise toward restoration of aquatic plants with clear water, particularly in Lake Koshkonong's large bays. To shift ecological condition of large turbid shallow lakes requires a combination of several aggressive management tools including temporary reductions in water levels. Even with aggressive management the clear water/aquatic plant dominant condition may very well be quite unstable, and will likely require infrequent drawdowns to maintain plants in the Lake's bays.

Water level management can be used as a tool to improve environmental conditions for Lake Koshkonong. Here a modeling approach has much utility for forecasting Indianford Dam's capacity to emulate a drought event through successive summer drawdowns. Model simulations of all gates open can be used to determine the acreage of Lake Koshkonong's bed that can exposed during the growing season period under various rainfall patterns using historic data. Analysis would answer question; given the influence of the watershed/river, and the influence of the dam, how much riparian vegetation can be restored during dry seasons, or conversely wet seasons?

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BEFORE THE DEPARTMENT OF NATURAL RESOURCES 3-SD-82-809

In the Matter of Reestablishment of Water Levels for Lake Koshkonong in Dane, Jefferson and Rock Counties

ORDER

THE DEPARTMENT ORDERS:

1. Water levels for Lake Koshkonong from May 1 through October 31 are established as follows:

A. Minimum lake elevation:	775.73 feet, MSL
B. Maximum lake elevation:	776.33 feet, MSL

C. Power generation is not allowed when the lake elevation is below 775.73 feet, MSL.

D. Subject to the provisions of 1.E., 1.F. and 1.G., the owner of the dam shall attempt to maintain the lake level as close to 776.20 feet, MSL, as possible, except after October 15 when the transition to the November 1 through April 30 lake level occurs.

E. Three slide gates shall be fully opened and shall remain open whenever the lake elevation exceeds 776.10 feet, MSL.

F. Six slide gates and the wicket gates shall be fully opened and shall remain open whenever the lake elevation exceeds 776.33 feet, MSL.

G. The owner of the dam shall monitor the average daily flows of the Crawfish River at the USGS Gaging Station at Milford and the Rock River at the USGS Gaging Station at Watertown daily. The intent of sub-paragraphs (1) and (2) is to establish minimum performance standards to enable the operator of the dam to keep lake levels within the established limits. Flow releases described in sub-paragraphs (1) and (2) shall be accomplished by operation of the slide and wicket gates in accordance with the rating tables prepared by the Department and incorporated by reference as Exhibit A.

(1) Whenever the lake level is above 776.20 feet, MSL, and the combined average daily flow of the Crawfish and Rock Rivers has increased more than 200 cubic feet per second from the previous day, the operator shall release at least 1.5 times the latest combined average daily flow measured at the Milford and Watertown gages.

(2) Whenever the lake level falls below 776.20 feet, MSL, and the combined average daily flow of the Crawfish and Rock Rivers has declined over the four previous consecutive days, the operator shall release no more than 1.5 times the latest combined average daily flow measured at the Milford and Watertown gages.

2. Water levels for Lake Koshkonong from November 1 through April 30 are established as follows:

A. Minimum lake elevation	775.00 feet, MSL
B. Maximum lake elevation	775.77 feet, MSL

C. Power generation is not allowed when the lake level is lower than 775.00 feet, MSL.

D. Six slide gates and the wicket gates shall be fully opened and remain open when the lake level is higher than 775.77 feet, MSL.

3. Rock County shall continue to operate and maintain the existing lake stage telemetry station. Lake levels referred to in this order shall be measured at this gaging station. If the station becomes temporarily inoperable, the dam may be operated using alternate methods of monitoring lake levels approved by the Department. Rock County shall fund installation of the telemetry devices and shall fund ongoing telephone line costs at the USGS gaging stations at Milford and Watertown as long as the USGS maintains the stations at those locations.

4. The slide gates shall be maintained in a condition that will allow all of the gates to be opened or closed in four hours.

5. The powerhouse and wicket gates shall be maintained in an operable condition and shall be used to achieve water levels and flows established in this order regardless of whether or not power is generated by the dam.

6. A minimum of 64 cubic feet per second shall be discharged through the dam at all times.

7. All manipulations of the dam shall be reported promptly to the operator of the next dam downstream.

8. The owner of the dam shall maintain a daily log of lake levels and gate manipulations and make the log available to the Department upon request.

9. This order may be amended only after conferring with all parties to these proceedings. If any party determines that a review of the operating regime is necessary, they should contact the Department of Natural Resources and Rock County requesting such a review.

(2) Whenever the lake level falls below 776.20 feet, MSL, and the combined average daily flow of the Crawfish and Rock Rivers has declined over the four previous consecutive days, the operator shall release no more than 1.5 times the latest combined average daily flow measured at the Milford and Watertown gages.

2. Water levels for Lake Koshkonong from November 1 through April 30 are established as follows:

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3-SD-82-809

NOTICE OF APPEAL RIGHTS

If you believe that you have a right to challenge this decision, you should know that Wisconsin law establishes time limits for filing requests for review of Department decisions.

To request a contested case hearing pursuant to section 227.42, Stats., you have 30 days after the decision is mailed to serve a petition for hearing on the Secretary of the Department of Natural Resources.

This notice is provided pursuant to section 227.48(2), Stats.

STATE OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES
For the Secretary

by Rob Hansis
Robert D. Hansis
Water Regulation Supervisor

Date mailed April 25, 1991

EXHIBIT A

The following gate settings and associated flows are the Department's best estimates of flow through the slide and wicket gates as of the date of this order. These flows are based on current USGS rating tables for the slide gates and theoretical flow calculations through the wicket gates without turbines/generators in place. This exhibit will be revised after actual wicket gate calibrations become available or turbines/generators are installed in the powerhouse.

	DISCHARGE (CFS) AT LAKE STAGE:		
OPENINGS	776.1	776.2	776.3
3 GATES	700	800	860
4 GATES	850	900	960
5 GATES	925	1000	1060
6 GATES	1050	1100	1150
6 GATES AND 25% OF #1 TURBINE	1150	1200	1300
6 GATES AND 25% OF #1 TURBINE 25% OF #2 TURBINE	1300	1350	1425
6 GATES AND 50% OF #1 TURBINE 25% OF #2 TURBINE	1450	1500	1550
6 GATES AND 50% OF #1 TURBINE 50% OF #2 TURBINE	1600	1650	1700
6 GATES AND 75% OF #1 TURBINE 50% OF #2 TURBINE	1750	1770	1830
6 GATES AND 75% OF #1 TURBINE 75% OF #2 TURBINE	1875	1925	1960
6 GATES AND 100% OF #1 TURBINE 75% OF #2 TURBINE	2000	2050	2085
6 GATES AND 100% OF #1 TURBINE 100% OF #2 TURBINE	2160	2190	2230

~1000 cfs, but no indication of what tw condition was assumed.

FINDINGS OF FACT

1. On September 8, 1982, the Department of Natural Resources issued an order pursuant to Section 31.02, Stats., establishing water levels for Lake Koshkonong and operating procedures for the Indianford Dam. The order contained several new provisions for management of lake levels and operating the dam. Among them were the requirement to operate the dam according to levels at the lake as opposed to at the dam, the installation of flashboards on the crest of the dam during low flows and a faster response to changes in the level of the lake. The Department completed intensive environmental and hydraulic studies and prepared a lengthy environmental assessment for the proposal.

2. The order was appealed by Charles Shearer, John Haight, Jr., Earl Rehbaum, Carcajou Shooting Club, Inc., Thiebau Hunting Club, Inc., Rock River Basin Property Owners Association and the County of Rock. After hearing seven days of testimony on the merits of the Departments's order, Jefferson County Circuit Court denied the appelants' request for an injunction and also affirmed the Department's order.

3. The decision of Jefferson County Circuit was appealed to District IV of the Wisconsin Court of Appeals by Shearer, et al. and the County of Rock. The Court of Appeals ruled that the Department was required to hold a hearing before issuing the water level order and ordered that the Department hold a hearing on the matter as argued by Shearer, et al.

4. After the case was remanded to the Department, several meetings were held to explore the possibilities of negotiating an order that would satisfy the involved parties. Represented at these meetings were the parties involved in these proceedings, including Charles Shearer, et al., by Attorney Glenn C. Reynolds, Rock County by Attorney James H. Fowler III, Rock River-Koshkonong Association by Attorney John H. Short, Wisconsin Edison Corporation by Peter H. Burno, and the Department of Natural Resources.

5. The attached order represents a compromise that has been agreed to by all of the parties involved.

6. Lake Koshkonong is a natural widening of the Rock River which has been raised by the Indianford Dam. The dam is located approximately 7 miles downstream from the lake's outlet in the NW1/4 of the NW1/4, Section 21, T4N, R12E, Town of Fulton, Rock County. The dam is owned by Rock County and its operation is overseen by the Rock County Public Works Department, Division of Parks, 3715 Newville Road, Janesville, WI 53545.

7. The dam consists of a slide gate section consisting of six slide gates on the east bank, a 227 foot wide open spillway with an average crest elevation of 775.27 feet, Mean Sea Level datum (MSL), and a powerhouse containing head gates and wicket gates on the west bank.

8. Original operating orders for the dam were issued by the Wisconsin Railroad Commission in 1919. Those orders are not adequate for conditions that currently exist.

9. In order to allow reasonable recreational use of the lake, to protect fish and wildlife habitat, to protect water quality and to minimize shoreline erosion during the open water season, it is desirable to keep lake levels between 775.73 feet and 776.33 feet, MSL, between May 1 and October 31.

10. In order to allow reasonable recreational use of the lake, to protect fish and wildlife habitat, to protect water quality and to minimize shoreline erosion, it is desirable to keep lake levels between 775.00 feet and 775.77 feet, MSL, between November 1 and April 30.

11. A representative ordinary high water mark determined on the west shore of Lake Koshkonong is at elevation 776.7 feet, MSL. Allowing the lake to be held above this elevation would infringe on present uses of private property abutting the lake.

12. Water levels above 776.33 feet, MSL, will cause inundation of some shorelines and could lead to excessive erosion and siltation from wave action and destruction of peripheral wetlands.

13. A flow of at least 64 cubic feet per second is needed to maintain existing water quality in the Rock River downstream from the Indianford Dam.

14. All elevations listed in this order are referenced to Department of Natural Resources Benchmark 22-D which is a square cut in the west end of the concrete walkway on the upstream side of the powerhouse at elevation 783.28 feet, MSL.

15. The water levels and operating procedures established in this order will not adversely impact wetlands as defined in Section NR 1.95(4)(c), Wisconsin Administrative Code.

16. The water levels and operating procedures established in this order will not increase water pollution in surface waters and will not cause environmental pollution as defined in Section 144.01(3), Wisconsin Statutes.

17. The Department has prepared an environmental assessment of this order and has concluded that the action is not a major state action significantly affecting the quality of the human environment.

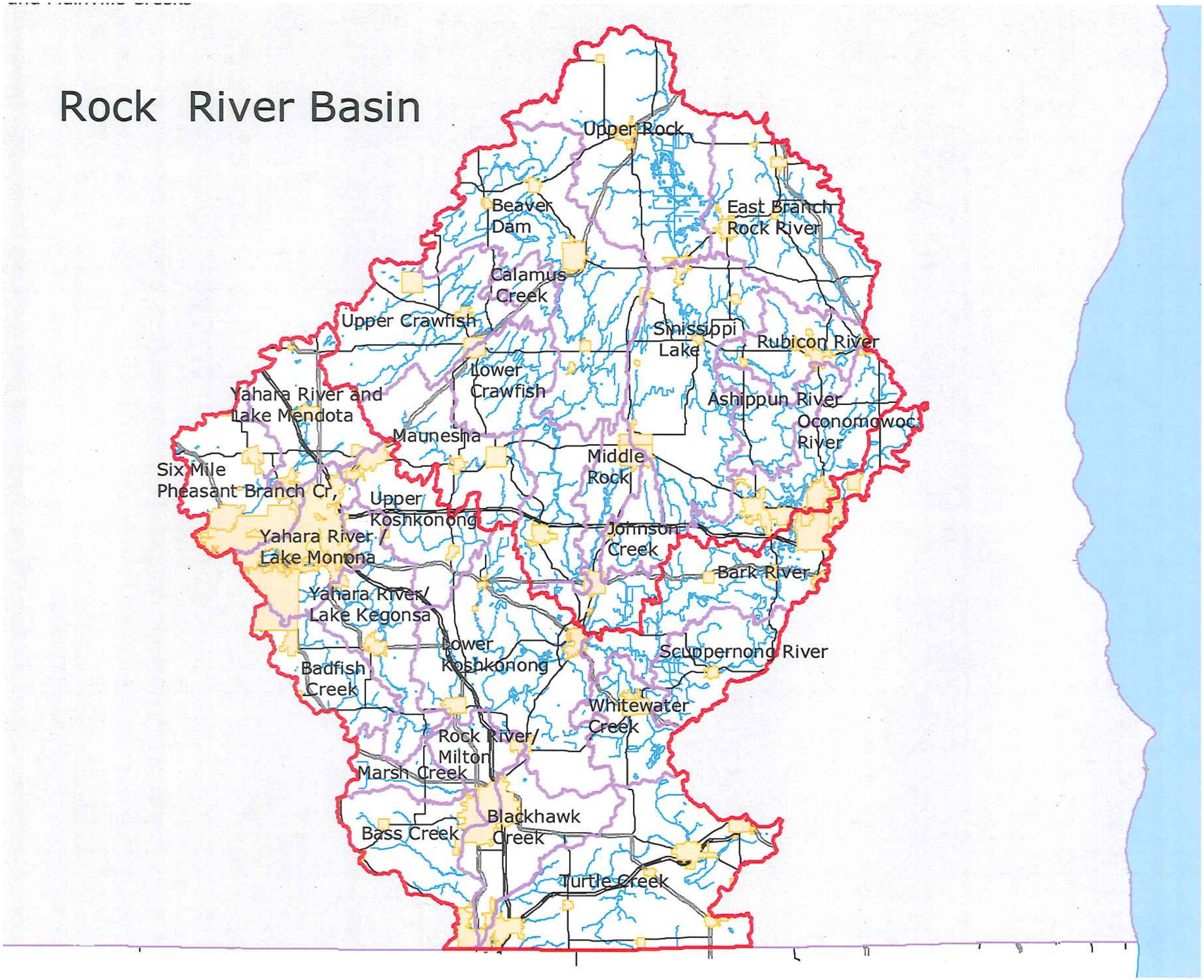
CONCLUSIONS OF LAW

1. The Department has authority under Section 31.02, Wisconsin Statutes, to issue an order establishing water levels for Lake Koshkonong and operating procedures for the Indianford Dam.

2. The Department has complied with the procedural requirements of Sections 31.02 and 1.11, Wisconsin Statutes.

3. The Department has complied with Section NR 1.95, Wisconsin Administrative Code.

Attachment 2.



Rock River Basin

Memorandum

Nine pages

INDIAN FORD DAM NEAR
EDGERTON, ROCK COUNTY,
WISCONSIN, OWNED BY THE
JANESVILLE ELECTRIC COMPANY

Submitted by W. G. Hoyt,
June 28, 1917.

The first investigation of the Indian Ford Dam was made by C. A. Halbert of the Engineering Department during August 1916. The following is a copy of his memorandum "Bench Marks and elevations of old crest of Indian Ford Dam, Rock County, owned by the Janesville Electric Co. submitted by C. A. Halbert, August 14, 1916."

"Bench marks were set at the Indian Ford Dam owned by the Janesville Electric Company, by C. A. Halbert, on August 10, 1916; also some information was obtained concerning the crest of the old spillway now being replaced.

The dam is located in Section 21, Town 4 North, Range 12 East, in the Rock River and about two miles southeast of Edgerton.

The spillway of the Indian Ford Dam consists of about 280' of wood crib spillway and about 40' of concrete spillway. The wood crib section only is being replaced. This section now being replaced was of the ordinary wood crib design with a built up crest of planking laid flat and secured to the upper portion of the crib. Some few years ago the upstream apron was protected by a concrete slab about 3" thick. The built up cresting was of variable thickness on account of the non-uniform elevation of the crib work. The crib work, the built up cresting, and the concrete slab have all been in poor condition for a year or more. The cresting has been washed or rotted away and the crib work has settled so that for some time it has not been possible to determine the exact elevation of the original crest from the elevation of the old crest.

At the time of this investigation about 100' of the most easterly portion of the wood crib spillway was still in place, the remainder having been removed and a portion of the new spillway constructed in its place. Of this 100' section about 60' still retains the cresting plank and is of about uniform elevation. Although it was not possible to definitely determine from a physical investigation whether a portion of the cresting plank had been washed away, or whether the cribbing had settled, we are of the opinion that the elevation of this 60' portion was at the time of the investigation practically as when constructed. Another 20' of the 100' section had no cresting plank or concrete apron and the remaining 20' had the concrete apron but no cresting plank.

Elevations were taken on the crest of each portion of the 100' section described above and on the old concrete spillway which is not being replaced and on the new concrete spillway, and permanent Railroad Commission Bench Marks were established. The elevations of the crests of the various spillways and the elevation and description of the location of the bench marks are given below.

The bench marks are the standard Railroad Commission design of aluminum bronze tablets marked "Railroad Commission of Wisconsin", set in concrete and described as follows:

Bench Mark No. 22-a; Aluminum bronze tablet set in a concrete post 5' long, the top of which is about level with the surface of the ground, located 70' east of the northwest corner of the parcel of land owned by the Janesville Electric Company and upon which the west end of dam abuts. Said corner being the intersection of the east and west highway, the church property and the Janesville Electric property. The bench mark is set about one foot south of the present highway fence. Elevation assumed 20.00 feet.

Bench Mark No. 22-b; An aluminum bronze tablet set in the west abutment of the dam. Elevation 15.61 feet.

Bench Mark No. 22-c; Surface of the east end of the concrete door sill in the north end of the power station. This sill is the same elevation as the main floor of the power station. Elevation 18.37'.

Elevations of crest of 100' section of old dam now being replaced;

20' section concrete apron		10.11 feet
20' wood crib section		10.76 "
60' built up plank section -	west end 11.10 feet	
	middle 11.04 "	
	east end 11.18 "	
	Average	11.11 feet

Elevation of forty foot concrete spillway at east end of dam not being replaced

west end 12.04 feet	
middle 12.04 "	
East end 12.36 "	
Average	12.11 Feet

Elevation of new concrete spillway just completed

	west end 11.58 feet	
about 100' from	" " 11.49 "	
	Average	11.54 Feet

The new concrete spillway is provided with bolts so that plank may be secured to the crest thus raising its elevation."

On February 21, 1917 the writer, assisted by E. L. Williams set a bench mark near the outlet of Lake Koshkonong and referred the elevation of the water surface to it.

<u>Bench Mark</u> Head of spike nail driven through washer in base of most southerly root of south fork of four prong ash tree, situated on farm of Herman Krueger, 75 feet north of Lake shore, 125 feet west of lake shore, directly north of cottages on outstanding knoll across the outlet of lake, 175 feet from corner of fence running due east from barn and about 1000 feet from house of Herman Krueger. Elevation assumed at 100.00 feet.

Elevation of lake 11 a.m. February 21, 97.47 feet.

The following elevations were also taken at Indian Ford Dam, levels starting from bench mark No. 22-b.

Top of concrete west end of dam	11.54 feet
Top of planks on spillway west end of dam	12.20 "
Water surface above dam 2.00 p.m.	12.54 "
Water surface near tail race below dam	6.16 "
Head on wheels	6.38 "

A discharge measurement of the Rock River was also made in the vicinity of the dam.

At the outlet of Lake Koshkonong and for a considerable distance down stream the river was practically free from ice. Ice was present in the pond above the dam. Downstream from the dam the river was more or less open until a point just above the mouth of the Yahara River about two miles below the dam was reached, at this point there was complete ice cover. A current meter discharge measurement was made at this point.

Time beginning measurement - - - - - - - -	3.30 p.m. February 21, 1917,
" end of " - - - - - - - -	4.25 p.m.
Number of measuring sections - - - - - - -	22,
Average thickness of ice - - - - - - - - -	0.80 feet,
Width of river - - - - - - - - - - - - - -	370 feet,
Total area cross-section under ice - - -	1230 sq. feet,
Mean velocity - - - - - - - - - - - - - - -	0.40 feet per second
Discharge - - - - - - - - - - - - - - - - -	492 cubic feet per second

On June 21 and 22, 1917, a more complete investigation was made by the writer assisted by C. A. Potts of the Engineering Department. In making these investigations a telescopic alidade; plane table and a 20 inch level were used. The adjustment of these instruments was tested and Bound to be in perfect condition. The investigation made may be divided into two parts.

1st Determination of elevations of present crest of dam and cofferdam or earthen embankment above the dam.

2nd Determination of elevation of bench mark used by John Nader* when his surveys of the dam and river were made during 1908 and 1909.

* John Nader was the engineer for the plaintiff in the case of State of Wisconsin ex rel L. M. Sturdevant, Attorney General, Plaintiff, vs. Pliny Norcross, Defendant, Rock County, Circuit Court, Hon. George Grimm, Circuit Judge presiding, December 8, 1909.

When the new dam was constructed during the summer of 1916 an earthen cofferdam or roadway was used above the line of the old dam. When the dam was completed this embankment was scraped down to an elevation about level with the top of the concrete. With water flowing over the dam the surface of the water takes a position which to the eye makes it appear that the top of the embankment upstream from the dam, is really higher than the dam proper. In order to determine if this was the case, elevations were taken on about the highest points along this embankment, submerged roadway, or cofferdam. A twenty inch Gurley level was used to determine the elevation and a telescopic alidade and plane table to determine the location of the sounding. There was at the time of the investigation about 1.6 feet of water at a high velocity passing over the crest. A boat was first let down from the bridge by means of a 1/2" rope. It was found that the boat could not be held in one position long enough to secure a reading on the rod. So the boat was dispensed with and the rope fastened to the waist of the rod-man. The rod man thus supported could hold the rod vertically and on the highest point. As near as could be told, with the water at the present high stage, the embankment was about 5 or 6 feet wide and sloped rapidly downward toward the bridge and to some extent toward the dam. Due to the greater depth off the embankment the rod man had to stay on top of it to keep from having his feet washed out from under him so that the following elevations show the average elevations of the top of the embankment from a point near the west end of the dam to the east end. All elevations refer to the Wisconsin Railroad Commission B.M.

Observation Number	Approximate Distance From west abutment	Elevation	Observation Number	Approximate Distance From west abutment	Elevation
1	22 feet	11.5 feet	18	130 feet	11.1 feet
2	27 "	11.3 "	19	132 "	11.0 "
3	27 "	11.9 "	20	132 "	11.4 "
4	35 "	11.2 "	21	137 "	11.4 "
5	36 "	10.5 "	22	148 "	10.7 "
6	38 "	10.6 "	23	160 "	11.2 "
7	45 "	10.9 "	24	170 "	11.2 "

Observation Number	Approximate Distance From west Abutment	Elevation	Observation Number	Approximate Distance From west Abutment	Elevation
8	51 feet	10.5 feet	25	180 feet	11.2 feet
9	62 "	11.0 "	26	190 "	11.0 "
10	67 "	11.5 "	27	190 "	10.6 "
11	72 "	10.6 "	28	207 "	10.7 "
12	81 "	11.3 "	29	218 "	10. "
13	87 "	11.0 "	30	232 "	10.4 "
14	98 "	11.3 "	31	245 "	10.6 "
15	110 "	11.3 "	32	250 "	10.8 "
16	118 "	11.0 "	33	254 "	10.8 "
17	125 "	11.0 "	34	270 "	10.8 "
			35	277 "	10.6 "

Minimum elevation	10.0	feet
Maximum "	11.5	"
Average "	11.0	"

The following elevations were also taken.

Concrete west end of dam	11.52	feet
Wood " " " "	12.04	"
Water surface below dam near tail race	8.42	"
Water surfacd 20'above crest	13.69	"
Water surface at crest	13.29	"
Water surface at bridge	13.69	"
West end of east spillway, top of concrete crest	12.02	"
East end of east spillway, Top of concrete crest	12.32	"

Due to the depth of water over crest and high velocity it was impossible to determine the elevation of the planks placed on the concrete at any place other than at the ends of the dam. From the appearance of the surface of the water as it passed over the crest the writer is of the opinion that at the time of the investigation the planks were off or partially off for nearly 100 feet at the east end of the main spillway. At the time of the visit of February 21, 1917, all the planks were in place at an average elevation of about 12.20 feet or .74 foot above the concrete crest, equal to about four or five 2" planks.

Determination of Elevations of Bench Marks or other Points to which John Nader referred his levels of 1908 - 1909.

Mr. Nader took as his datum the elevation of a bench mark at Fort Atkinson described by him; (page 85 Ex. A. submitted by Mr. Jeffres, hearing held 12-13-16) as engraved on the east corner of South abutment of the railroad bridge at Fort Atkinson and is elevation 26.23 feet. All of his elevations are referred to this bench mark. During the trial the elevations of no other bench marks were introduced. Certain elevations are however shown on (exhibit B introduced) and the elevations of other bench marks in the vicinity of the dam have been furnished by Mr. Rockwell the engineer who assisted Mr. Nader in making the original survey and who is now making investigations for the plaintiff. Mr. Korst of the Janesville Electric Co. was interviewed on the site of the dam but could furnish no information relative to bench marks to which the old dam had been referred nor elevations referred to the present crest.

One of the most permanent marks found, of which the elevation had been determined by Mr. Nader was a chisel draft on S.W. corner on top stone on downstream end of second pier from west end of the highway bridge, just above the dam.

Elevation Wis. R.R. Com. datum 17.60 feet,
Elevation as used by John Nader, reported by
C. A. Rockwell, 26.96 feet,
Correction to reduce Nader's elevations to
Wis. R.R. Com. datum = 9.36.

Two other bench marks were also tied in with levels as follows: Chisel draft on top stone, southwest corner of downstream end of first bridge pier from east end of bridge.

Elevation Wis. R.R. Com. datum 17.57 feet.
Elevation as used by Nader and reported by C. A. Rockwell ______
Correction to be used to reduce Nader's elevations to Wis. R.R. Com. datum ____
Chisel draft on top stone of east bridge abutment downstream side,
Elevation Wis. R.R. Com. datum 18.04.
Elevation as used by Nader and reported by C. A. Rockerll = _____
Correction to be used to reduce Nader's elevation to Wis. R.R. Com. datum = ___

The preceeding bench marks are definite points located on a structure which has beyond all doubt remained unchanged during the last few years. Numerous other bench marks are shown on Naders map (exhibit B) of the dam as follows:

Point on downstream west abutment of bridge. Elevation 25.57. Point could not be located.

Two points on east wall of tail race, elevation 19.24 feet, and 23.60 feet. This wall has been removed and therefore all trace of bench marks gone.

Point on west wall tail race, elevation 19.05. This wall has probably been changed as the point could not be located.

Point on stone of east abutment to second gate to wheels from west bank. At the corner of the wall where this stone was, the present appearance is, that stone on which bench mark was most likely placed has fallen off. The elevation of the water table of the old Light and Power plant is shown at an elevation of 28.00 feet. A definite point is shown on the map, (exhibit B) as the north east corner of water table, elevation 28.00 feet. Since the fire which destroyed the old plant, concrete has been placed on top of the old floor, the water table at the northeast corner is however very clearly defined. W.W. Powers, the present operator and who also operated the old plant, stated that the point used by the writer was without any doubt the old water table. Elevation as determined by writer = 18.57. Wis. R.R. Com. datum elevation determined by Nader = 28.00 feet. Correction to use to reduce Nader's elevations to Wis. R.R. Com. datum = 9.43 feet.

The elevation of the top of the west abutment as shown by Exhibit B at an elevation of 25.00 feet. The elevation of the present abutment represents closely the elevation of the old abutment and is at an elevation of approximately 15.45 feet. The point is not as well defined as the remainder of the points given but is probably correct within .20 feet.

The difference between Nader's datum and the Wis. R.R. Com. datum as determined by preceeding levels seems very consistent and a correction factor of -9.40 feet is undoubtedly correct within .10 feet and can be used to reduce Nader's elevations of the crest of the dam as shown on exhibit to Wis. R.R. Com. datum.

The elevation of the crest of the dam as shown on a map submitted as exhibit B in the trial referred to at the beginning of this memorandum is 20.66 feet or reduced to present datum 11.26 feet by the correction factor of -9.40 feet. The elevation of the 60' built up plank section which was in place when Mr. Halbert made his investigation and which he believed to represent nearly the elevation of the crest was found at an elevation of 11.11 feet. The average elevation of the 180 feet of concrete spillway at the present time is approximately elevation 11.55 feet. The average elevation of the 96 foot spillway section is 12.15 feet. On top of the 180 foot concrete spillway section plank have been placed which during the winter had an average elevation of 12.20 feet. On the basis of the facts as presented the 180 feet of concrete crest is built approximately .35 feet higher than the crest shown on exhibit B, the 96 foot concrete spillway section is built 1.0 feet higher and when all the planks were in place as during February 1917, the 180 spillway section was 1.0 feet higher than the old crest.

Study of the Effect of Earthen Embankment on the Head.

The earth embankment or old cofferdam above the concrete crest has much the same effect upon the head in the pond as would a broad crested weir. The surface of water or nappe while flowing over a broad crested weir becomes of nearly uniform depth over a considerable portion of the downstream top of the dam or weir. Type "B" Plate (1) shows the theoritical nappe in flowing over such a weir or dam. A critical observer of the water flowing over the Indian Ford Dam as it is at present would believe that the bed of the river above the dam were higher than the dam itself; this is due to the increased head necessary to carry water over a broad crested weir and not to higher elevations as is shown by sounding and levels taken. In order to determine approximately what effect the earthen embankment has on the head a study was made of the flow over a dam having a flat crest of .93 foot wide and one having a flat crest 16.30 feet wide. See types "A" and "B" plate 1. The top of the concrete crest, as approved by the commission to be built at Indian Ford was 1.0 feet in width so that the discharge over a dam with a crest of type "A" should compare closely with the discharge over the dam as built if it were not for the embankment. The dam with a width of crest of 16.30 feet is taken as comparing some what favorably with the cross section of the Indian Ford dam as it is at present. The determination of the discharge over the dam type "A" and type "B" based on wier experiments made at the Cornell Hydraulic Laboratory as outlined in U.S. Geological Survey Water Supply paper no. 200 with derived coefficients to be used in connection a discharge table computed by Bazins formula for sharp crested rectangular weirs. See "River Discharge" Hoyt and Grover pages 166-171. In using this table the following coefficients were used.

Head	Type A	Type B
0.5	.792	.790
1.0	.899	.790
1.5	.982	.792
2.0	1.00	.793
2.5	1.00	.793
3.0	1.00	.791

The following table shows the discharge in second feet per foot of crest length for the two types.

Head	Type A	Type B
.1	.103	.103
.5	.958	.956
1.0	3.06	2.69
1.5	6.30	4.99
2.0	9.87	7.83
2.5	14.03	11.13
3.0	18.74	14.86

On plate 1 is shown the plotted values of the discharge and the vertical distances between the two curves representing graphically the increased head necessary to carry the same amount of water over the broad crested weir in comparison with a wier having a width of 0.93 feet.

Head Feet	Increased height necessary to carry the same amount of water over a broad crested weir
0	.0 feet
0.5	.0 "
1.0	.08 "
1.5	.20 "
2.0	.30 "
2.5	.40 "
3.0	.58 "

The models used in the weir experiments were of planed matched timber. In actual construction and as in the case of Indian Ford the approach to the dam is of earth, bowlders and possibly broken stone approaches which would require a considerably higher head then that shown by the experiments. Actual elevations of water surface at Indian Ford at a head of about 1.6 feet showed 0.4 foot fall from a point about 15 feet above the dam to the water surface at the crest of the dam or about twice the computed increase in head for the same stage.

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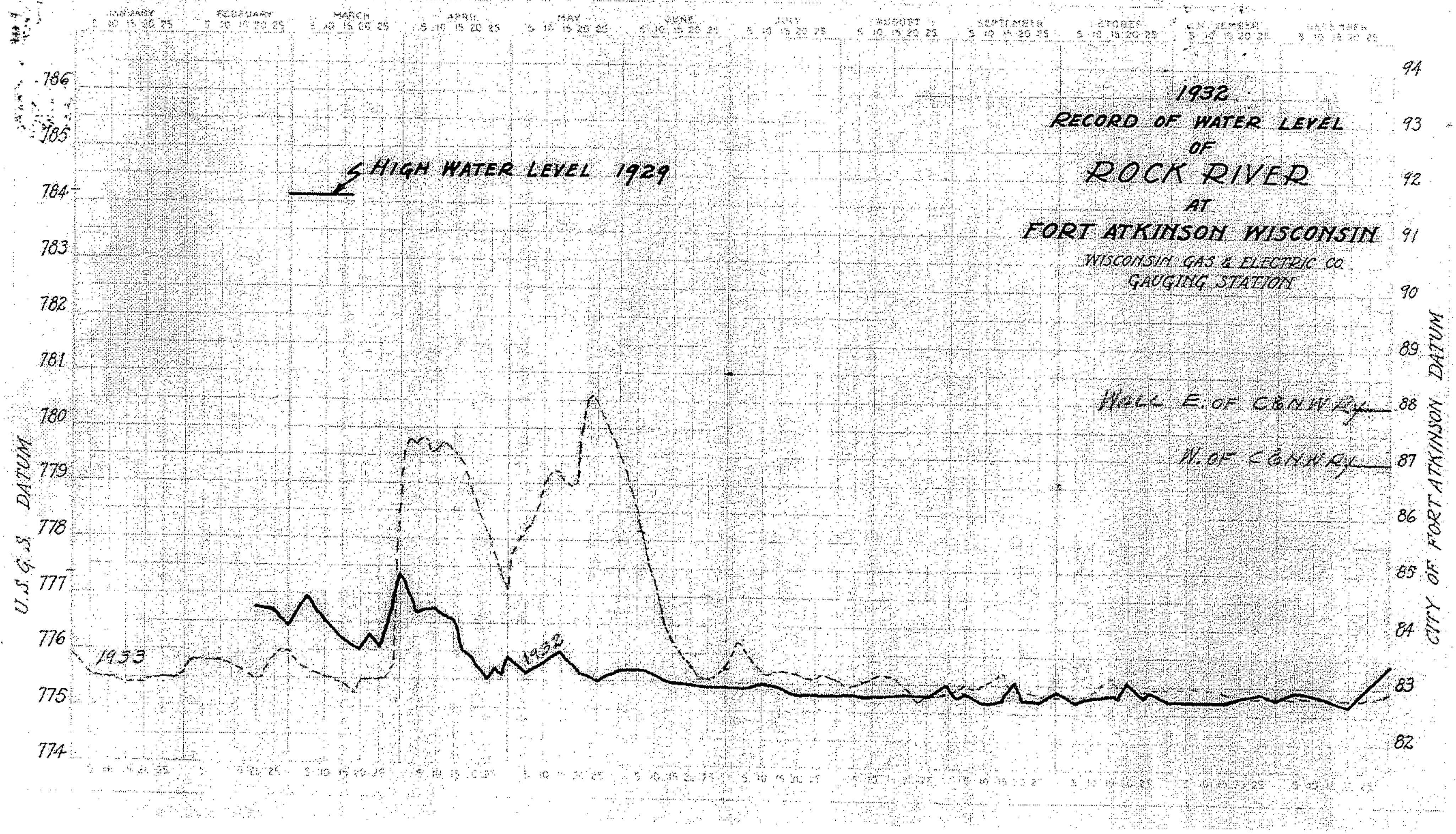
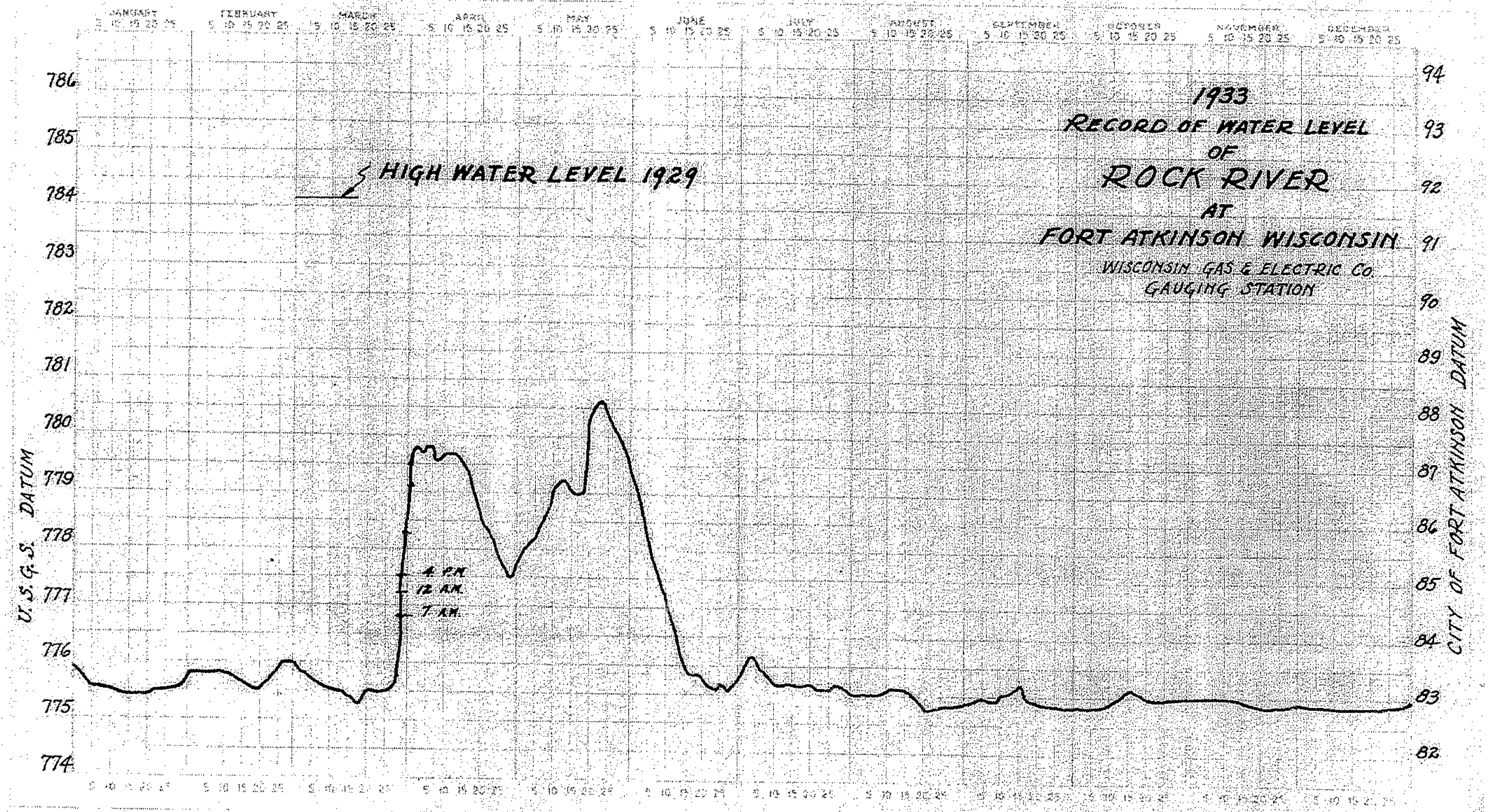
Attachment 4. Water Level Records

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RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WISCONSIN GAS & ELECTRIC CO.
GAUGING STATION
HIGH WATER LEVEL 1929
4 P.M.
12 A.M.
7 A.M.
U.S.G.S. DATUM
CITY OF FORT ATKINSON DATUM
786
785
784
783
782
781
780
779
778
777
776
775
774
94
93
92
91
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87
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82
JANUARY
FEBRUARY
MARCH
APRIL
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JULY
AUGUST
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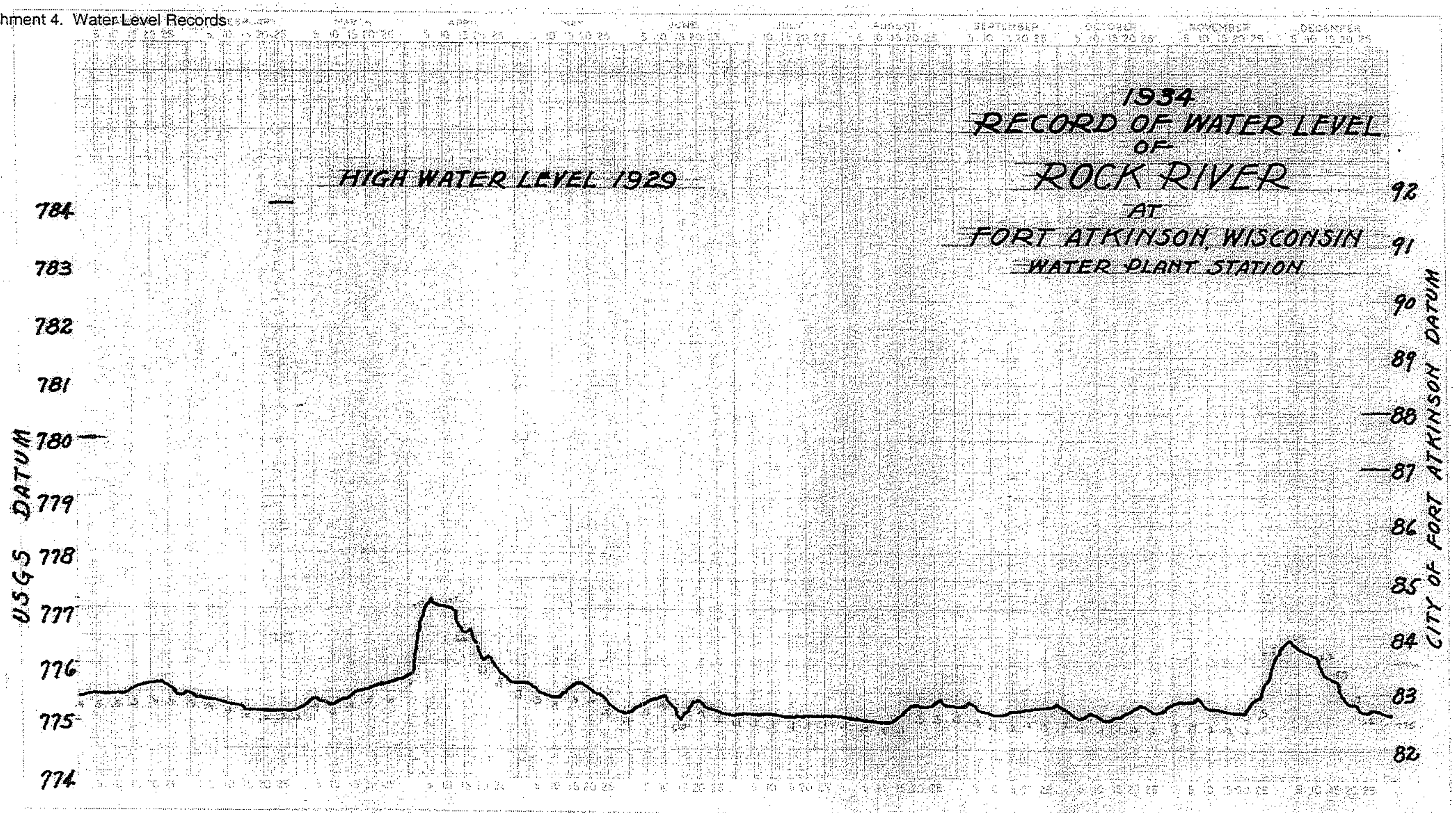
DECEMBER
5 10 15 20 25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RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON, WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
USGS DATUM
784
783
782
781
780
779
778
777
776
775
774
CITY OF FORT ATKINSON DATUM
92
91
90
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88
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84
83
82
MARCH
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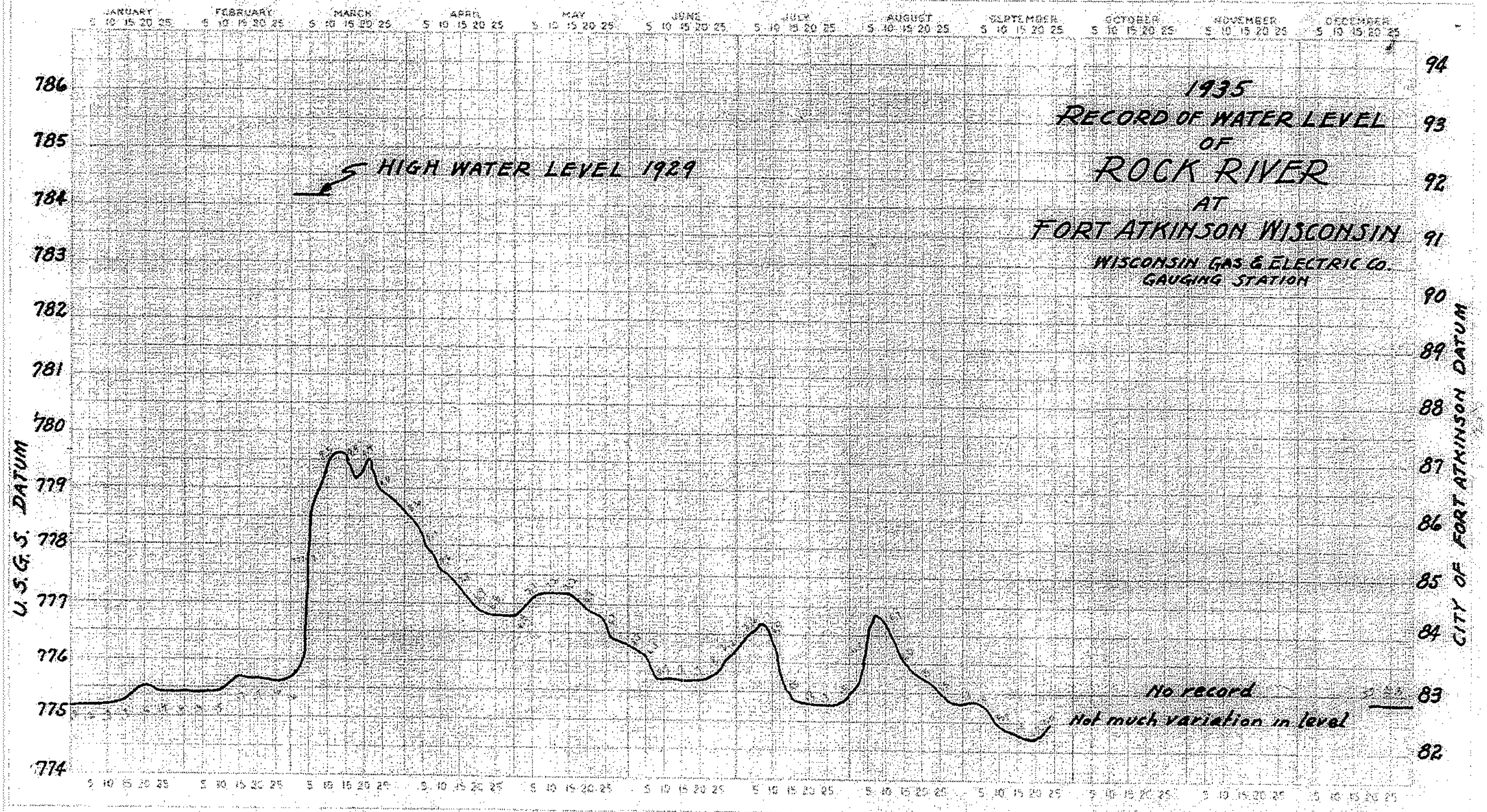
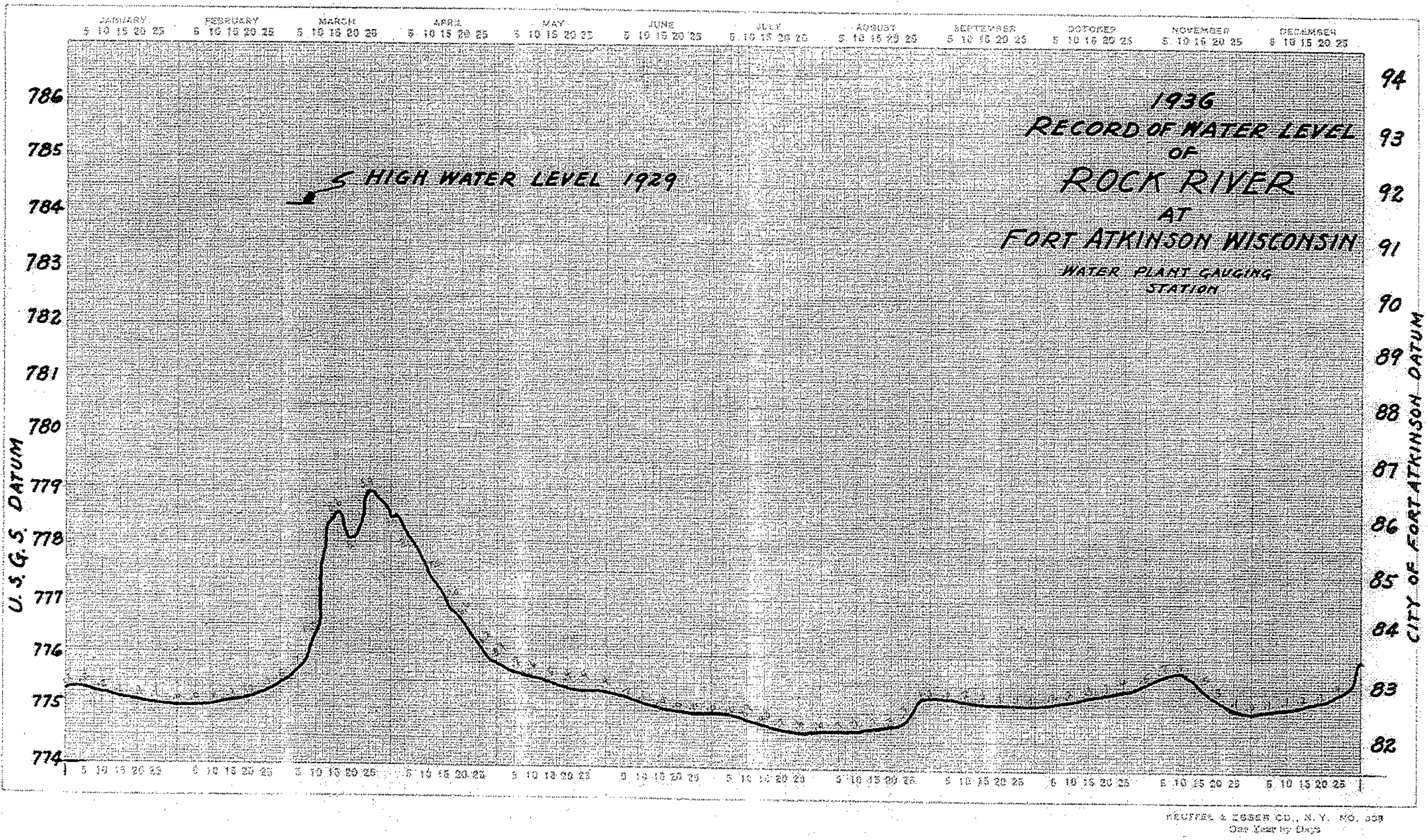
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

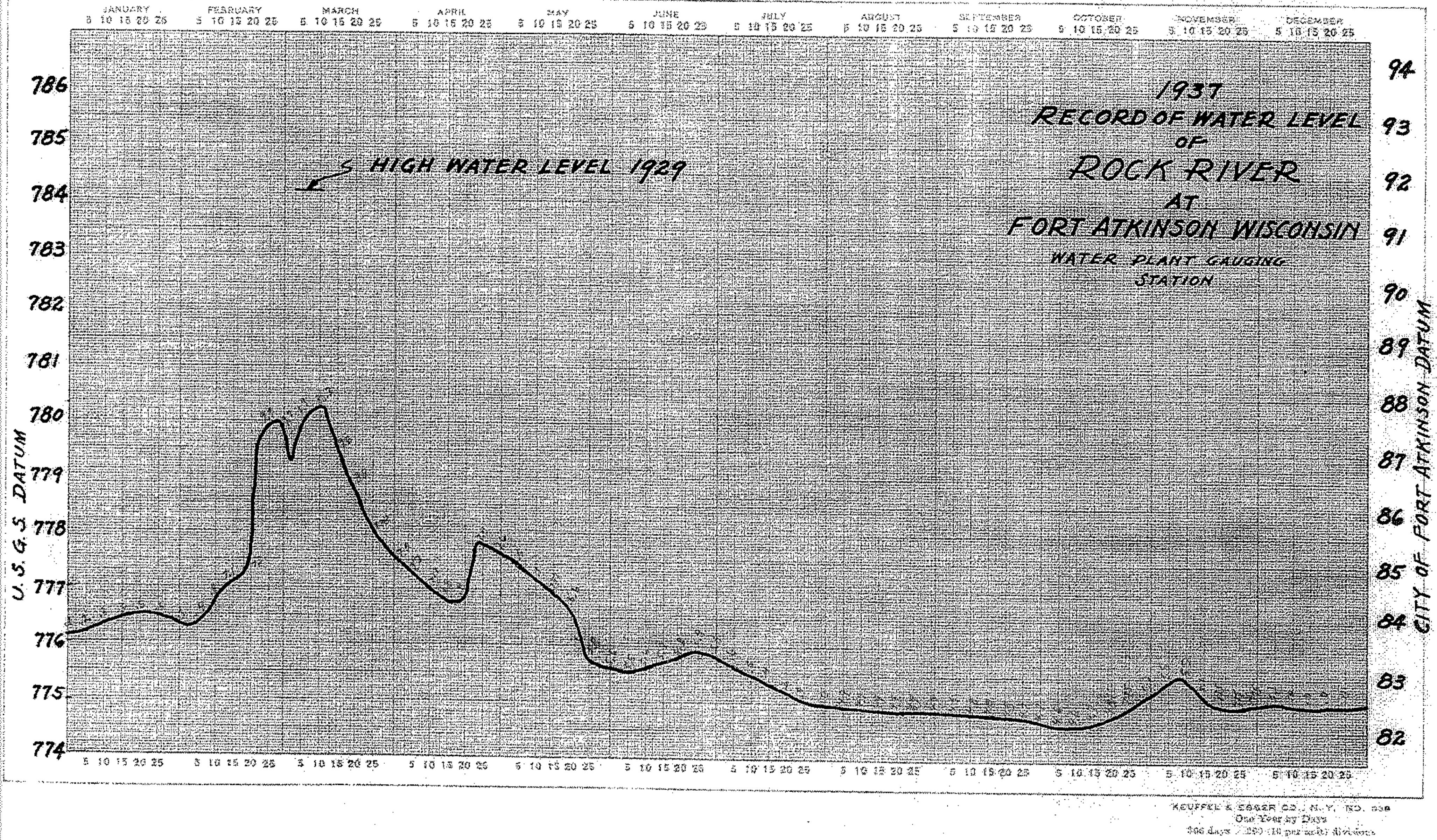
Attachment 4. Water Level Records



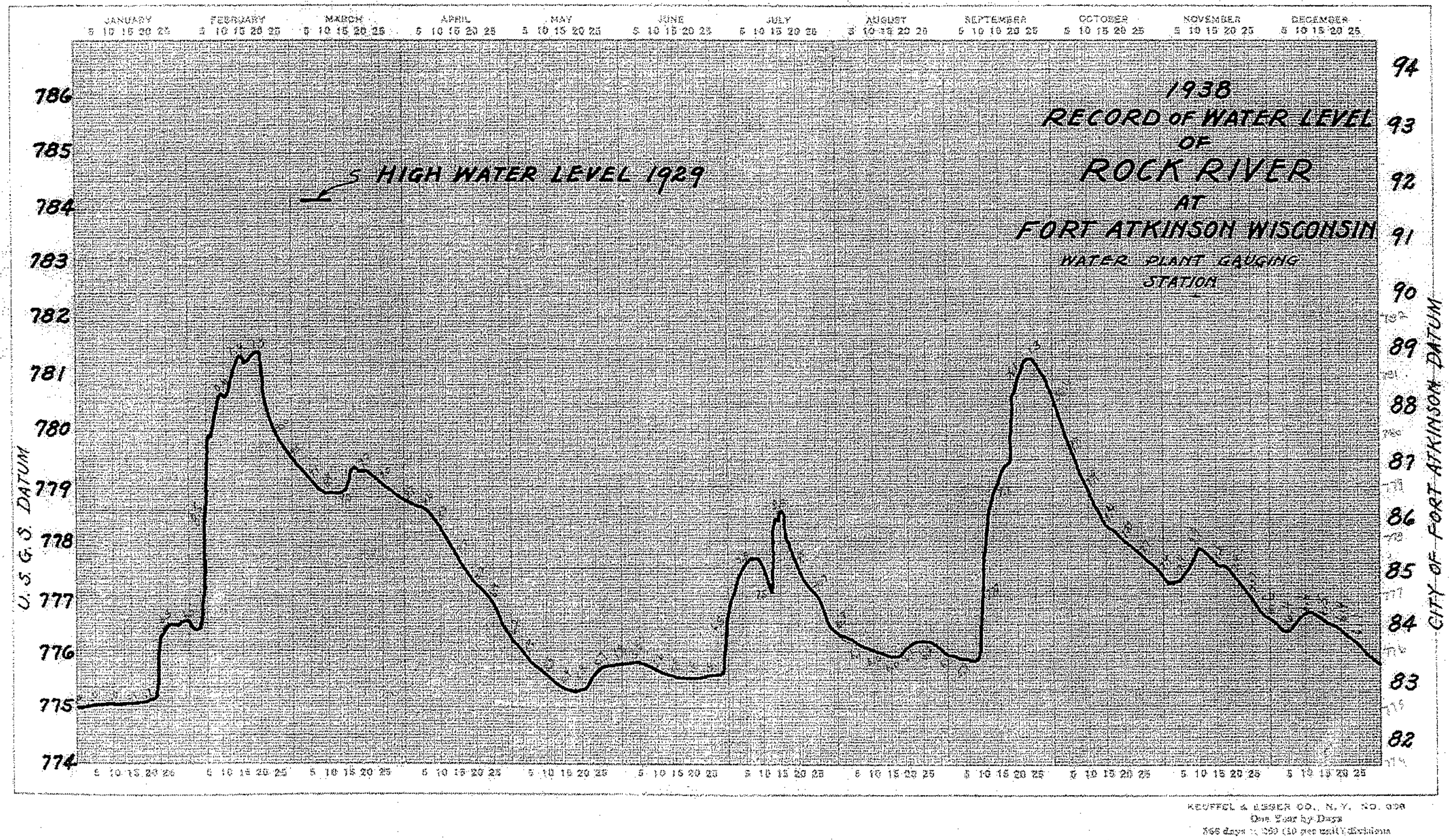
Attachment 4. Water Level Records

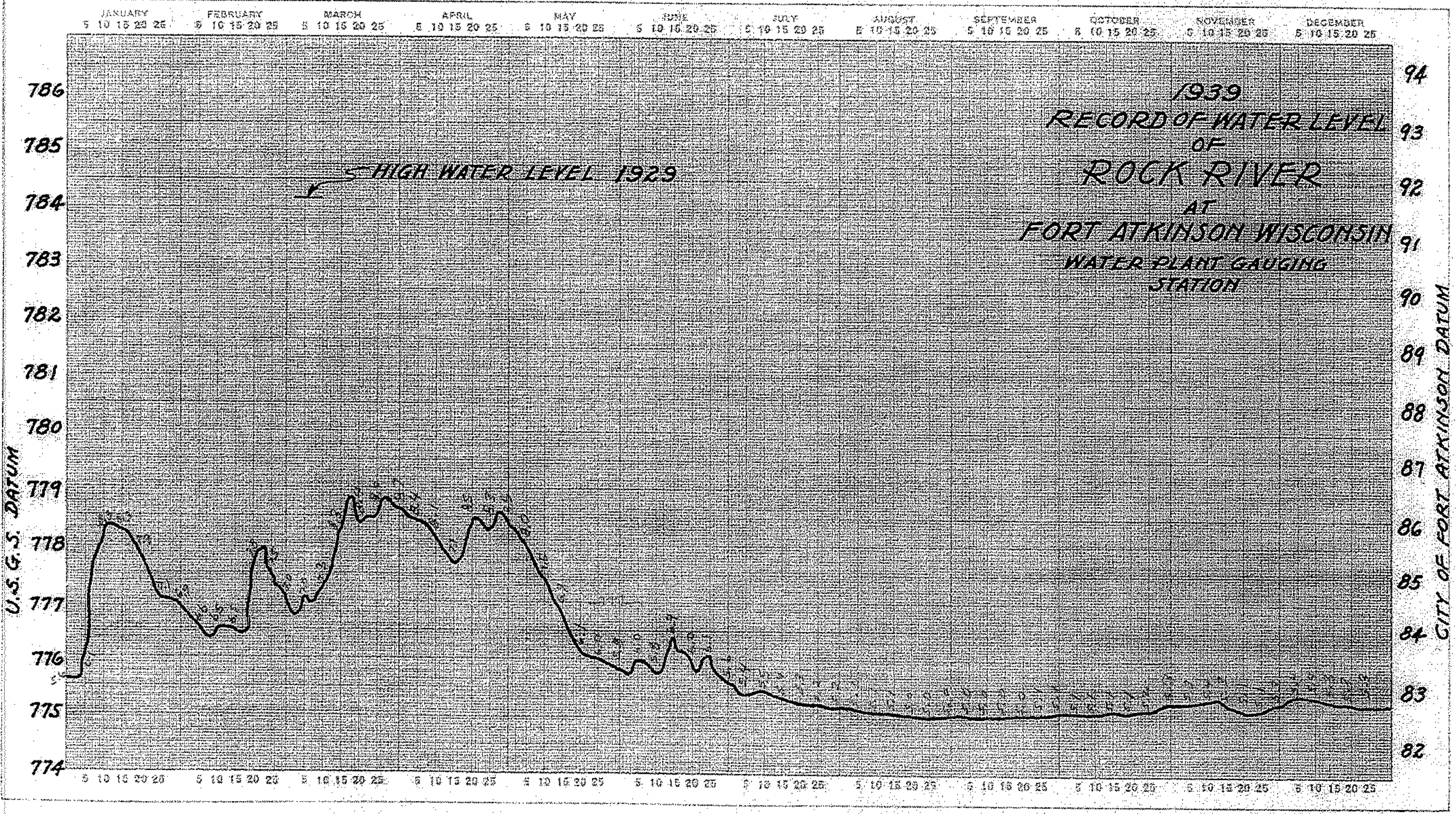


Attachment 4. Water Level Records



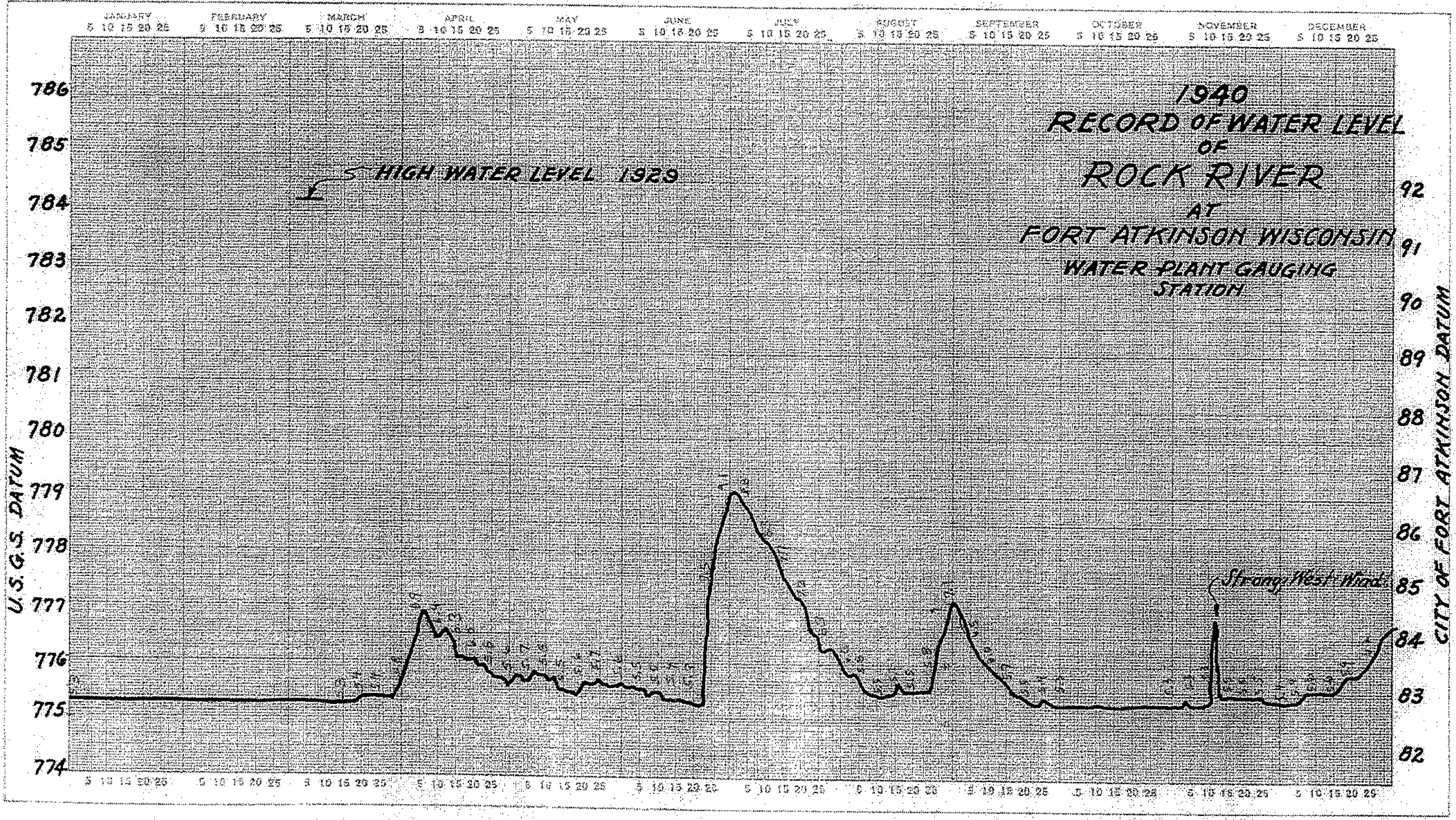
Attachment 4. Water Level Records

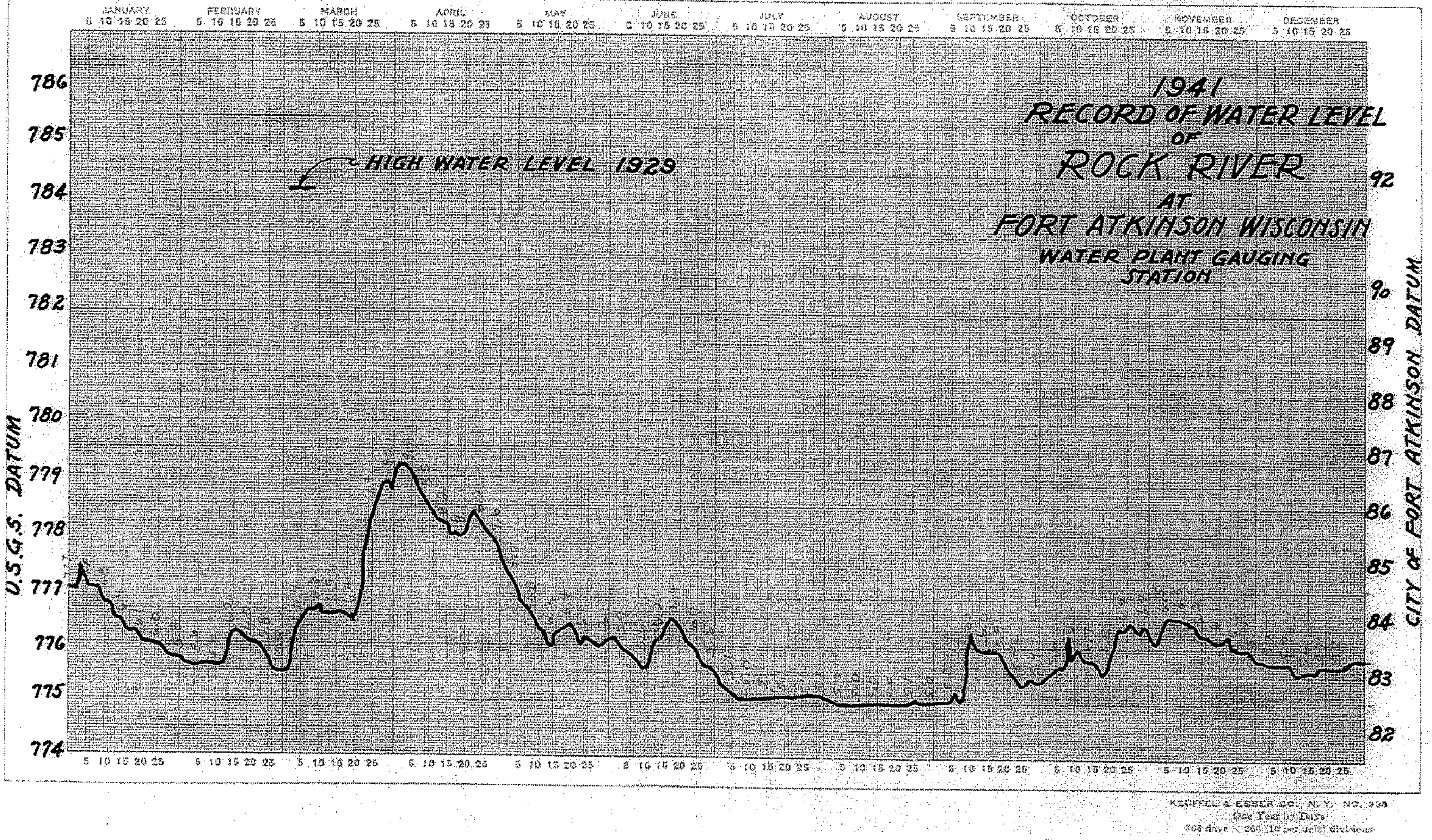




KEUFFEL & ESSER CO., N. Y. NO. 338
One Year by Days

Attachment 4. Water Level Records




1941
RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT GAUGING
STATION
HIGH WATER LEVEL 1929
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
U.S.G.S. DATUM
786
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CITY of FORT ATKINSON DATUM
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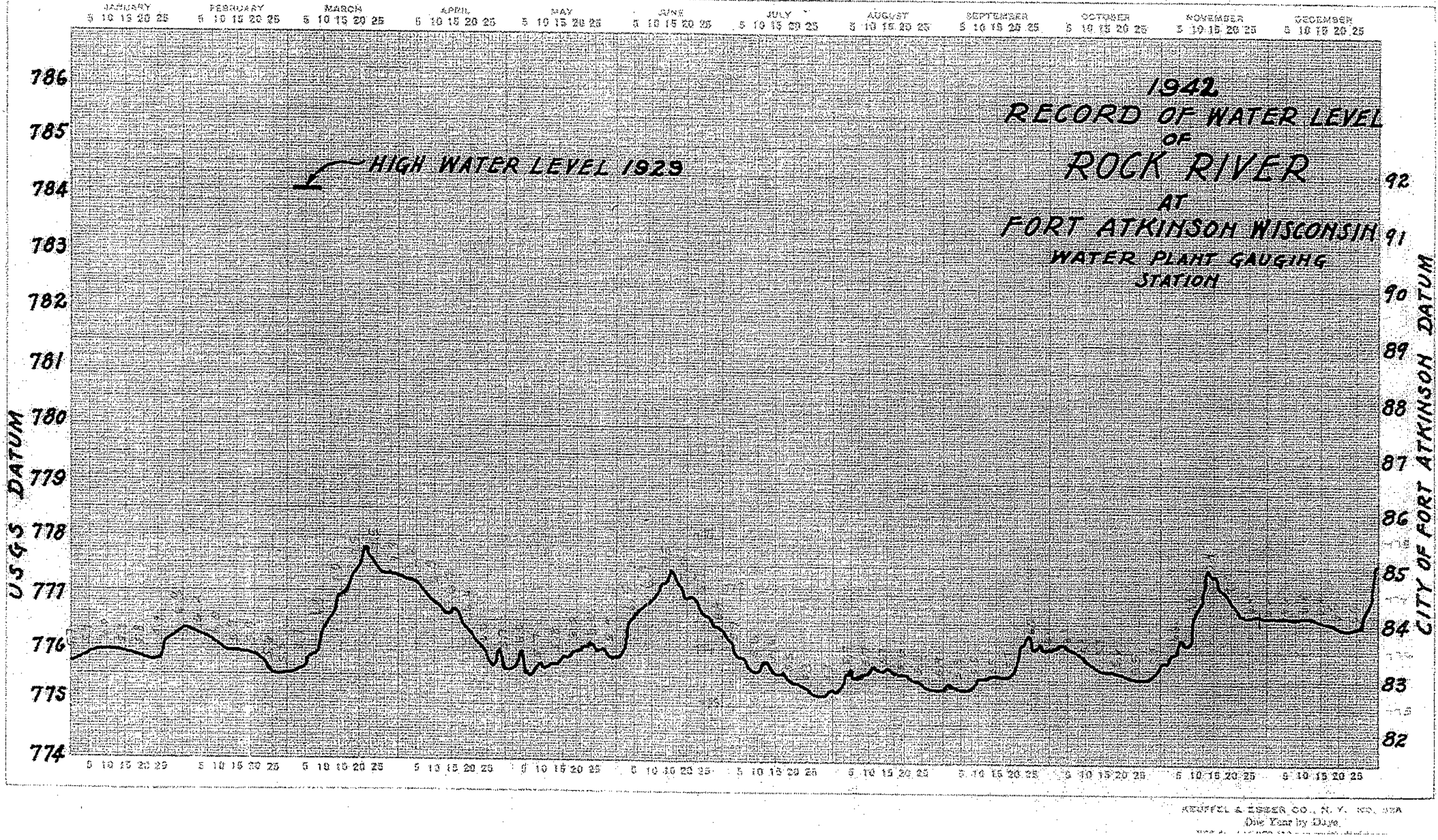
KEUFFEL & ESSER CO., N.Y. NO. 358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OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT GAUGING
STATION
HIGH WATER LEVEL 1929
JANUARY
FEBRUARY
MARCH
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JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
USGS DATUM
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CITY OF FORT ATKINSON DATUM
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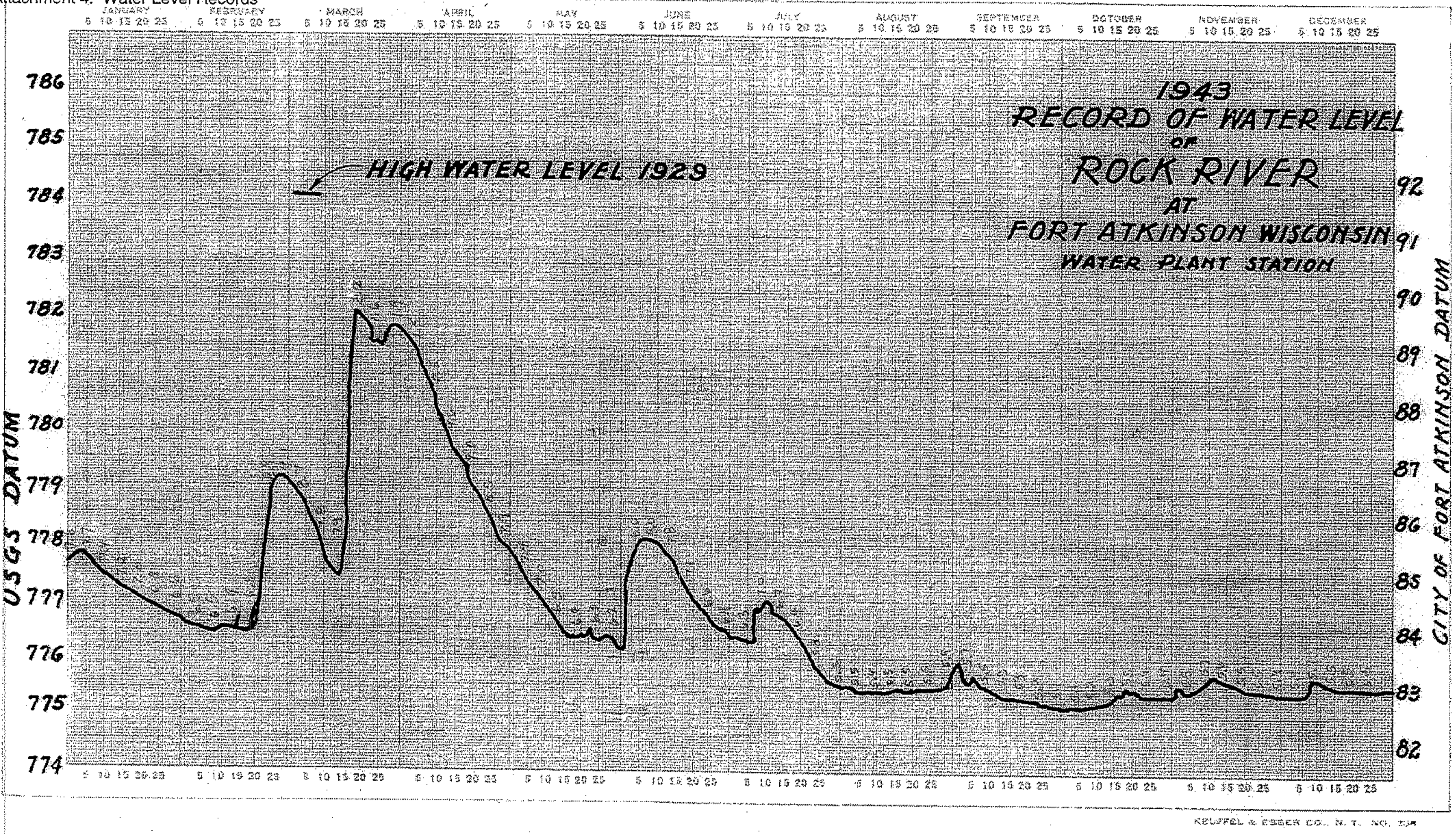
KEUFFEL & ESSER CO., N. Y.
One Year by Days

ttachment 4. Water Level Records



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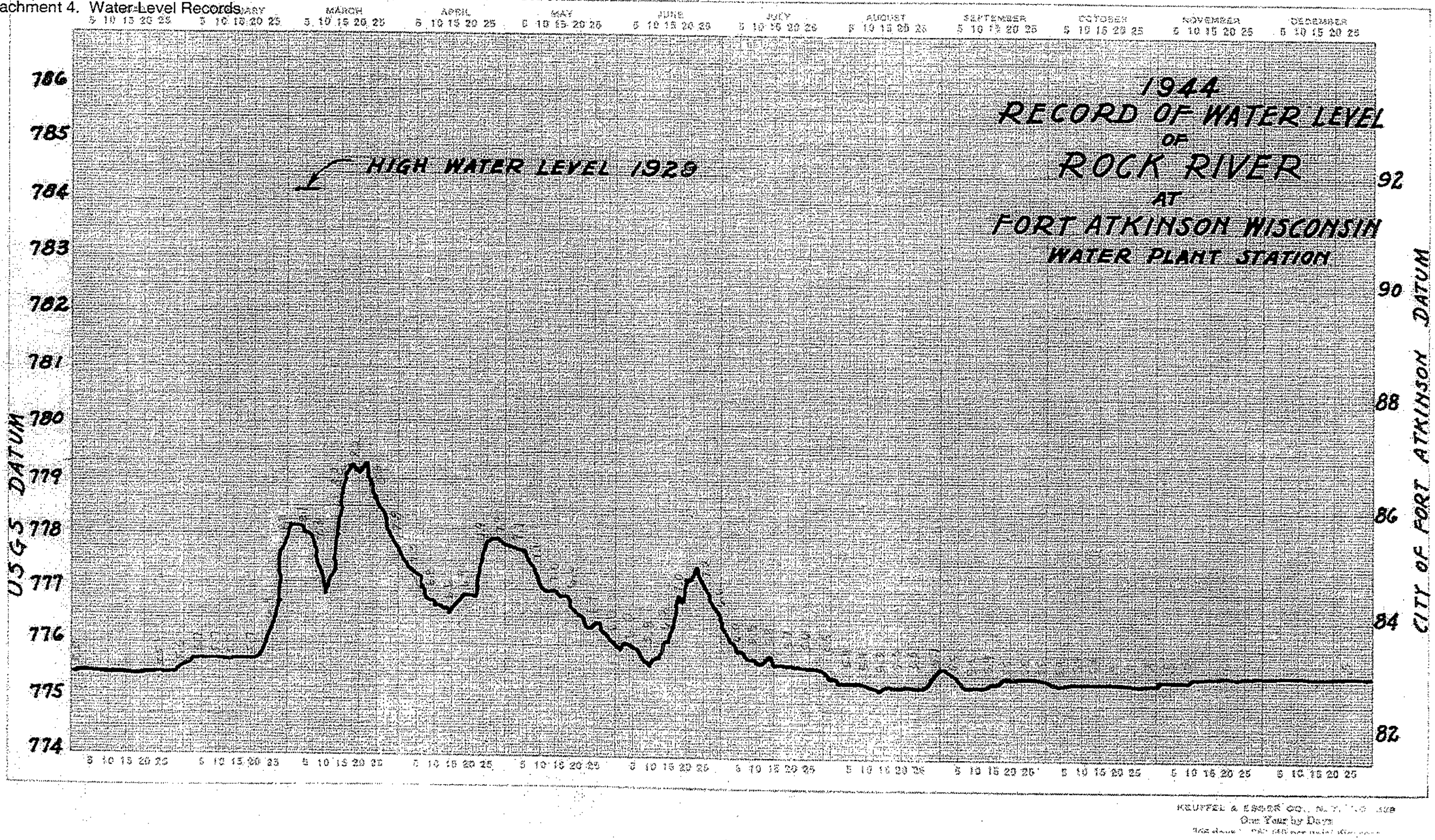

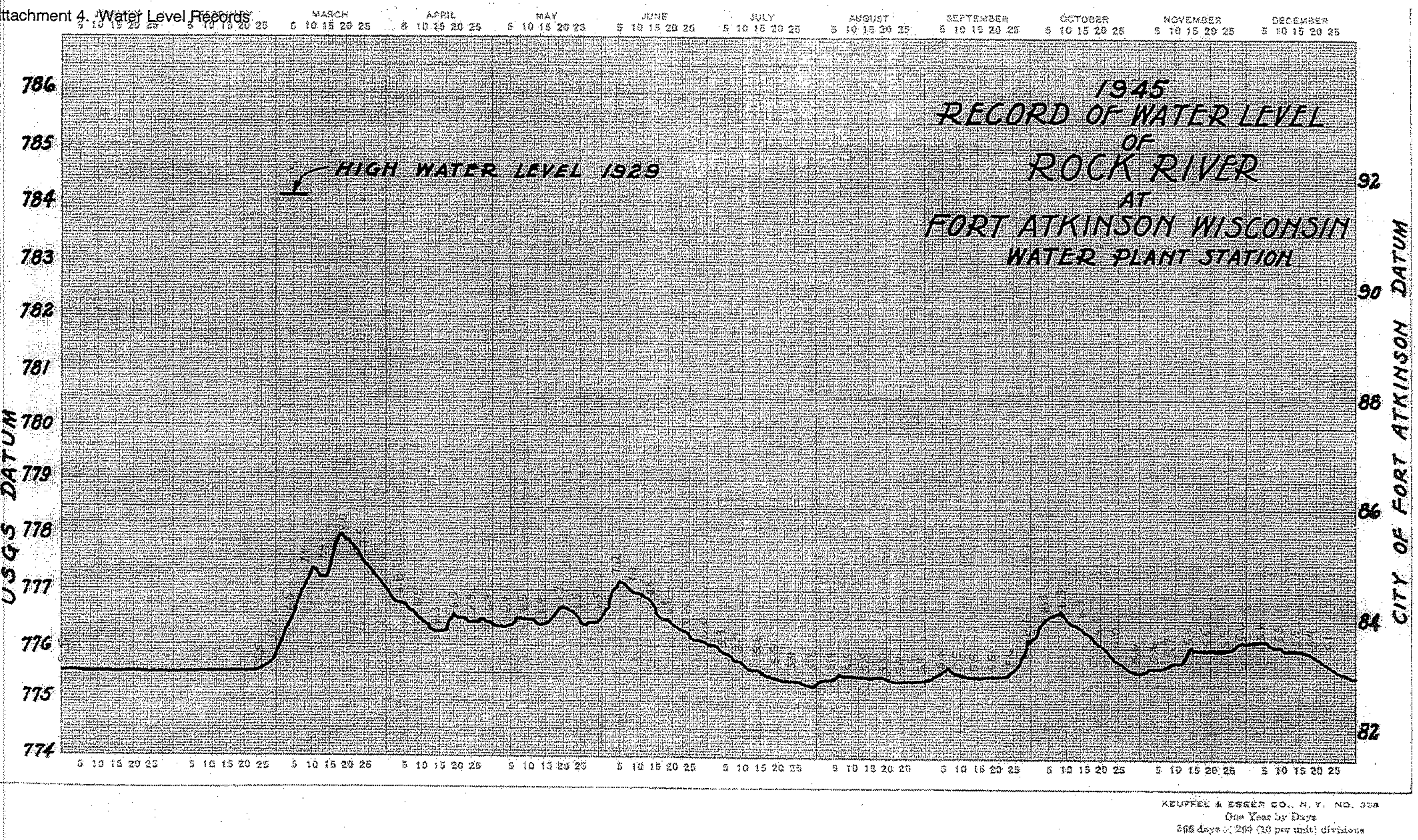
1945
RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
MARCH
APRIL
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SEPTEMBER
OCTOBER
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USGS DATUM
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CITY OF FORT ATKINSON DATUM
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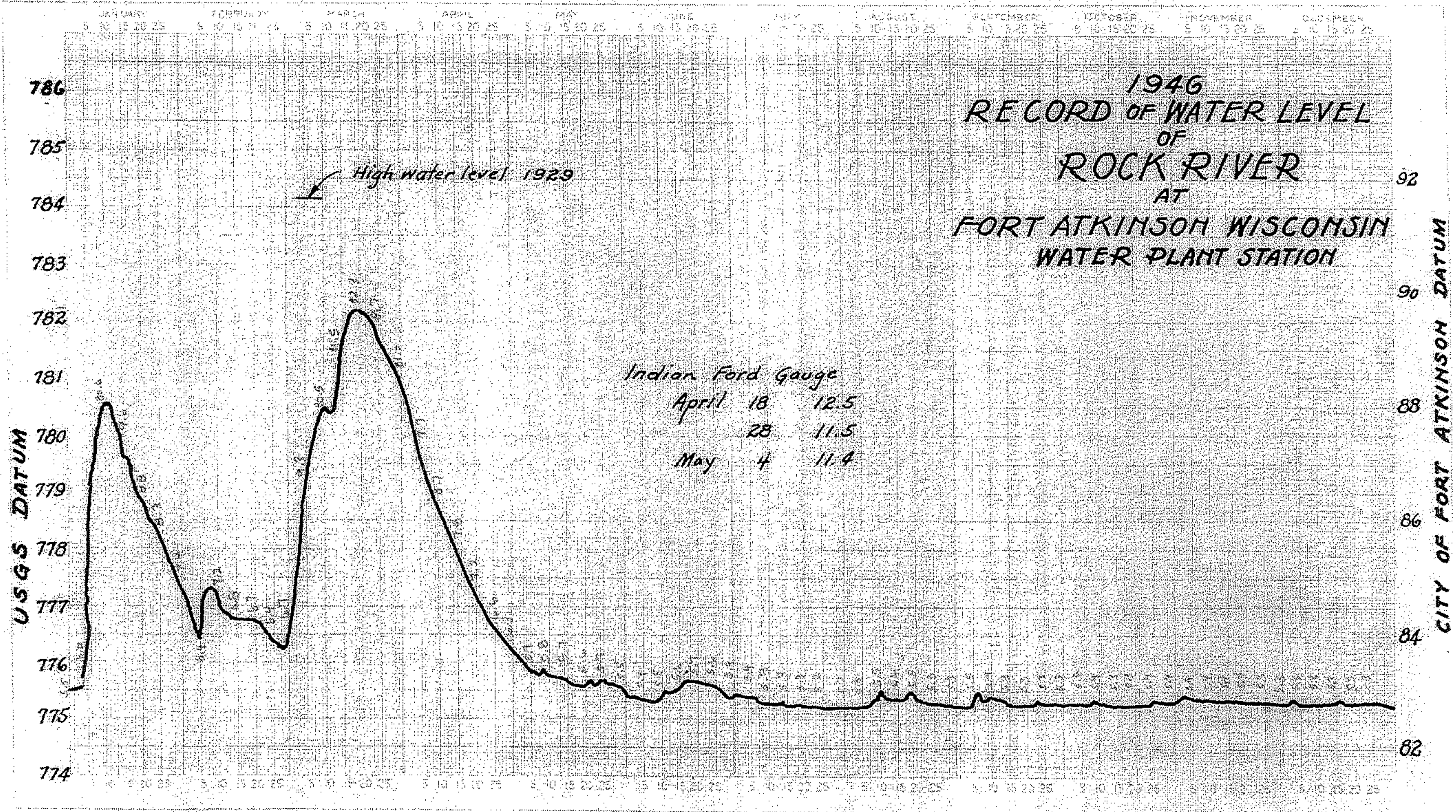
KEUFFEL & ESSER CO., N.Y. NO. 358
One Year by Days
366 days × 200 (10 per unit) divisions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RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
High water level 1929
Indian Ford Gauge
April 18 12.5
28 11.5
May 4 11.4
USGS DATUM
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CITY OF FORT ATKINSON DATUM
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JANUARY
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OCTOBER
NOVEMBER
DECEMBER
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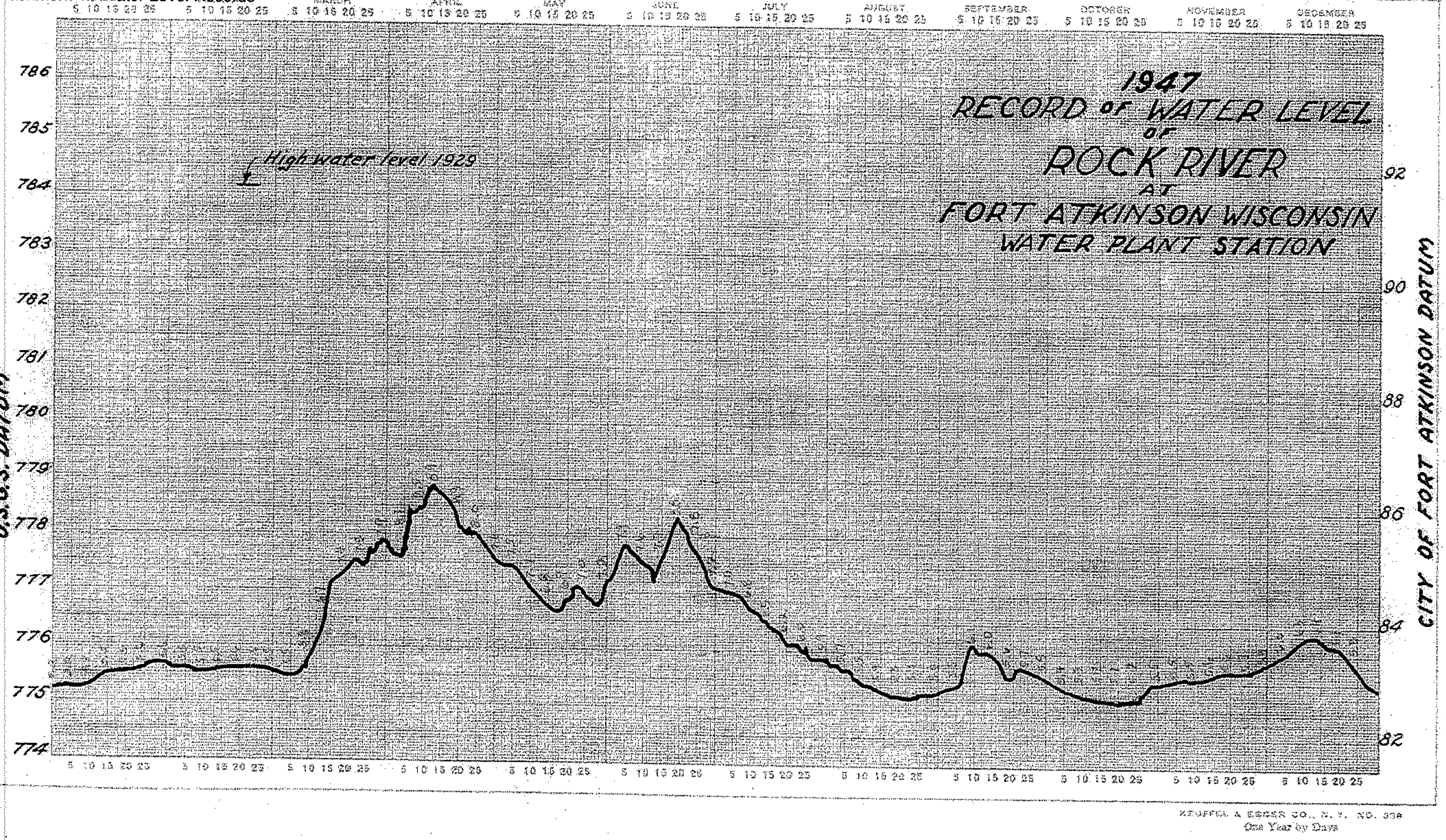
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OF
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AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
High water level 1929
MARCH
APRIL
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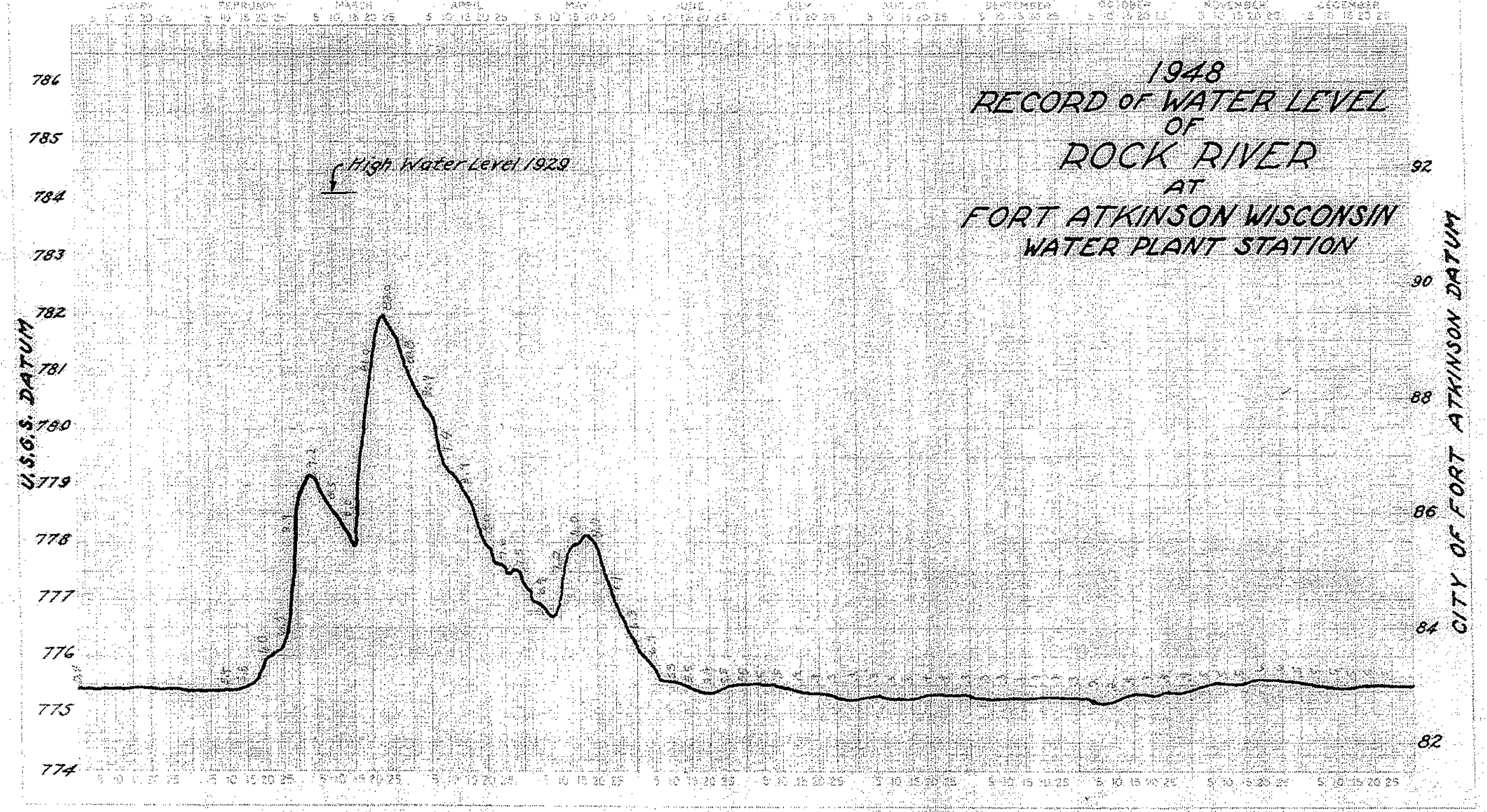
CITY OF FORT ATKINSON DATUM
KEUFFEL & ESSER CO., N. Y. NO. 358
One Year by Days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RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
High Water Level 1929
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CITY OF FORT ATKINSON DATUM
JANUARY
FEBRUARY
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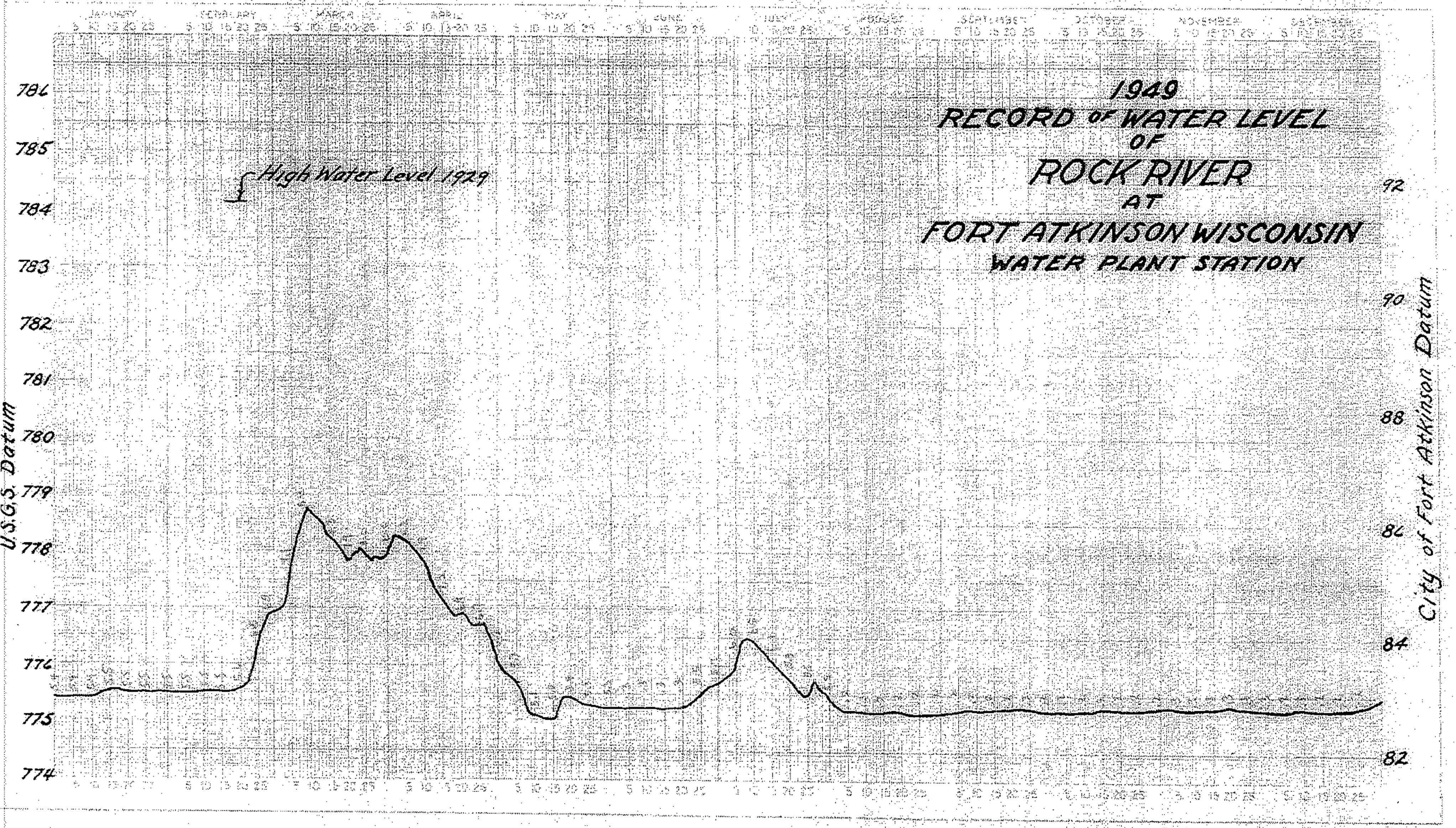
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ROCK RIVER
AT
FORT ATKINSON WISCONSIN
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High Water Level 1929
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MARCH
APRIL
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JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
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U.S.G.S. Datum
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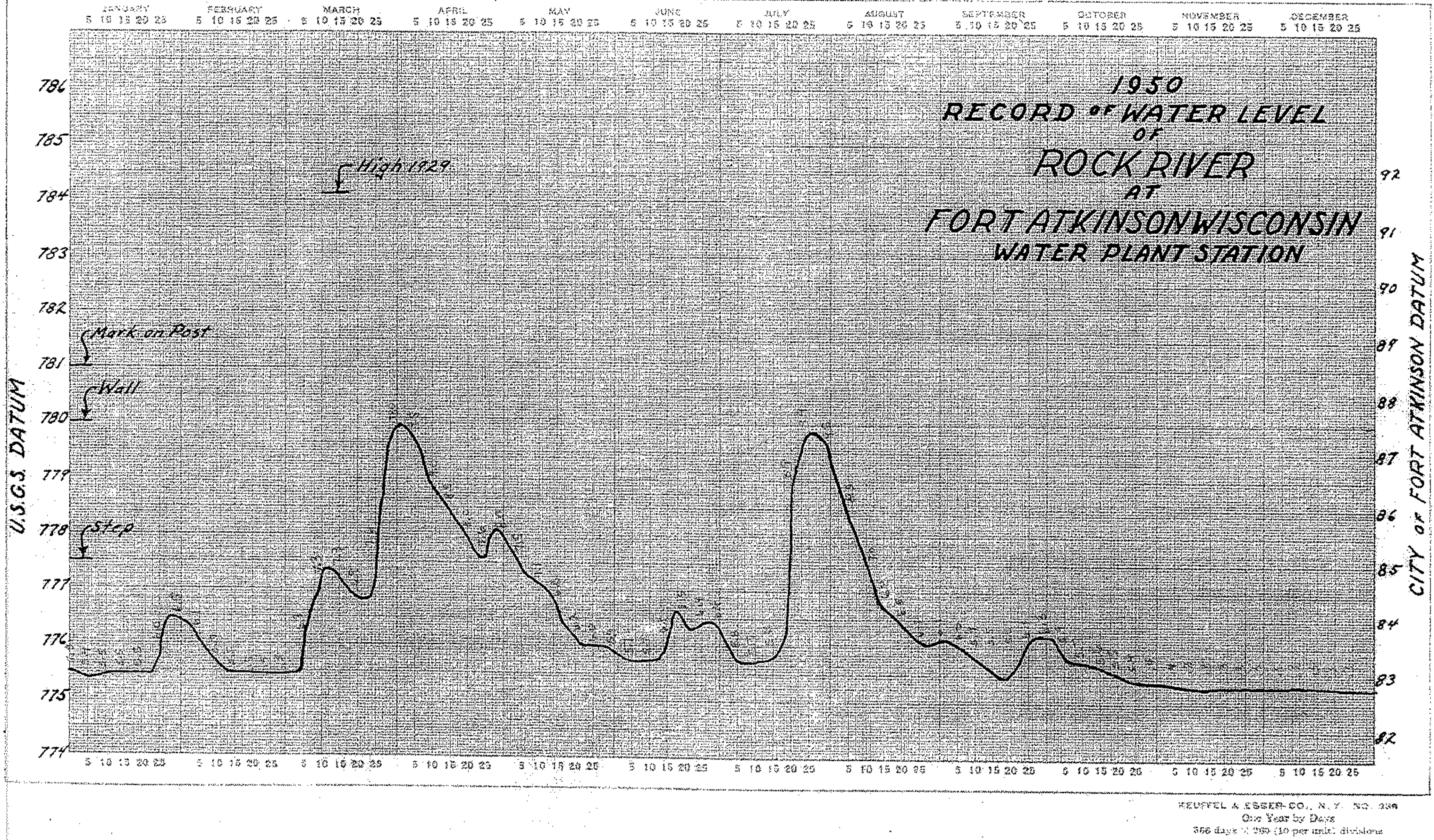
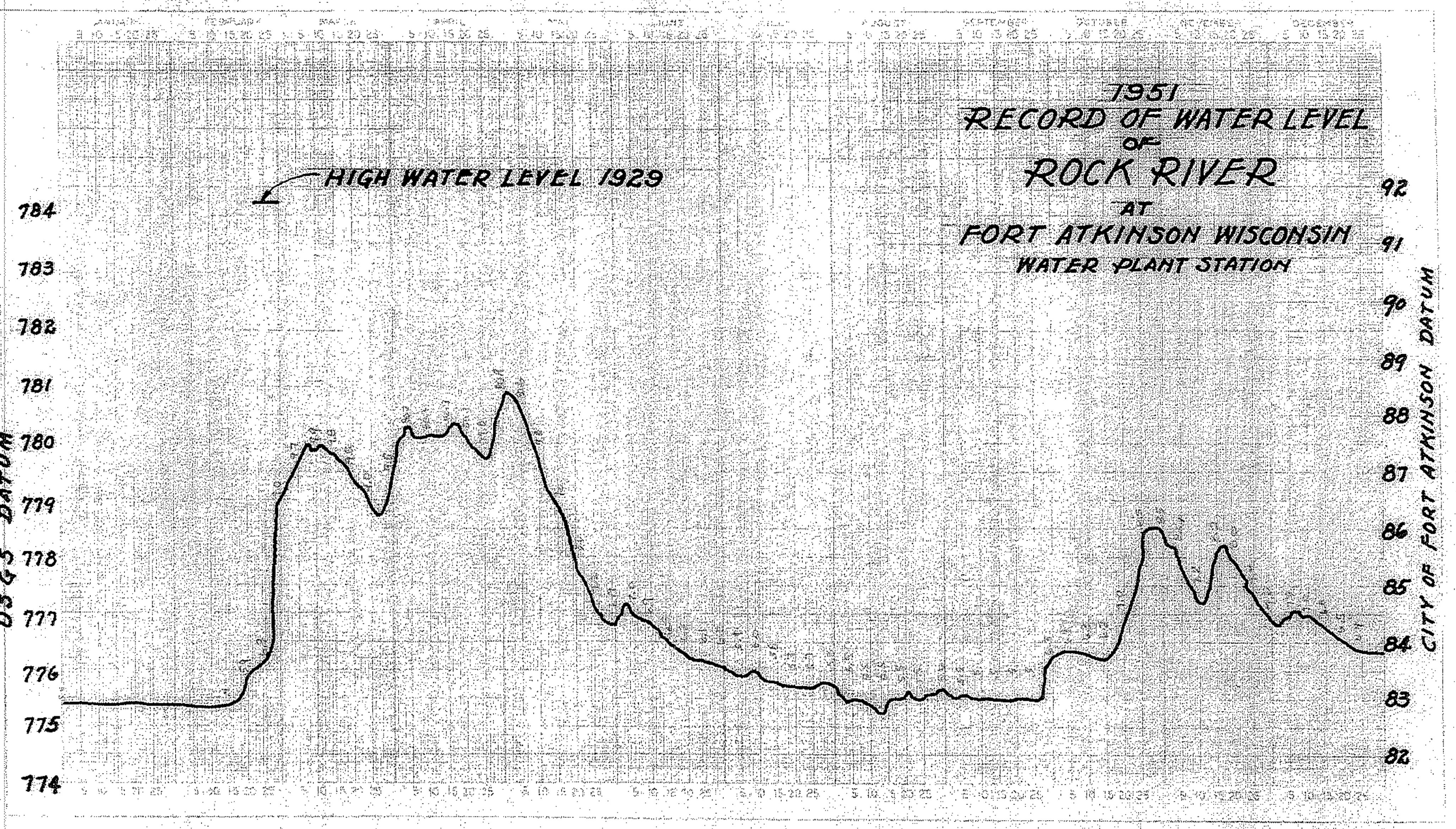
84
82
City of Fort Atkinson Datum

Attachment 4. Water Level Records

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RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
USGS DATUM
784
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CITY OF FORT ATKINSON DATUM
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JANUARY
FEBRUARY
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SEPTEMBER
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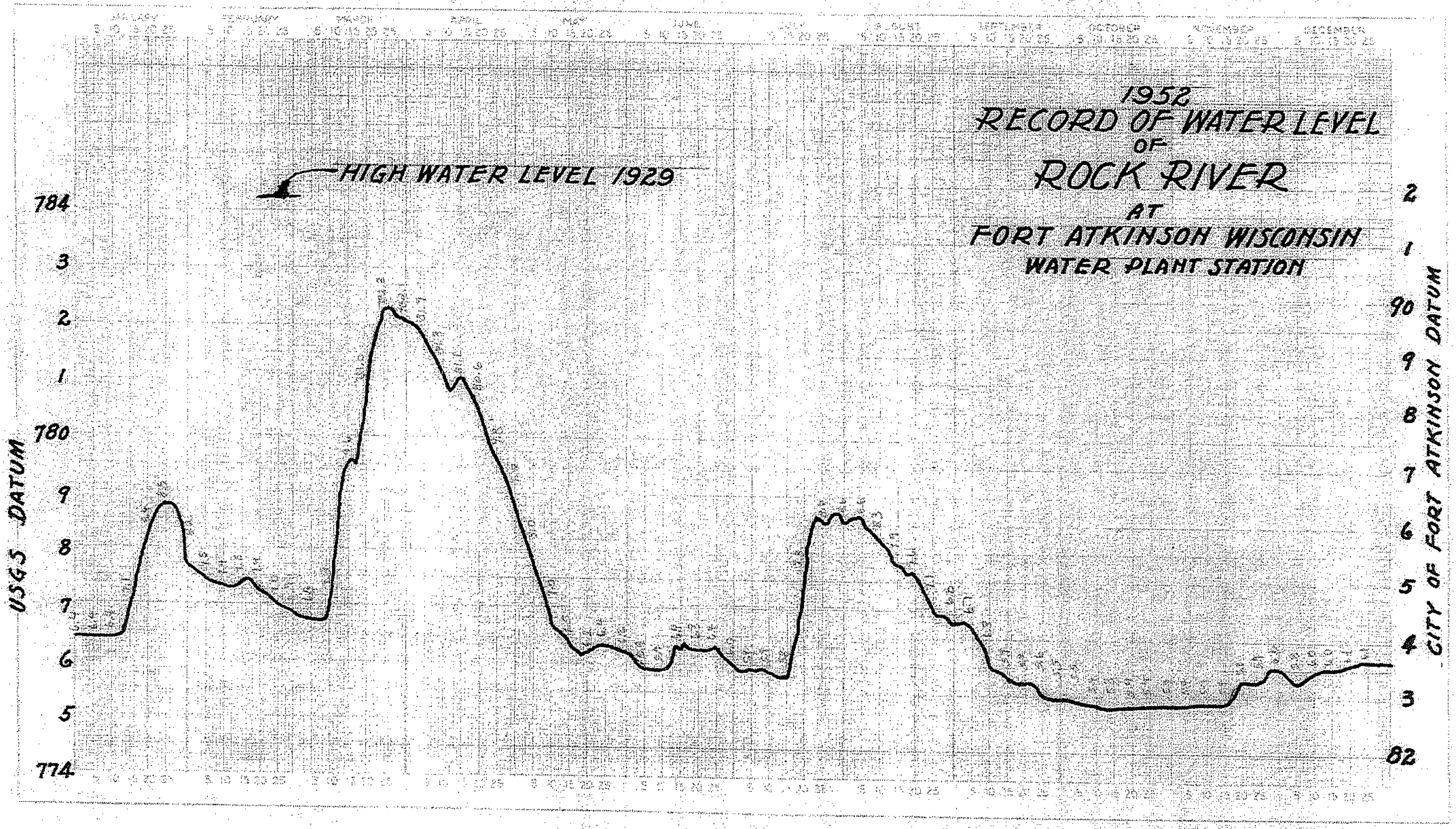
1952
RECORD OF WATER LEVEL
OF
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AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
USGS DATUM
CITY OF FORT ATKINSON DATUM
784
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780
9
8
7
6
5
774
2
1
90
9
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6
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82
JANUARY
FEBRUARY
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JUNE
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AUGUST
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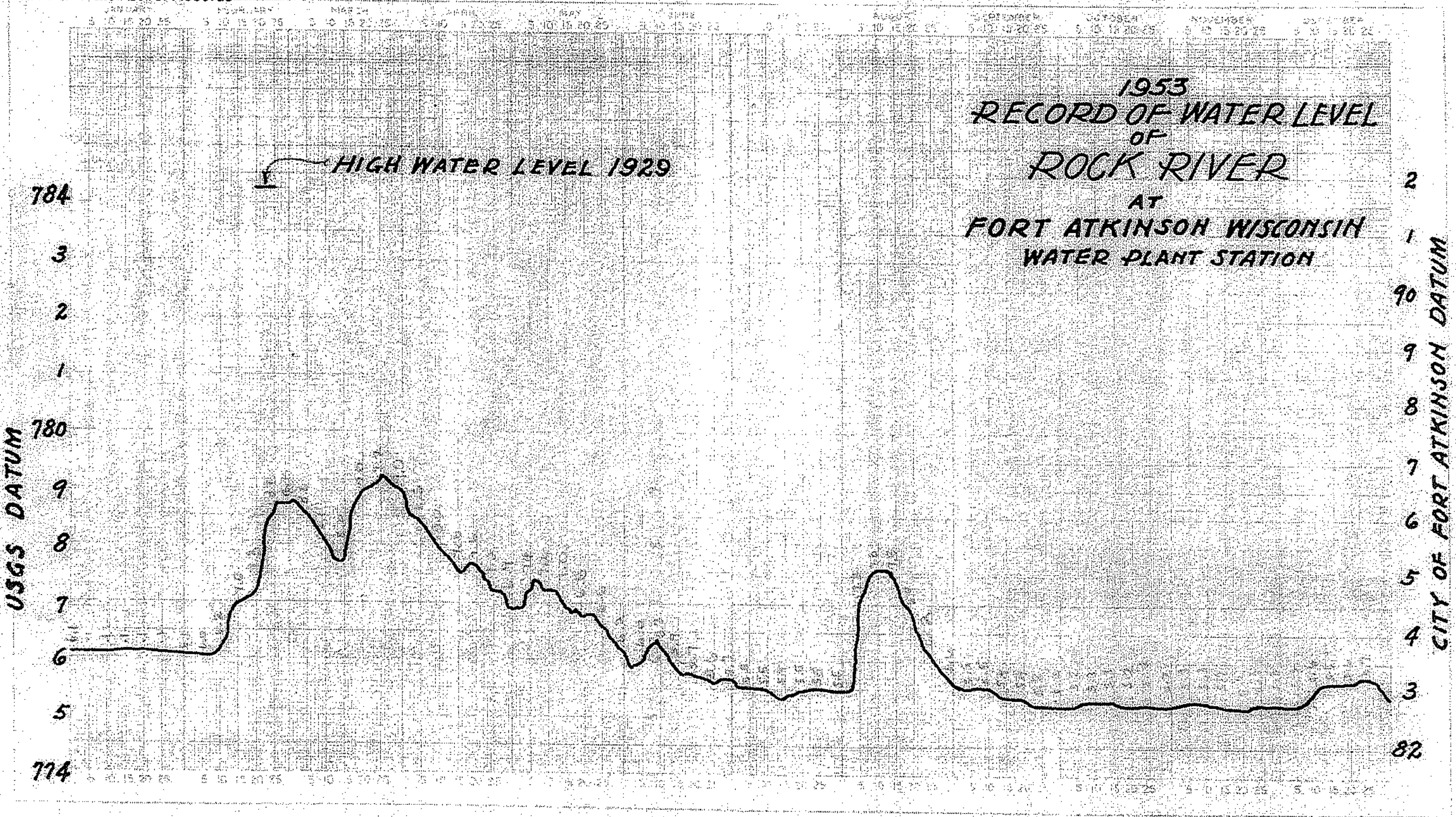
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25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RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
USGS DATUM
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9
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6
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774
CITY OF FORT ATKINSON DATUM
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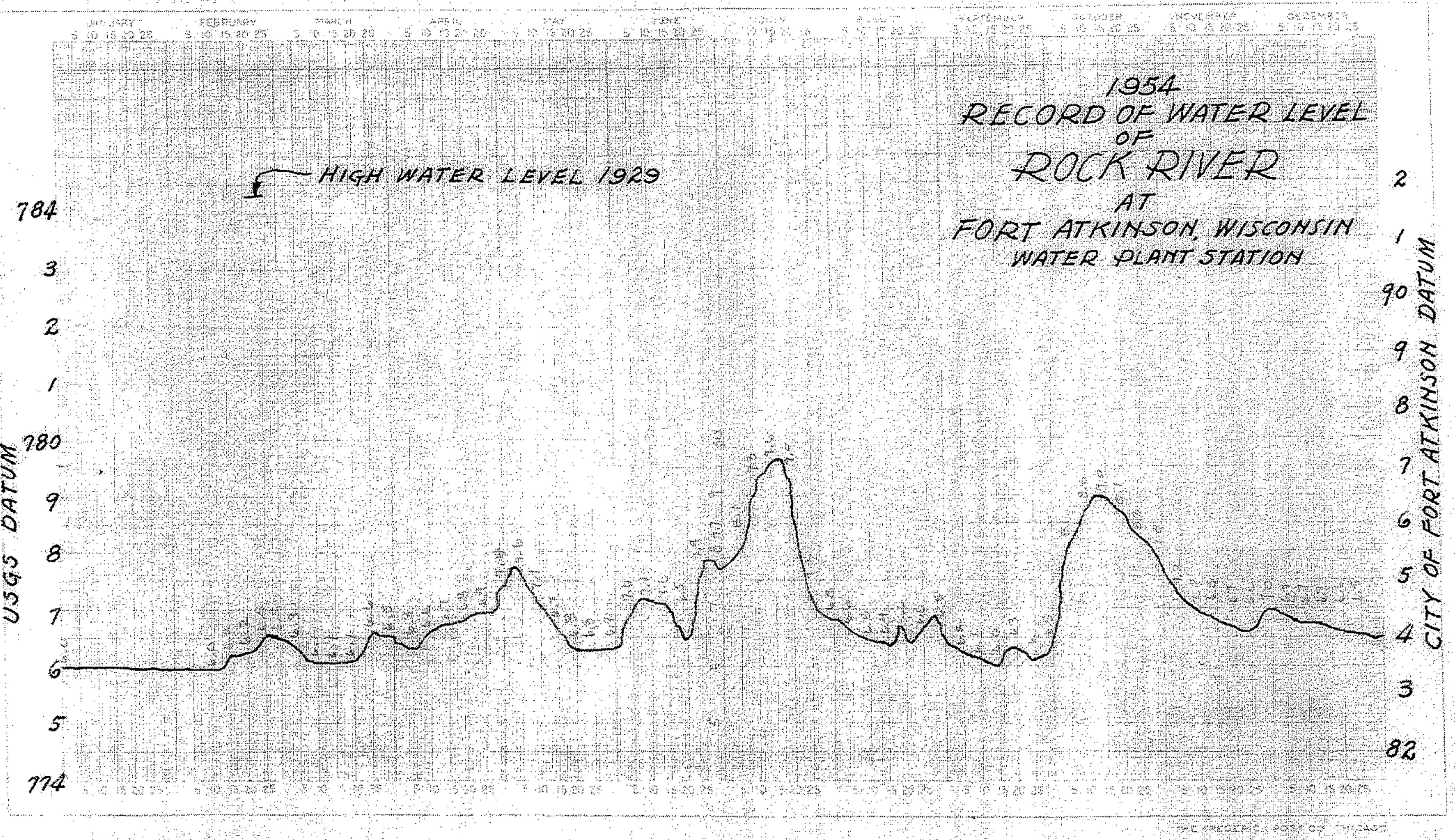
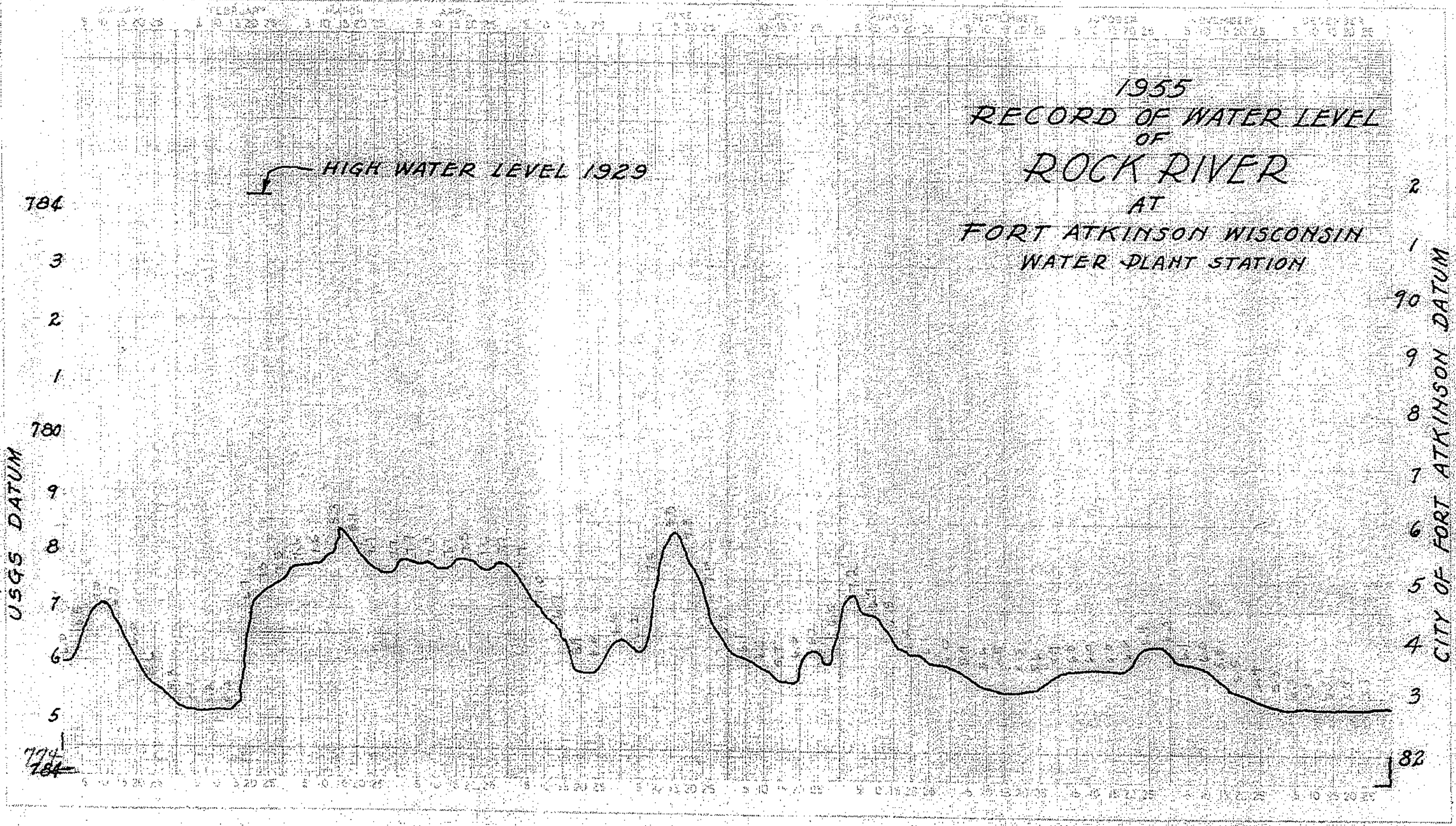
Attachment 4. Water Level Records





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RECORD OF WATER LEVEL

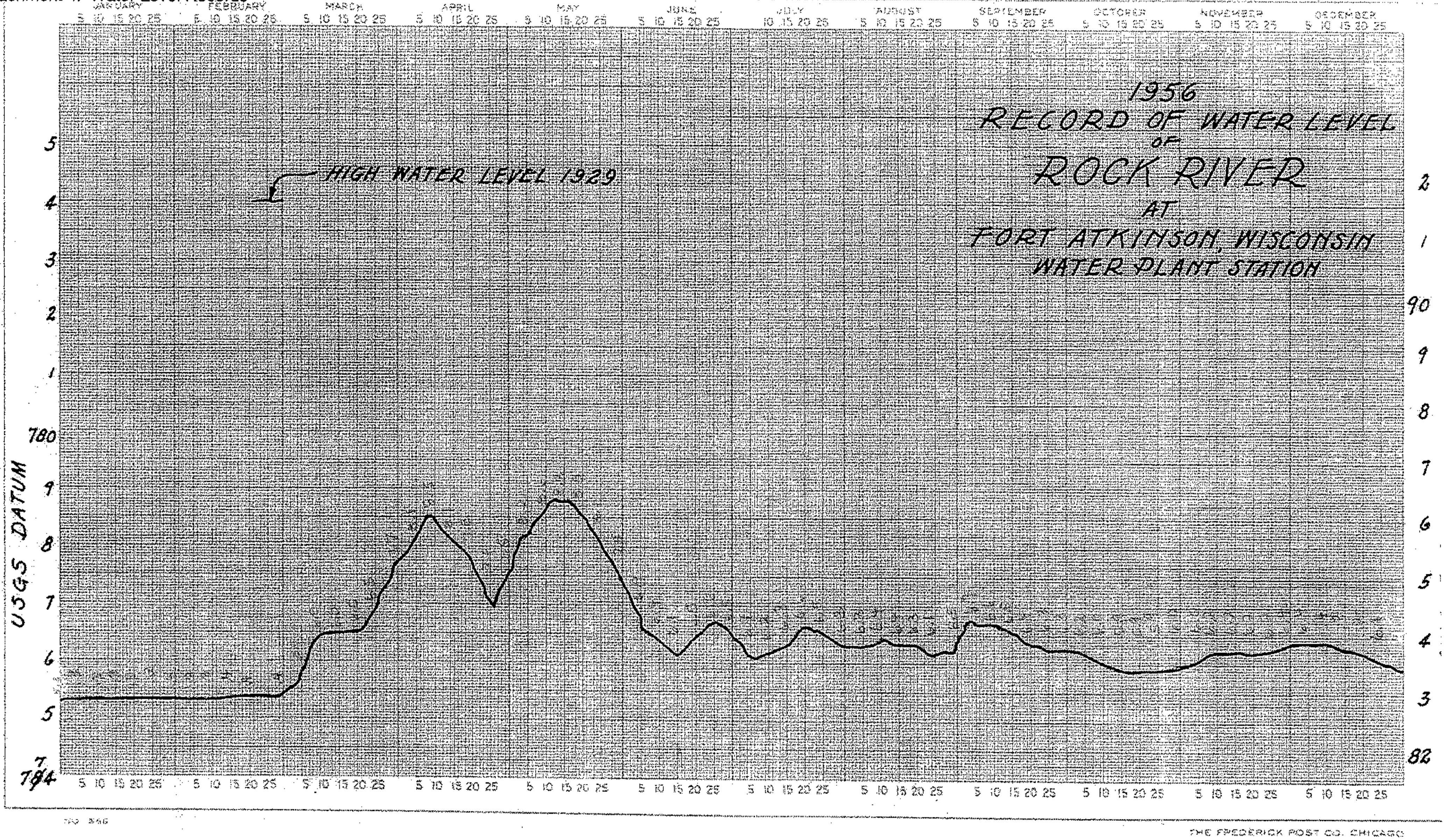
OF

ROCK RIVER

AT

FORT ATKINSON WISCONSIN

WATER PLANT STATION


1956
RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON, WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
USGS DATUM
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
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784
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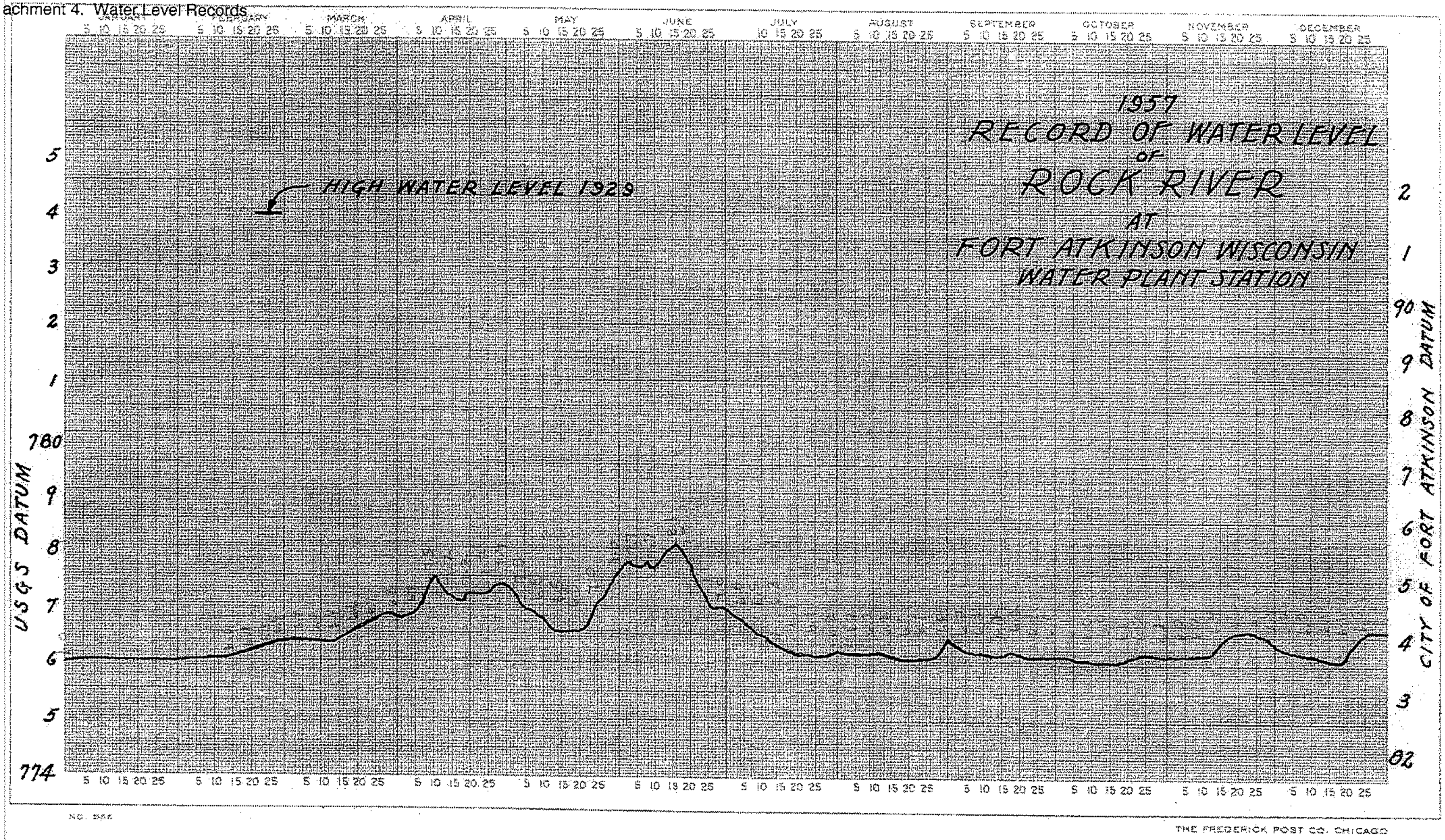
82
THE FREDERICK POST CO. CHICAGO



1957

RECORD OF WATER LEVEL

OF

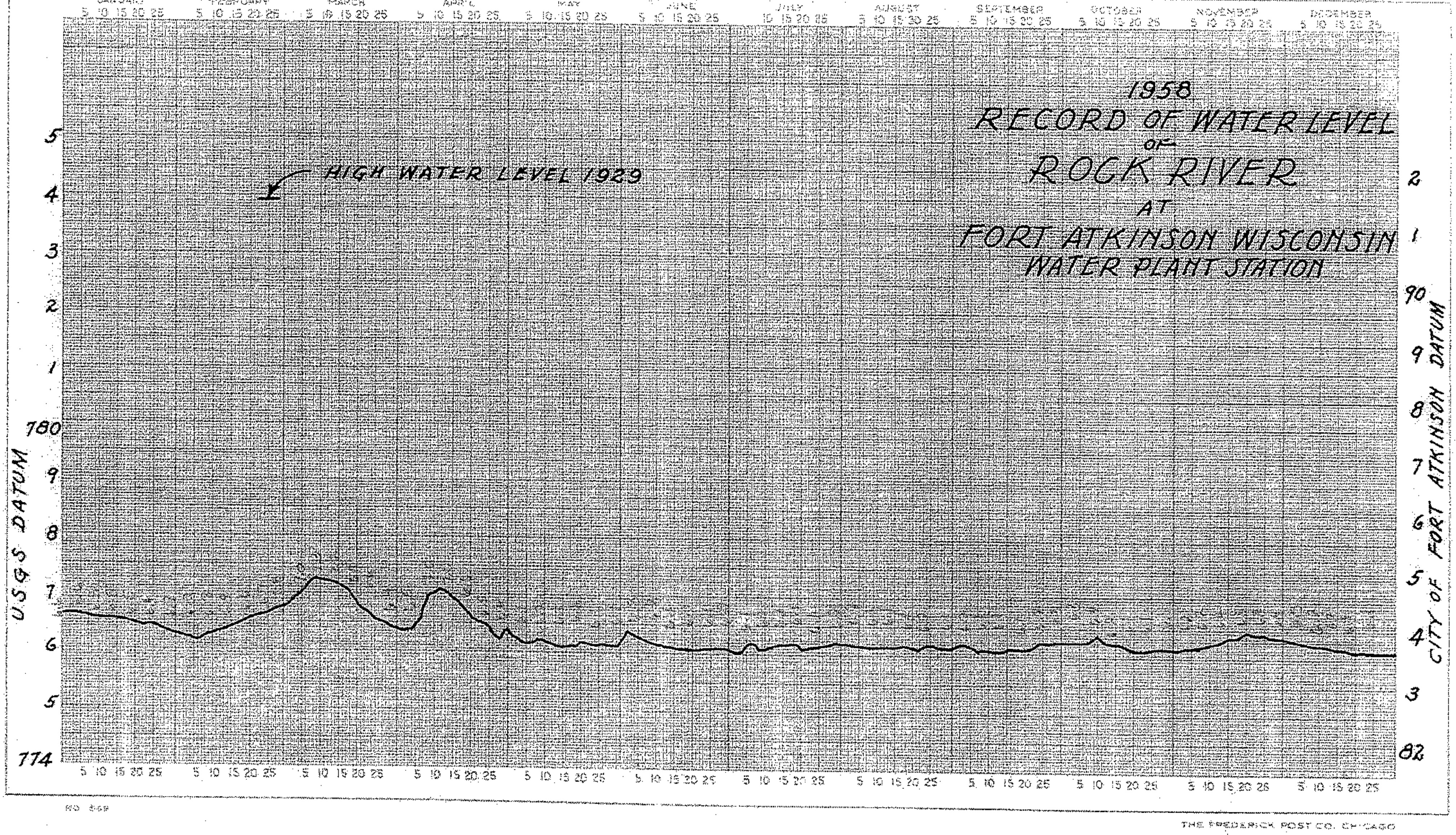
ROCK RIVER

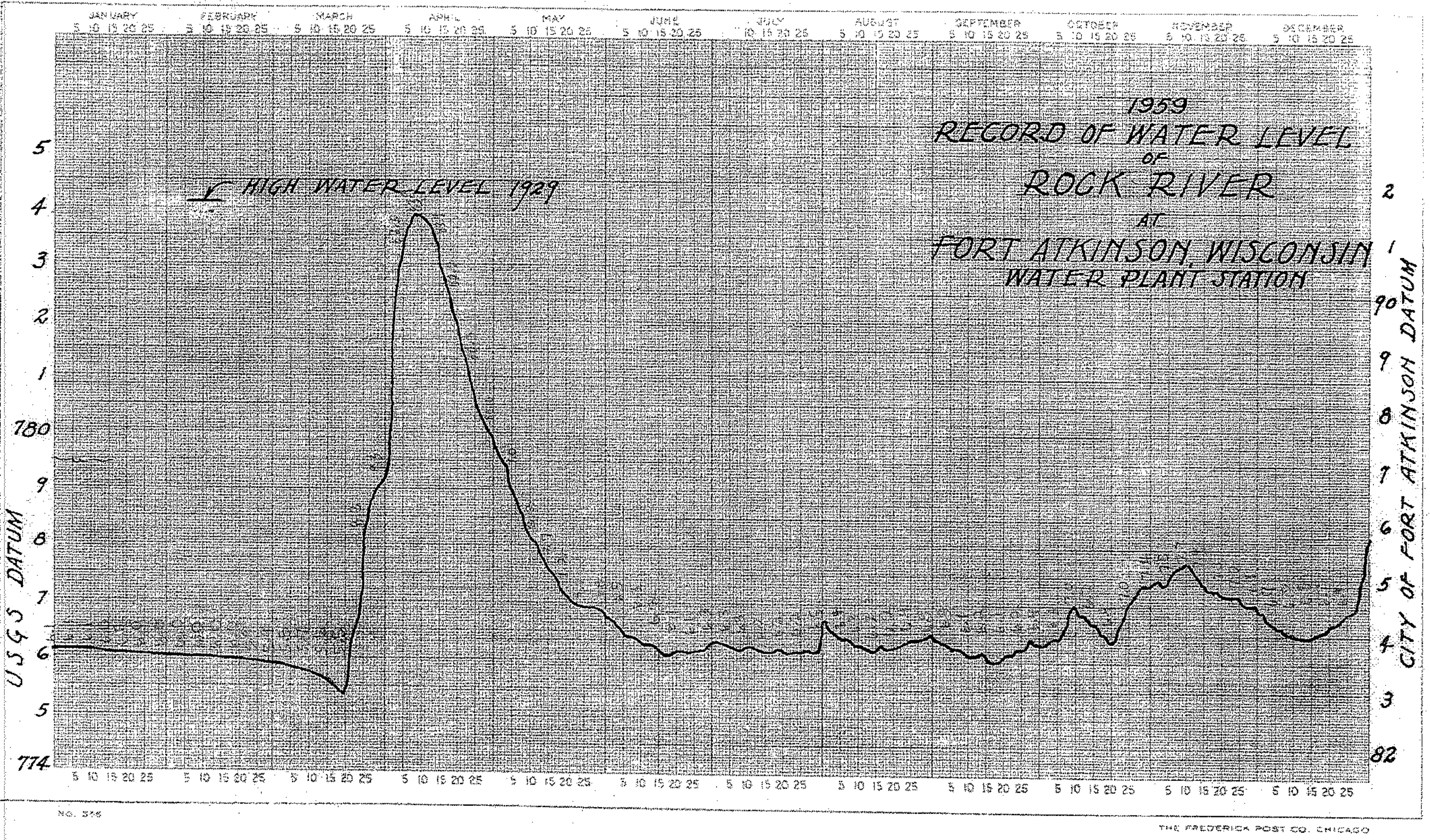
AT

FORT ATKINSON WISCONSIN

WATER PLANT STATION

Attachment 4. Water Level Records




1959
RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON, WISCONSIN
WATER PLANT STATION
HIGH WATER LEVEL 1929
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
USGS DATUM
5
4
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774
CITY OF FORT ATKINSON DATUM
2
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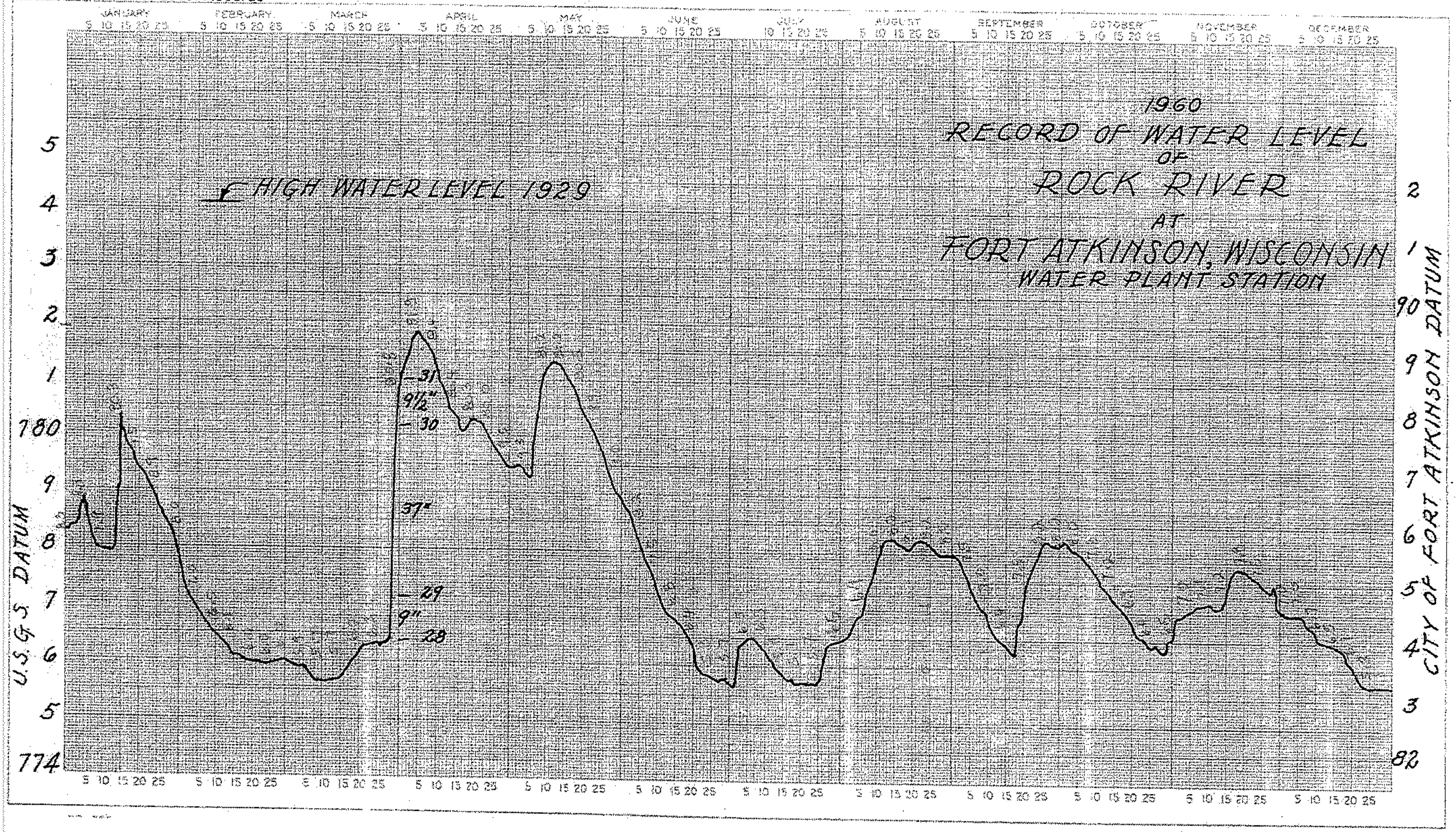
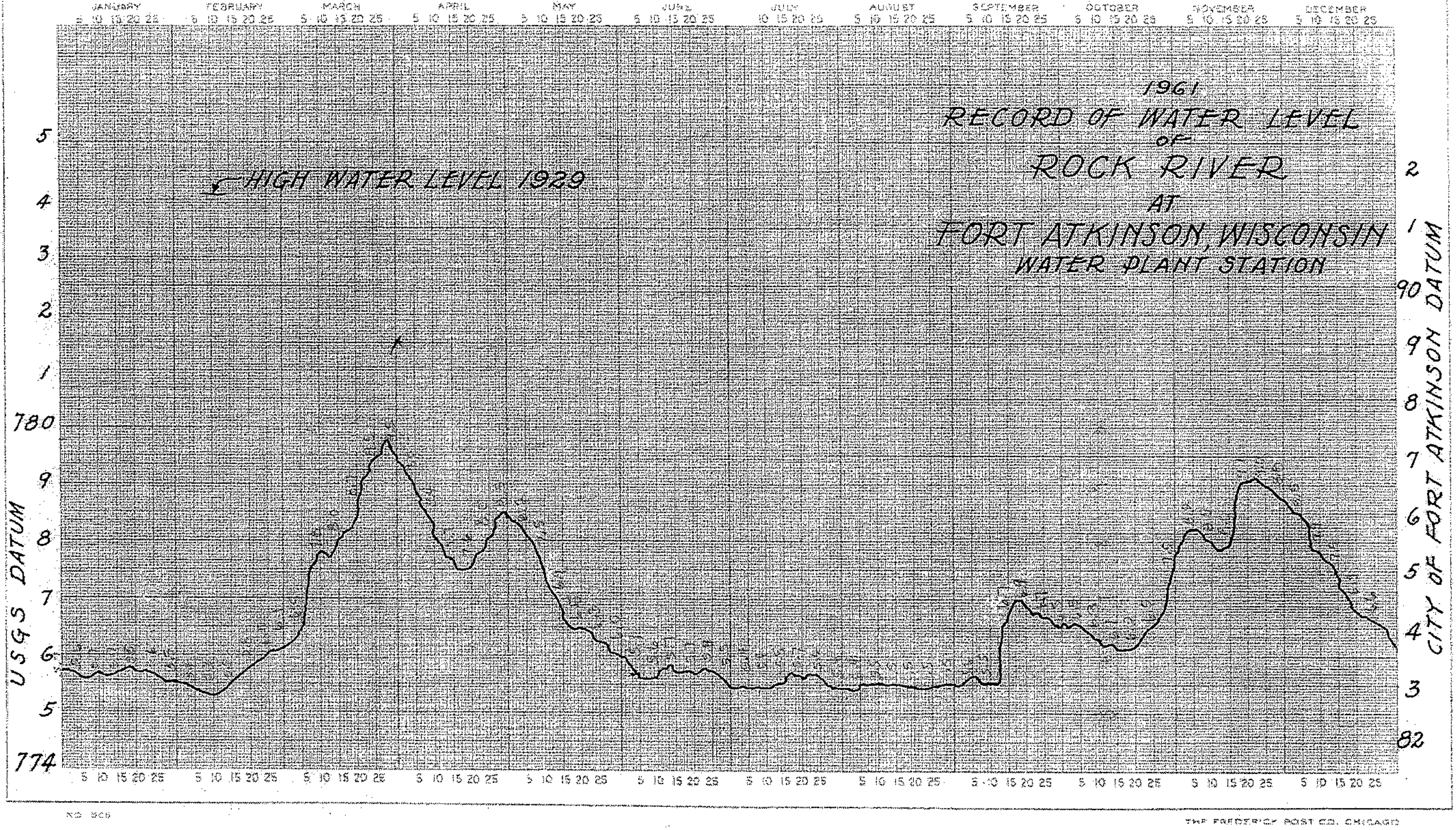
NO. 356
THE FREDERICK POST CO. CHICAGO

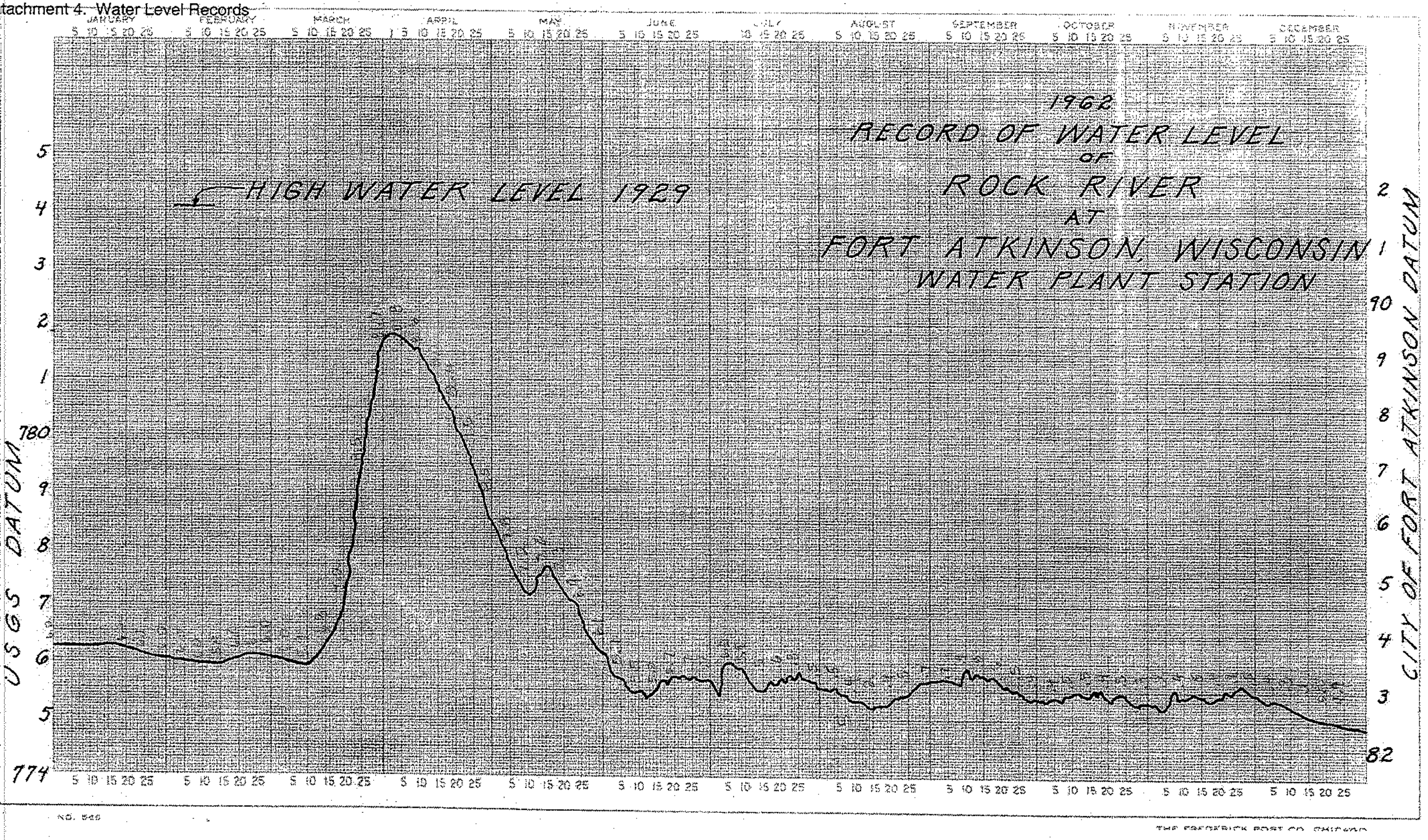
Attachment 4. Water Level Records



Attachment 4. Water Level Records

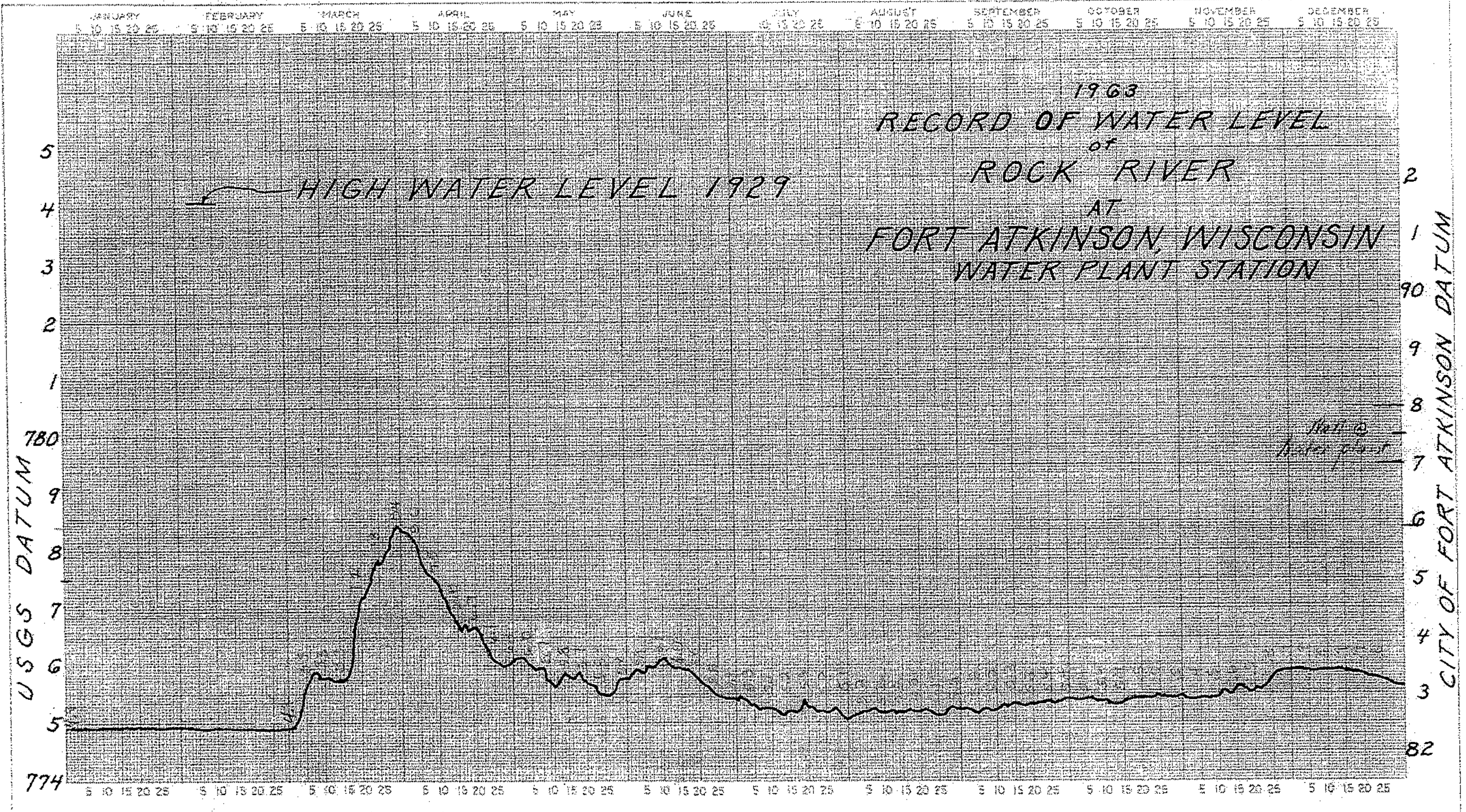


tachment 4. Water Level Records

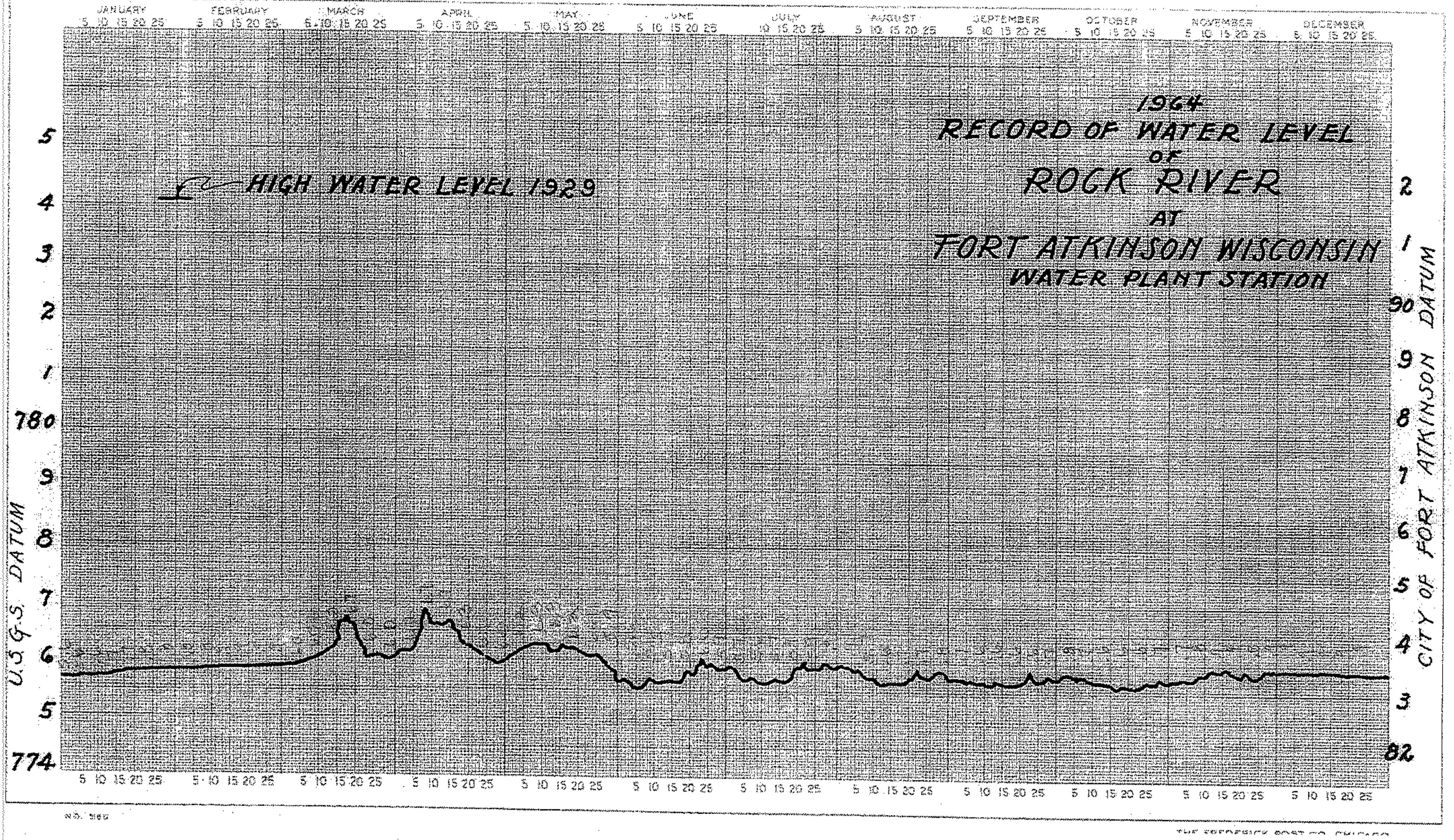


1962
RECORD OF WATER LEVEL
OF
ROCK RIVER
AT
FORT ATKINSON, WISCONSIN
WATER PLANT STATION

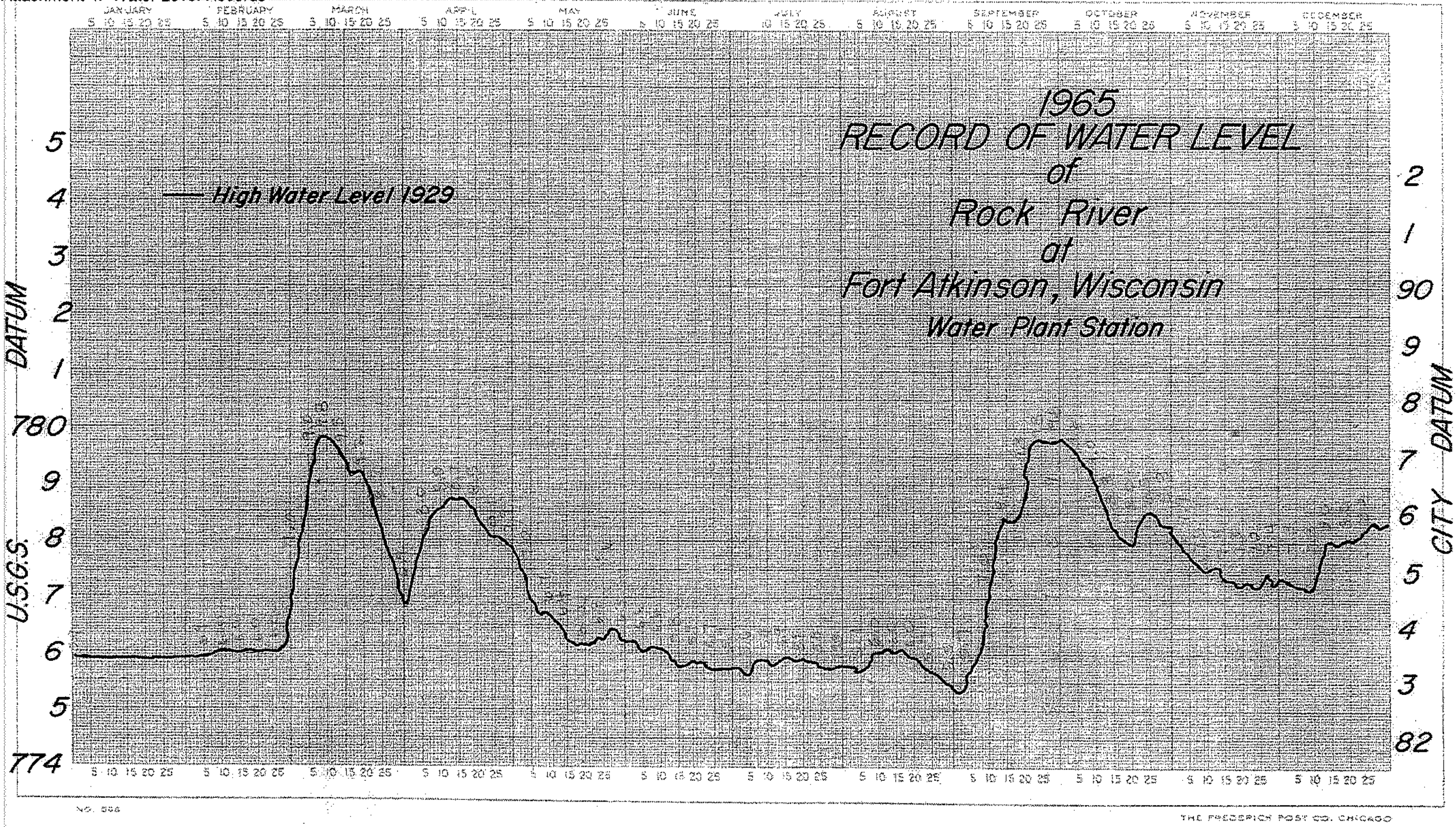
Attachment 4. Water Level Records

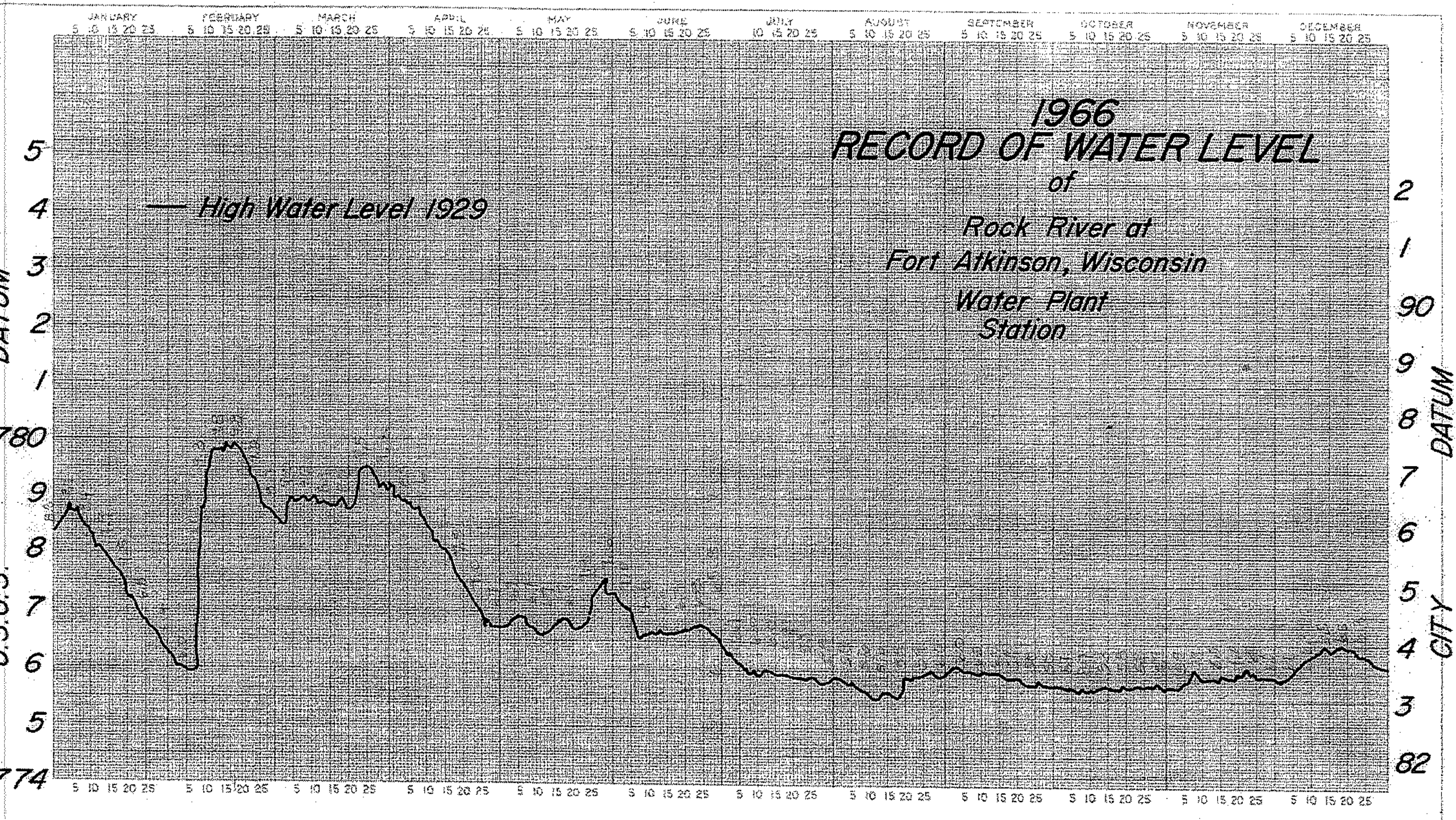


Attachment 4. Water Level Records

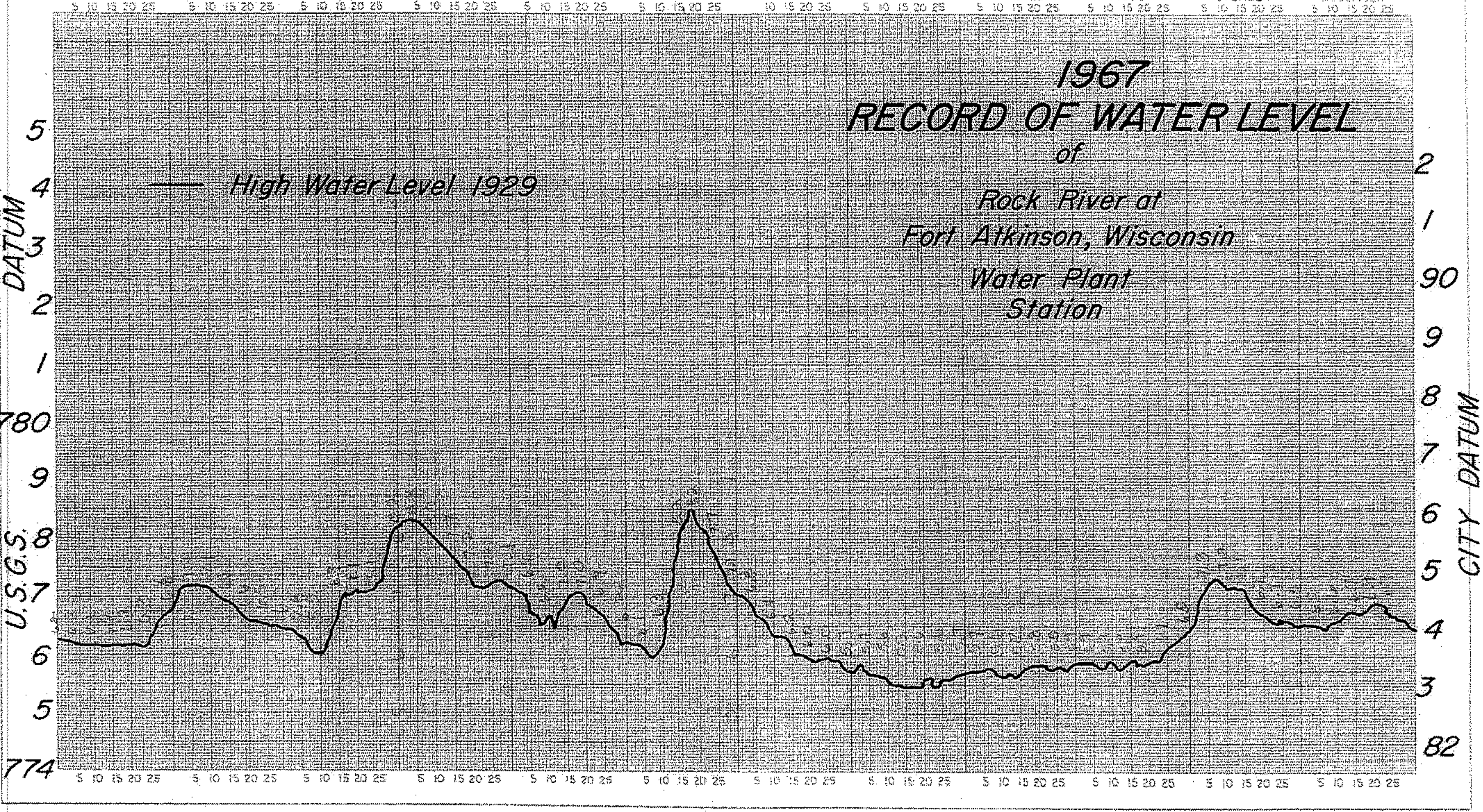


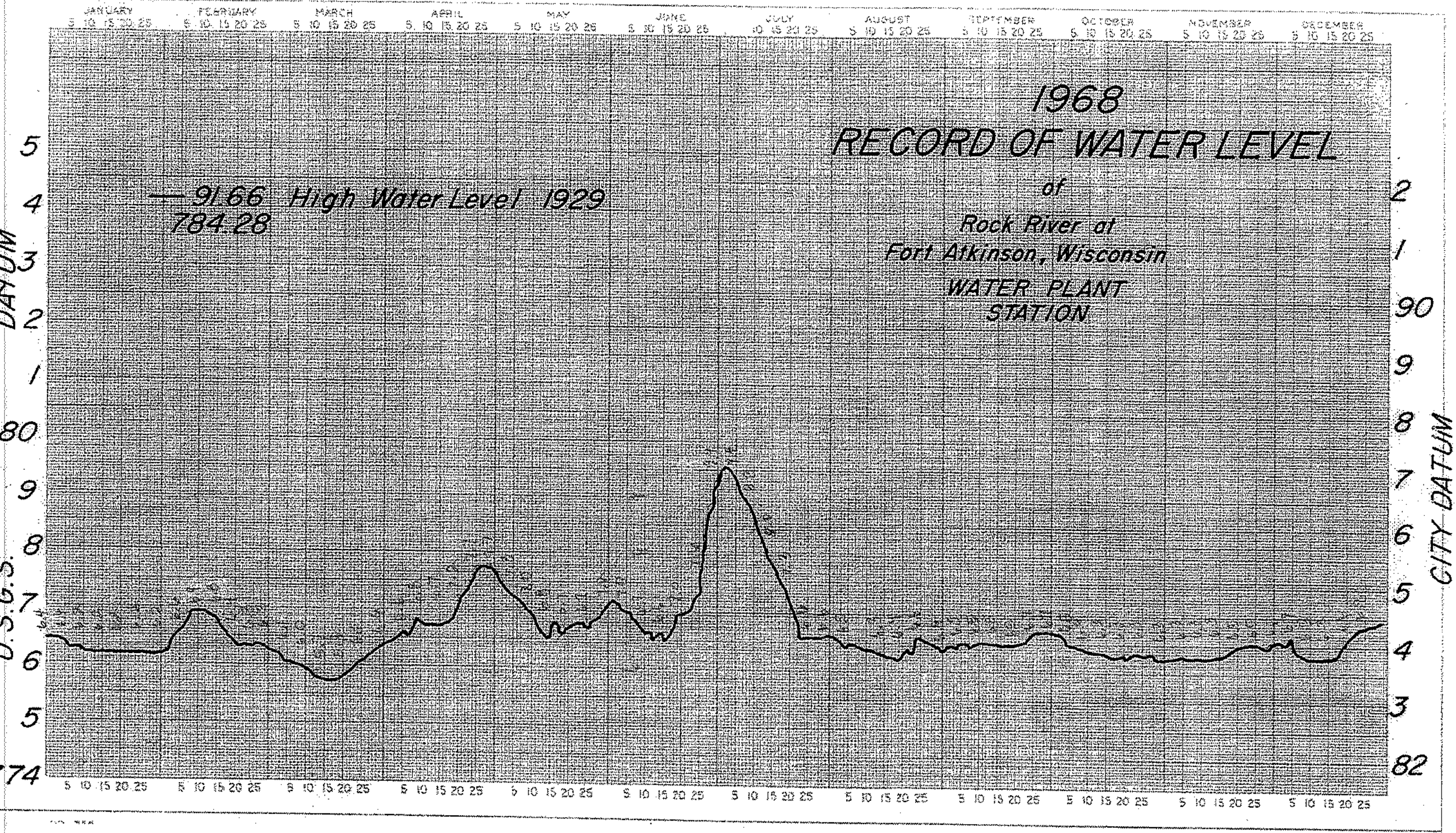
Attachment 4. Water Level Records



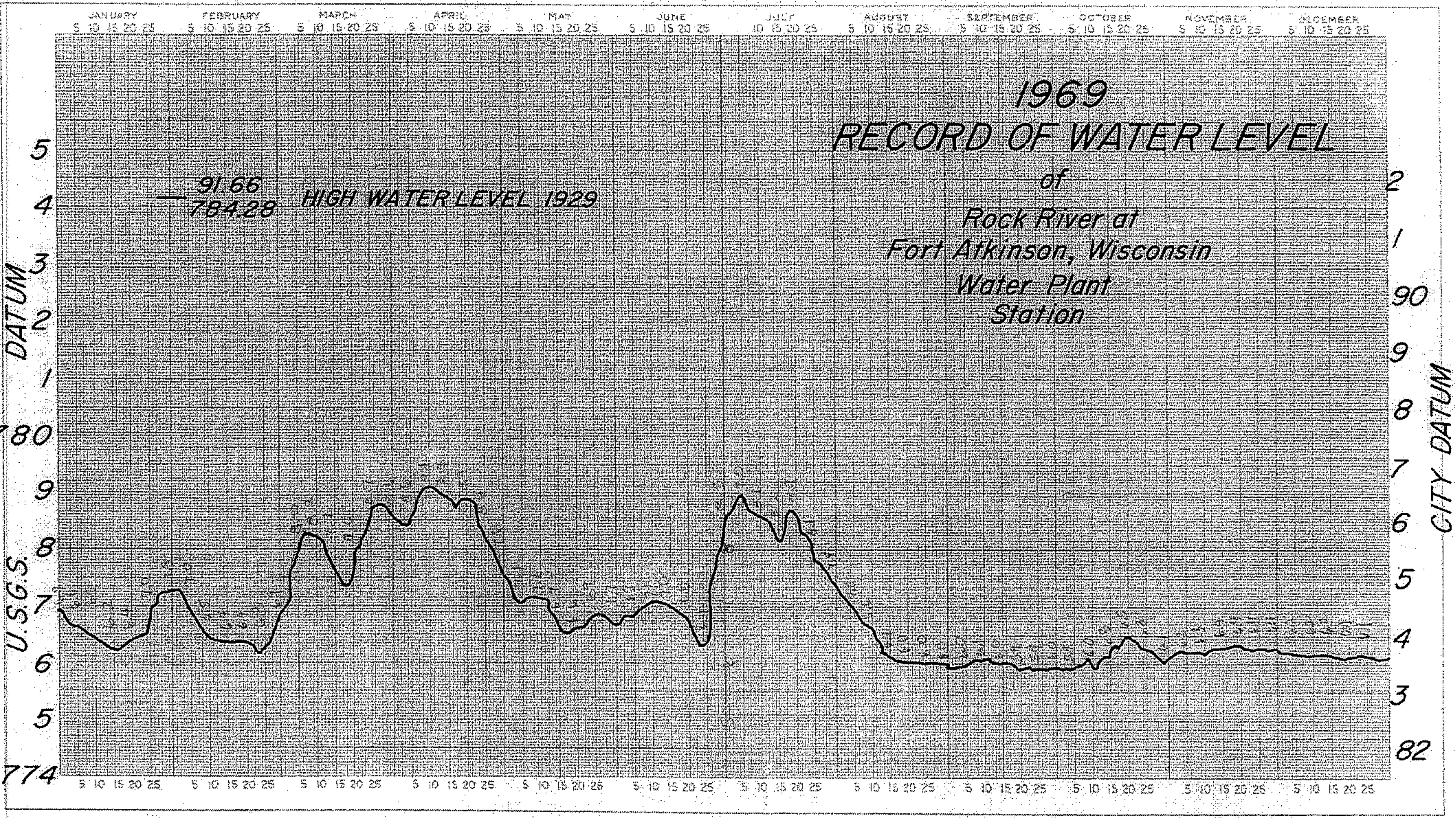

1966
RECORD OF WATER LEVEL
of
Rock River at
Fort Atkinson, Wisconsin
Water Plant
Station
High Water Level 1929
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
5
4
3
2
1
780
9
8
7
6
5
774
2
1
90
9
8
7
6
5
4
3
82
CITY DATUM

ttachment 4 - Water Level Records



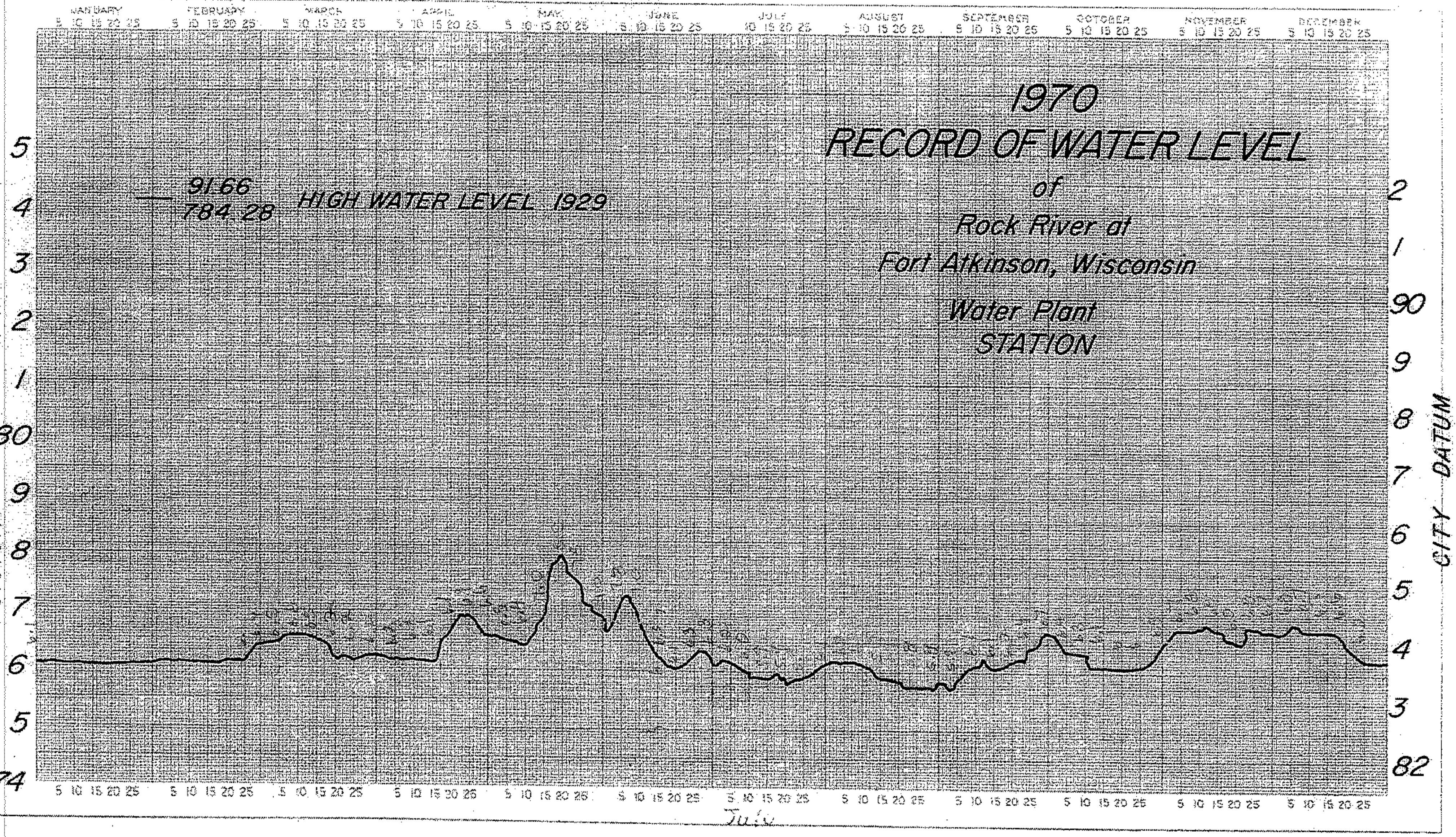

1968
RECORD OF WATER LEVEL
of
Rock River at
Fort Atkinson, Wisconsin
WATER PLANT
STATION
—91.66 High Water Level 1929
784.28
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
U.S.G.S.
DATUM
5
4
3
2
1
80
9
8
7
6
5
74
CITY DATUM
2
1
90
9
8
7
6
5
4
3
82

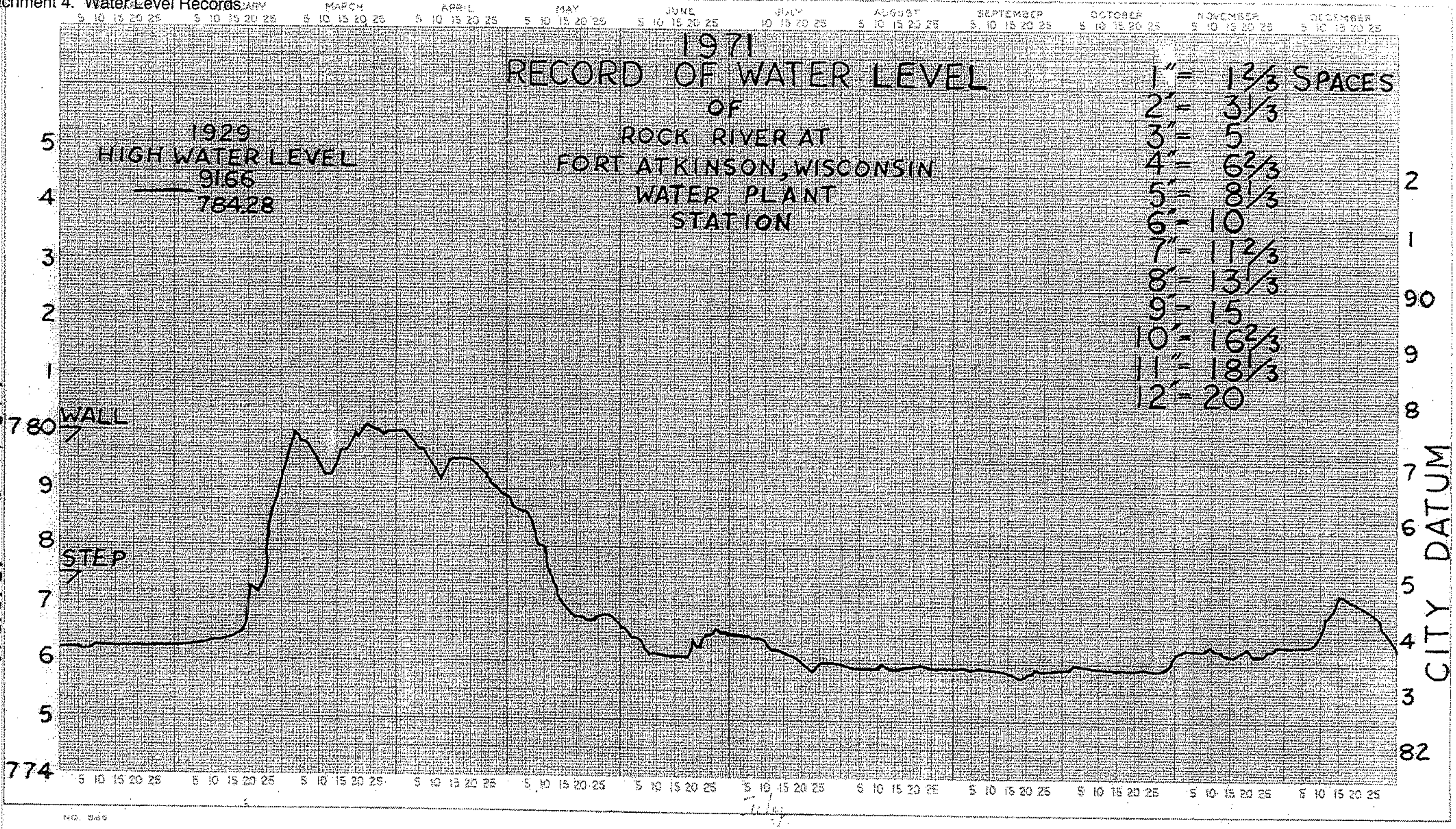
Attachment 4. Water Level Records



1969
RECORD OF WATER LEVEL
of
Rock River at
Fort Atkinson, Wisconsin
Water Plant
Station

achment 4. Water Level Records




1971
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
1929
HIGH WATER LEVEL
91.66
784.28
1" = 12/3 SPACES
2" = 31/3
3" = 5
4" = 62/3
5" = 81/3
6" = 10
7" = 112/3
8" = 131/3
9" = 15
10" = 162/3
11" = 181/3
12" = 20
WALL
STEP
CITY DATUM
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
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774
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1
90
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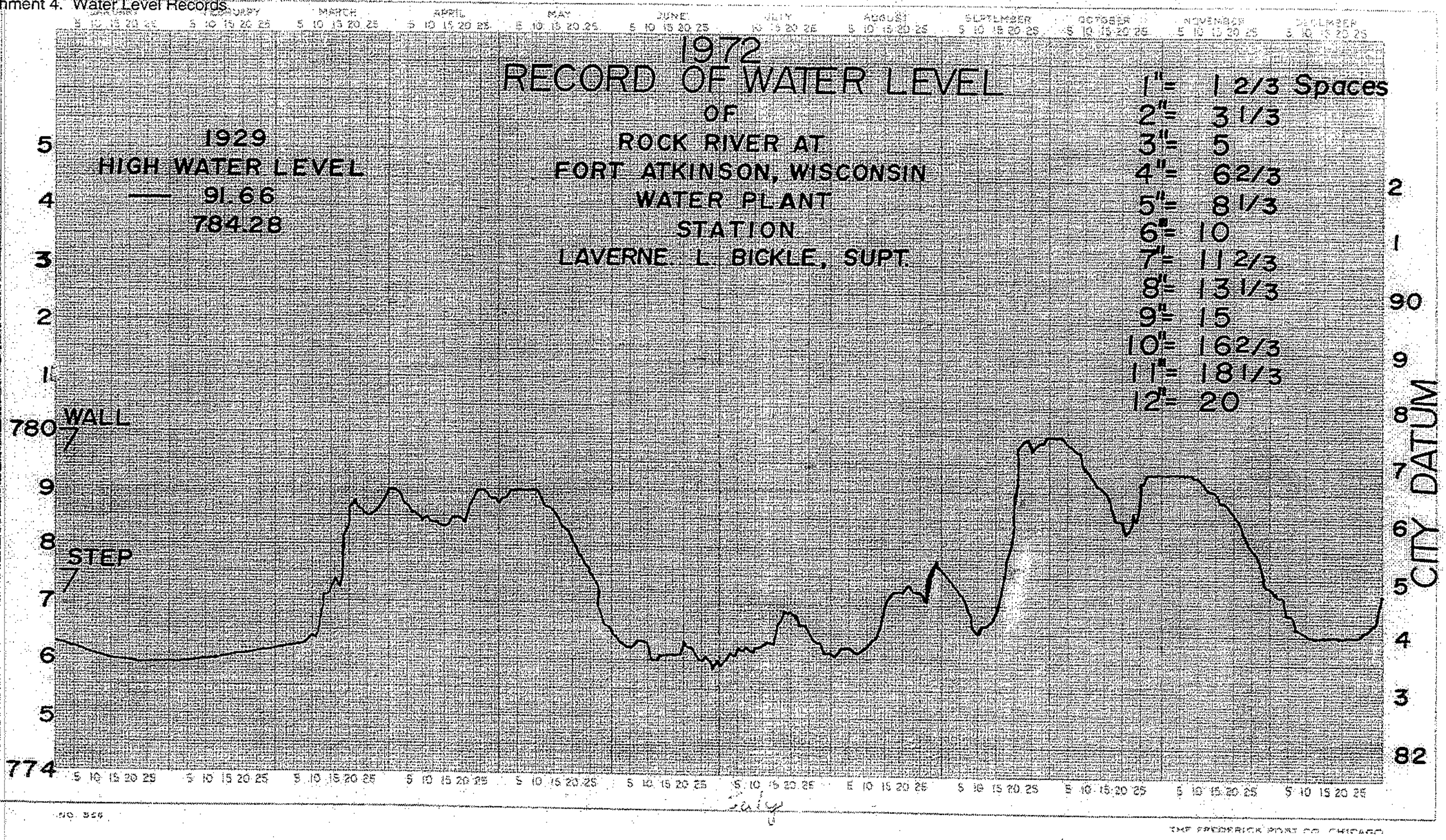
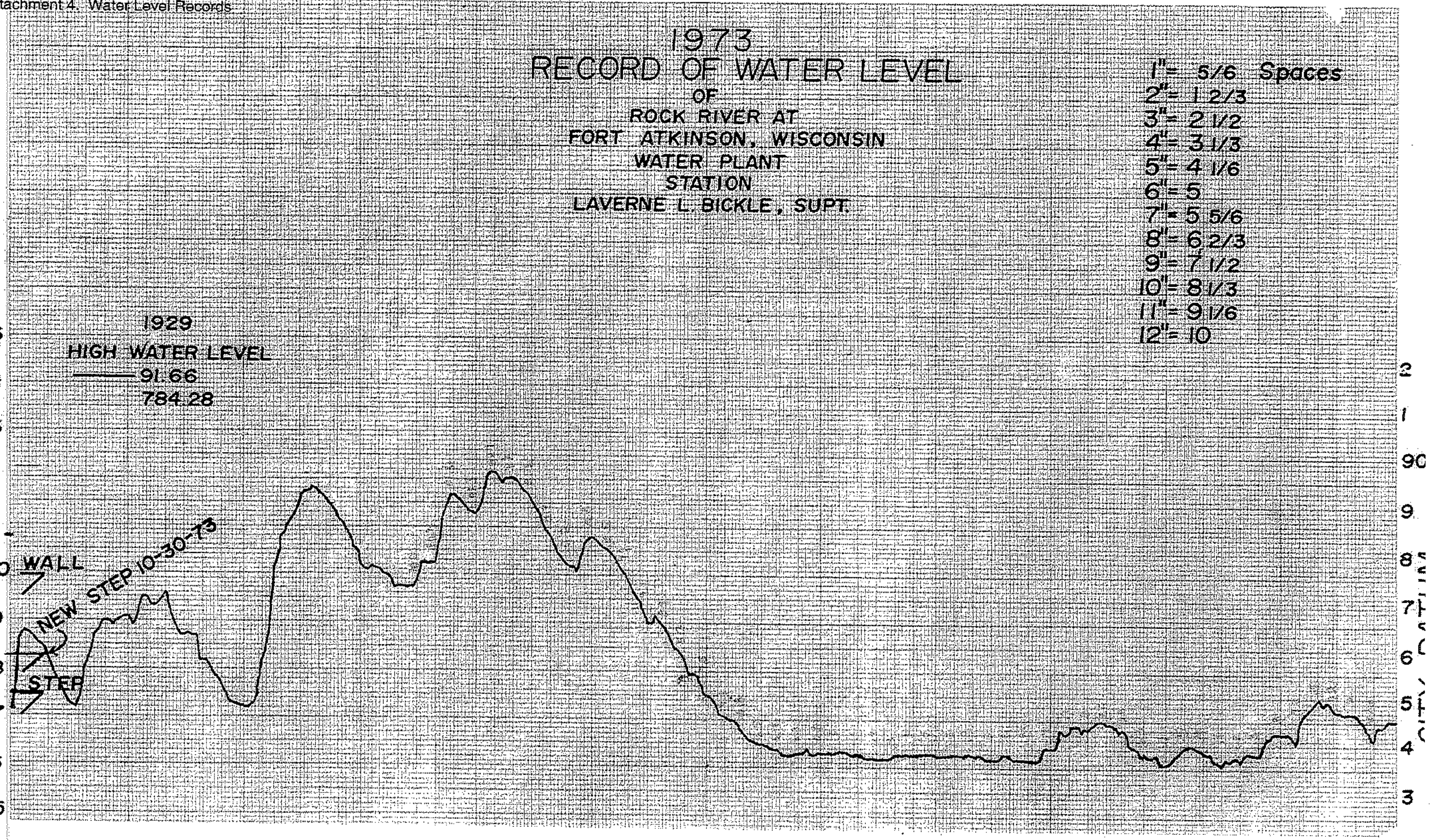
82
NO. 566
THE FREDERICK POST CO. CHICAGO



1972
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

1929
HIGH WATER LEVEL
— 91.66
784.28

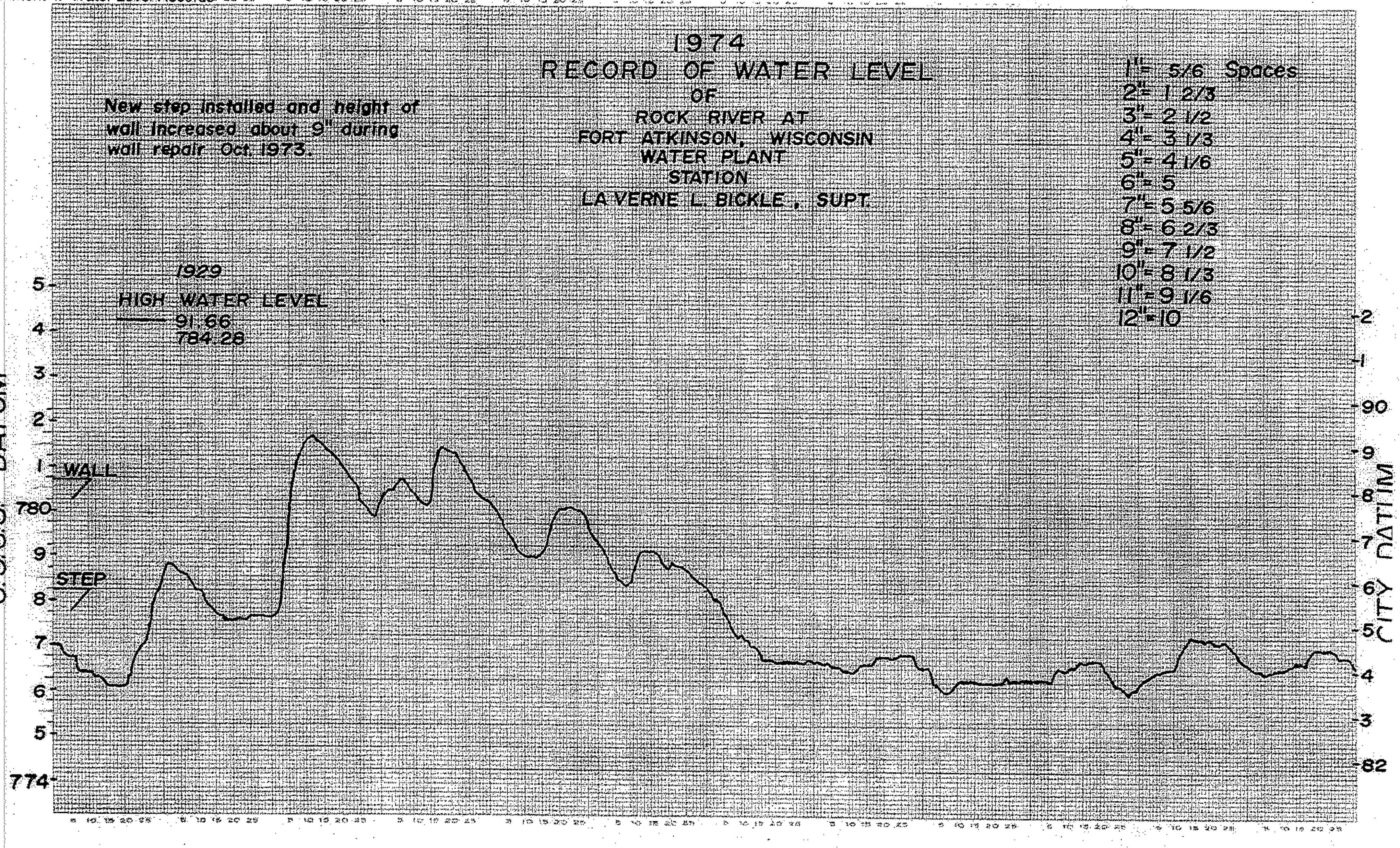
1" = 1 2/3 Spaces
2" = 3 1/3
3" = 5
4" = 6 2/3
5" = 8 1/3
6" = 10
7" = 11 2/3
8" = 13 1/3
9" = 15
10" = 16 2/3
11" = 18 1/3
12" = 20



1973
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10

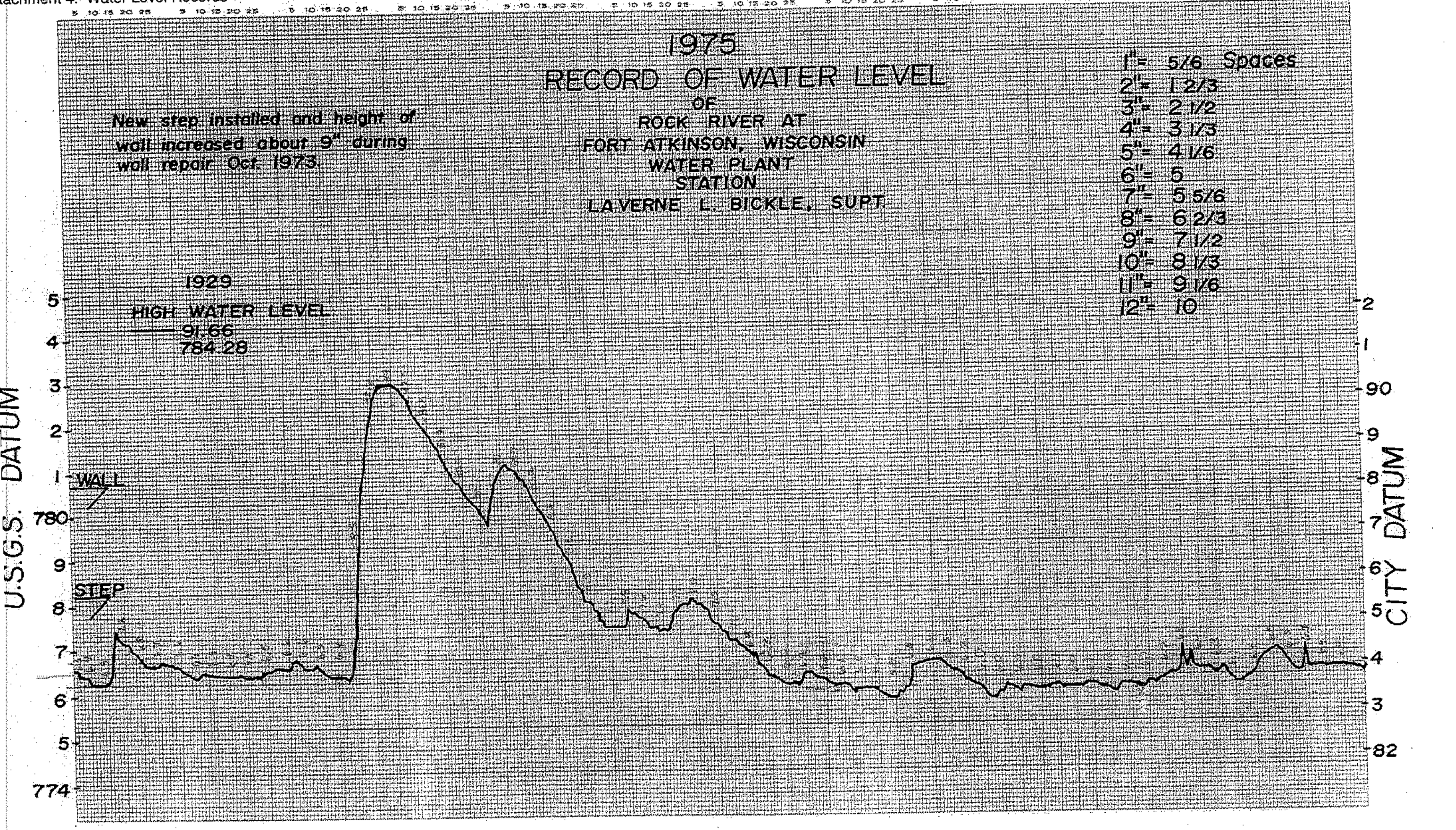
1929
HIGH WATER LEVEL
91.66
784.28

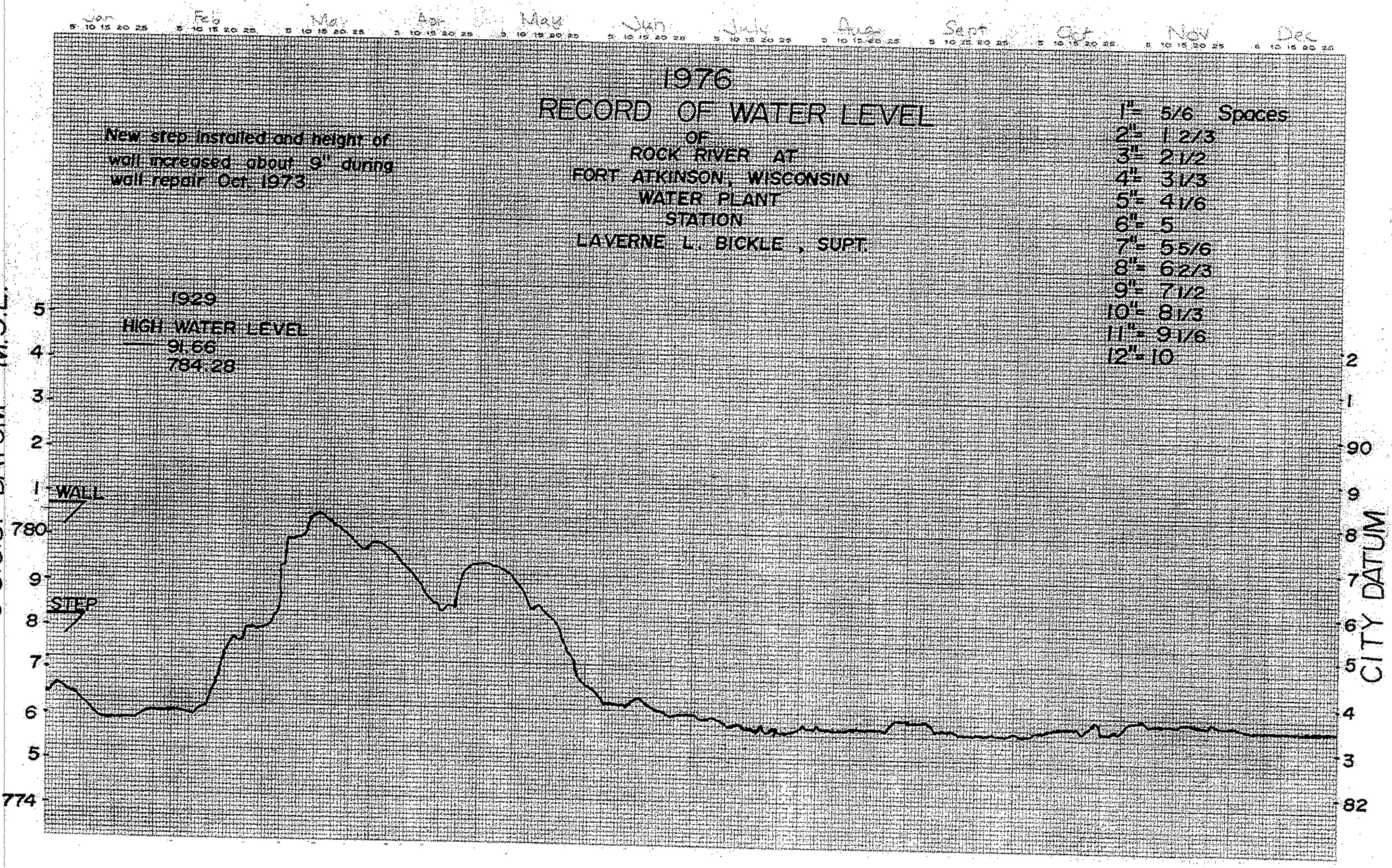


1974
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LA VERNE L. BICKLE, SUPT.

New step installed and height of wall increased about 9" during wall repair Oct. 1973.

1"= 5/6 Spaces
2"= 1 2/3
3"= 2 1/2
4"= 3 1/3
5"= 4 1/6
6"= 5
7"= 5 5/6
8"= 6 2/3
9"= 7 1/2
10"= 8 1/3
11"= 9 1/6
12"= 10


1975
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.
New step installed and height of wall increased about 9" during wall repair Oct. 1973.
1929
HIGH WATER LEVEL
91.66
784.28
1"= 5/6 Spaces
2"= 1 2/3
3"= 2 1/2
4"= 3 1/3
5"= 4 1/6
6"= 5
7"= 5 5/6
8"= 6 2/3
9"= 7 1/2
10"= 8 1/3
11"= 9 1/6
12"= 10
WALL
STEP
U.S.G.S. DATUM
5
4
3
2
1
780
9
8
7
6
5
774
CITY DATUM
2
1
90
9
8
7
6
5
4
3
82
5 10 15 20 25


Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec
5 10 15 20 25
1976
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE , SUPT.
New step installed and height of
wall increased about 9" during
wall repair Oct. 1973.
1929
HIGH WATER LEVEL
91.66
784.28
1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10
WALL
STEP
5
4
3
2
1
780
9
8
7
6
5
774
2
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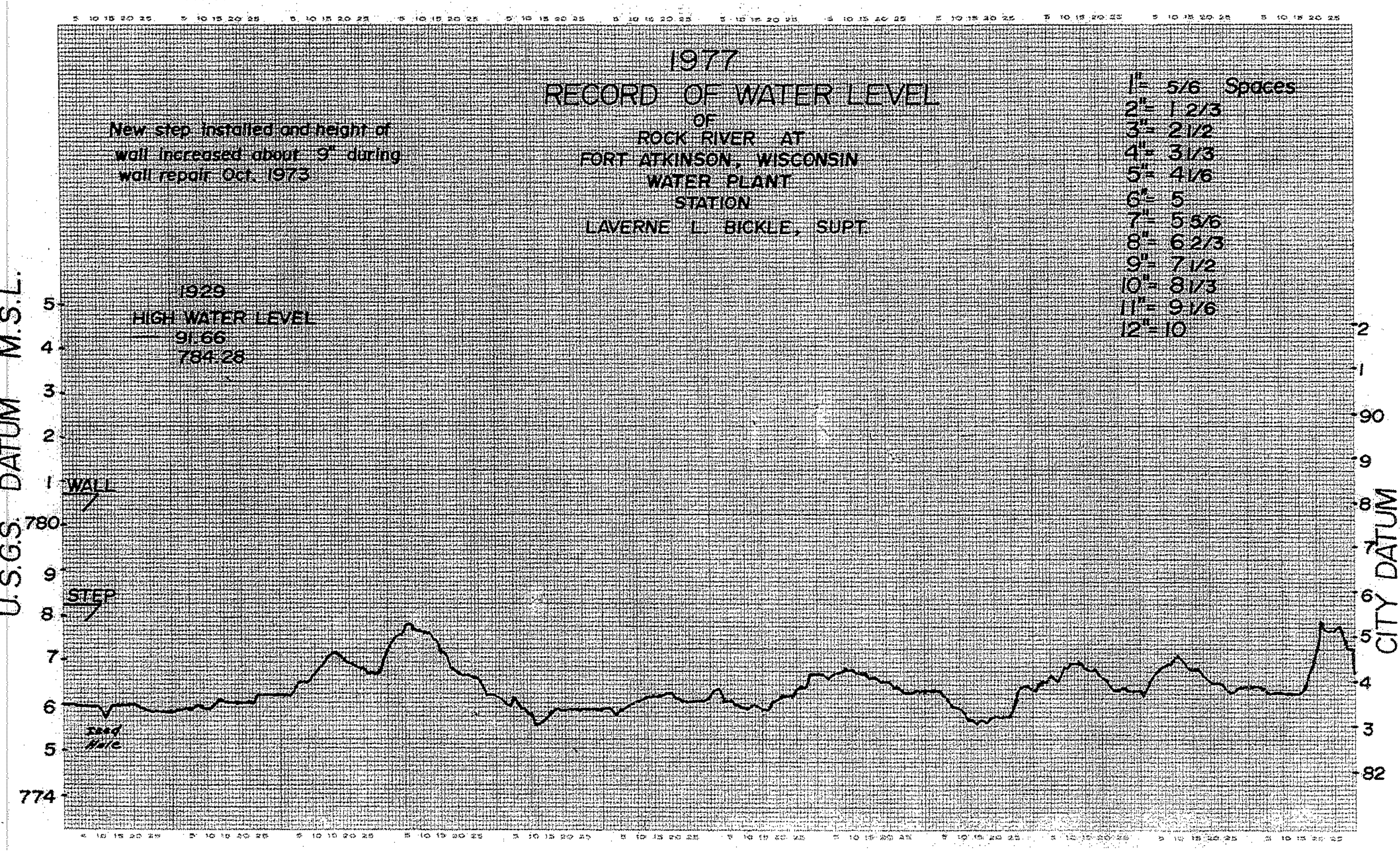
90
9
8
7
6
5
4
3
82
CITY DATUM
M.S.L.

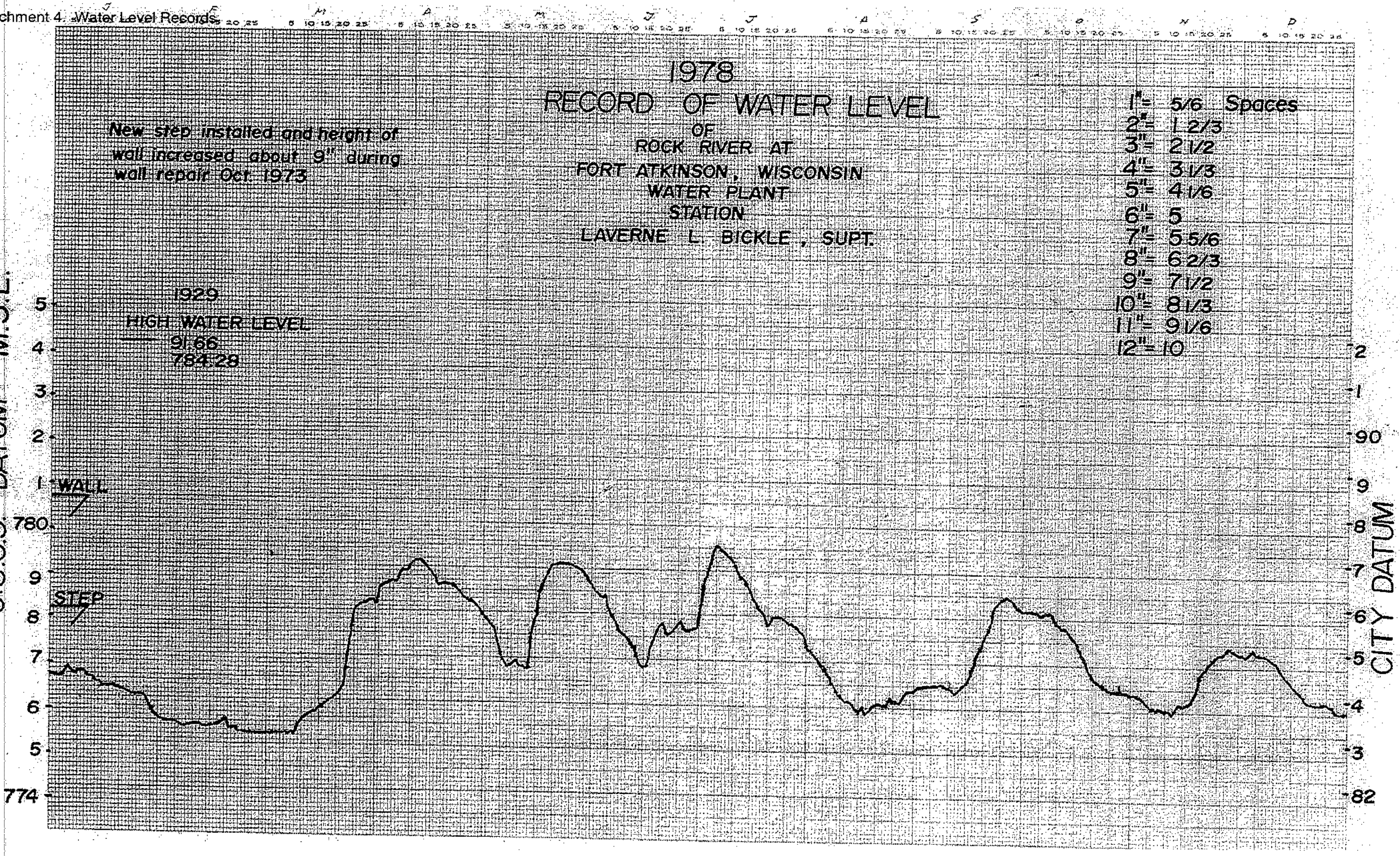


1977
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

New step installed and height of
wall increased about 9" during
wall repair Oct. 1973

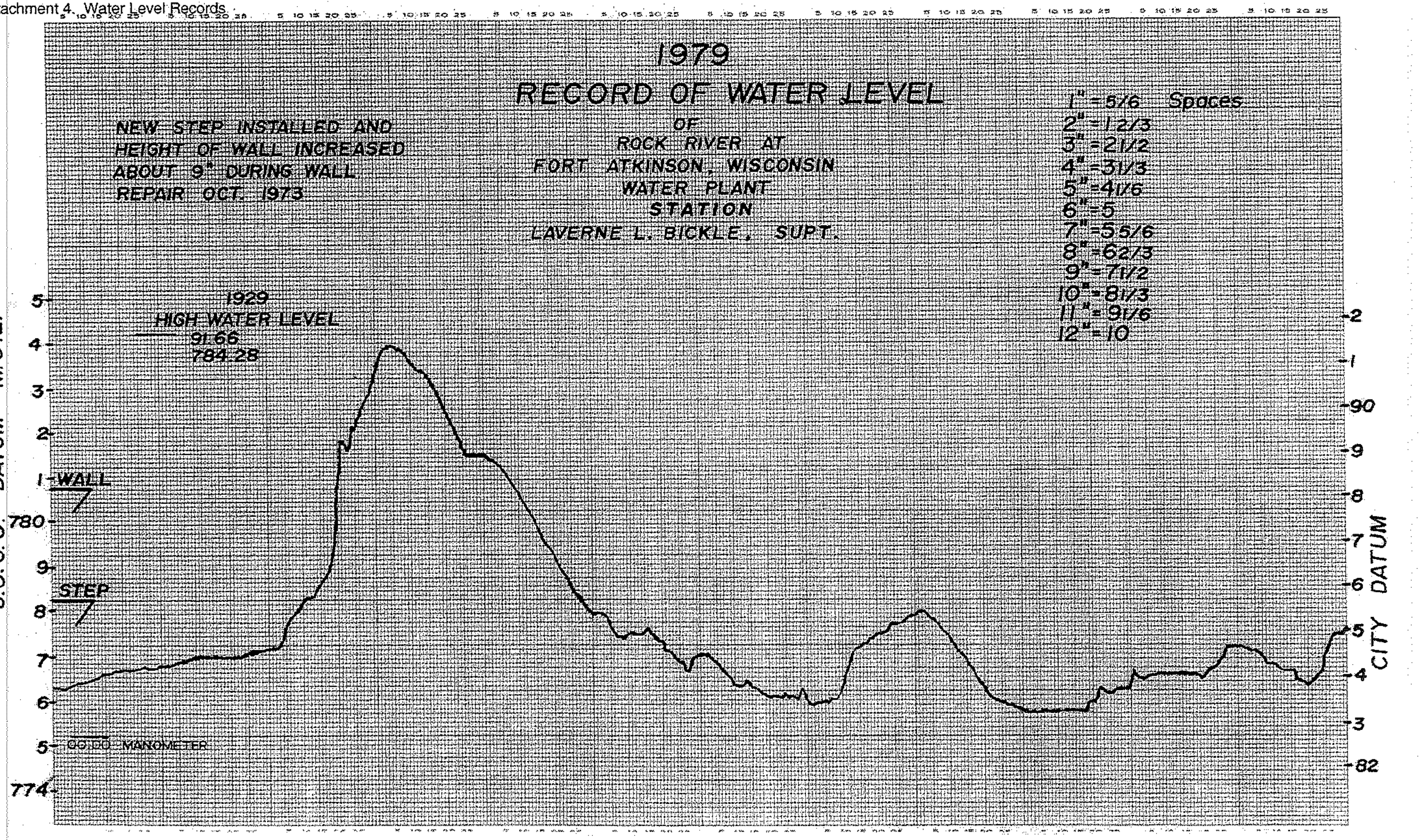
1929
HIGH WATER LEVEL
91.66
784.28

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10



1978
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

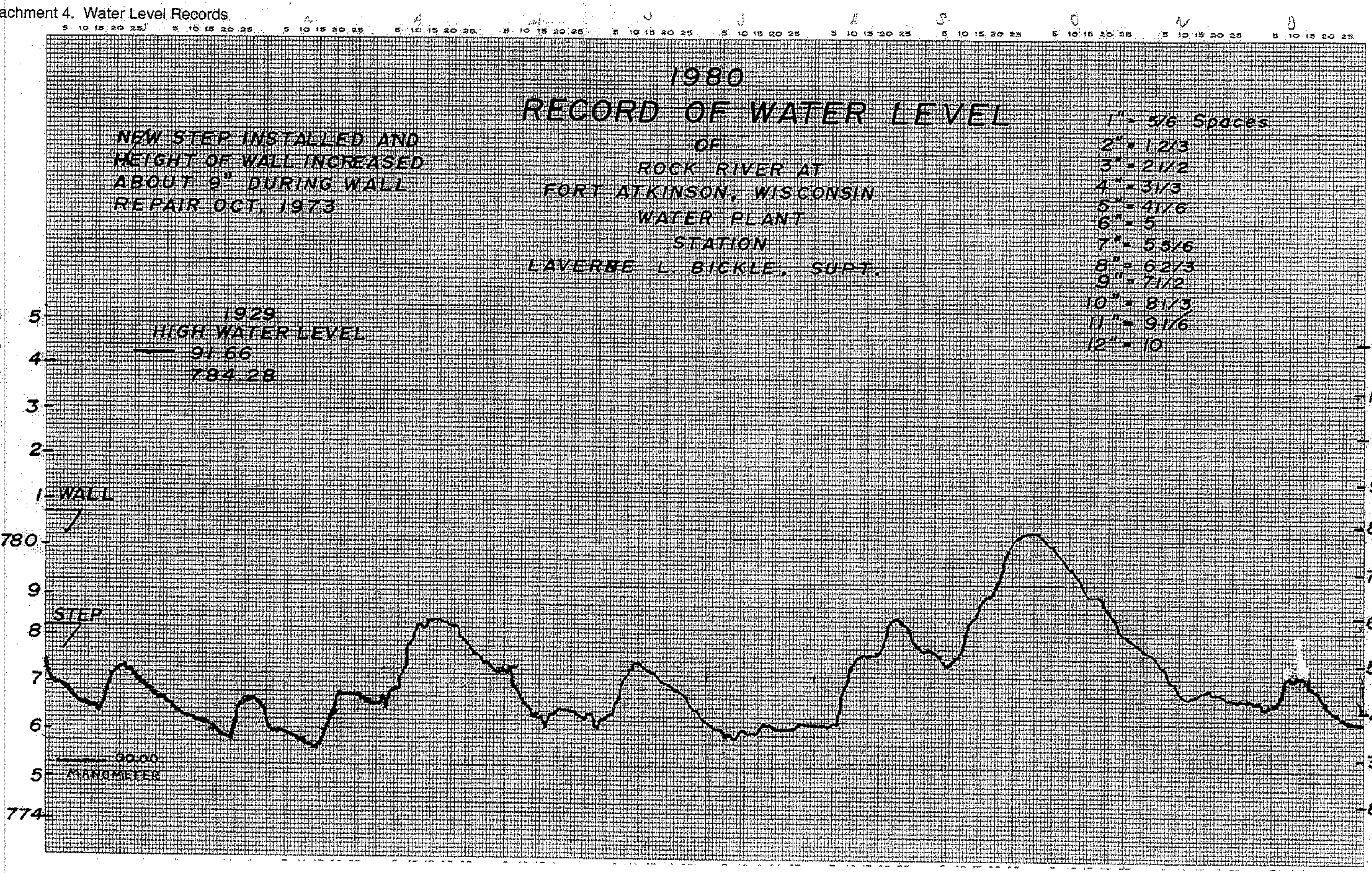
New step installed and height of wall increased about 9" during wall repair Oct. 1973



1979

RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973


1980
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.
NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT, 1973
1929
HIGH WATER LEVEL
91.66
784.28
1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10
WALL
STEP
90.00
MANOMETER
CITY DATUM
J F M A M J J A S O N D
5 10 15 20 25
5
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780
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6
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774
2
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90
9
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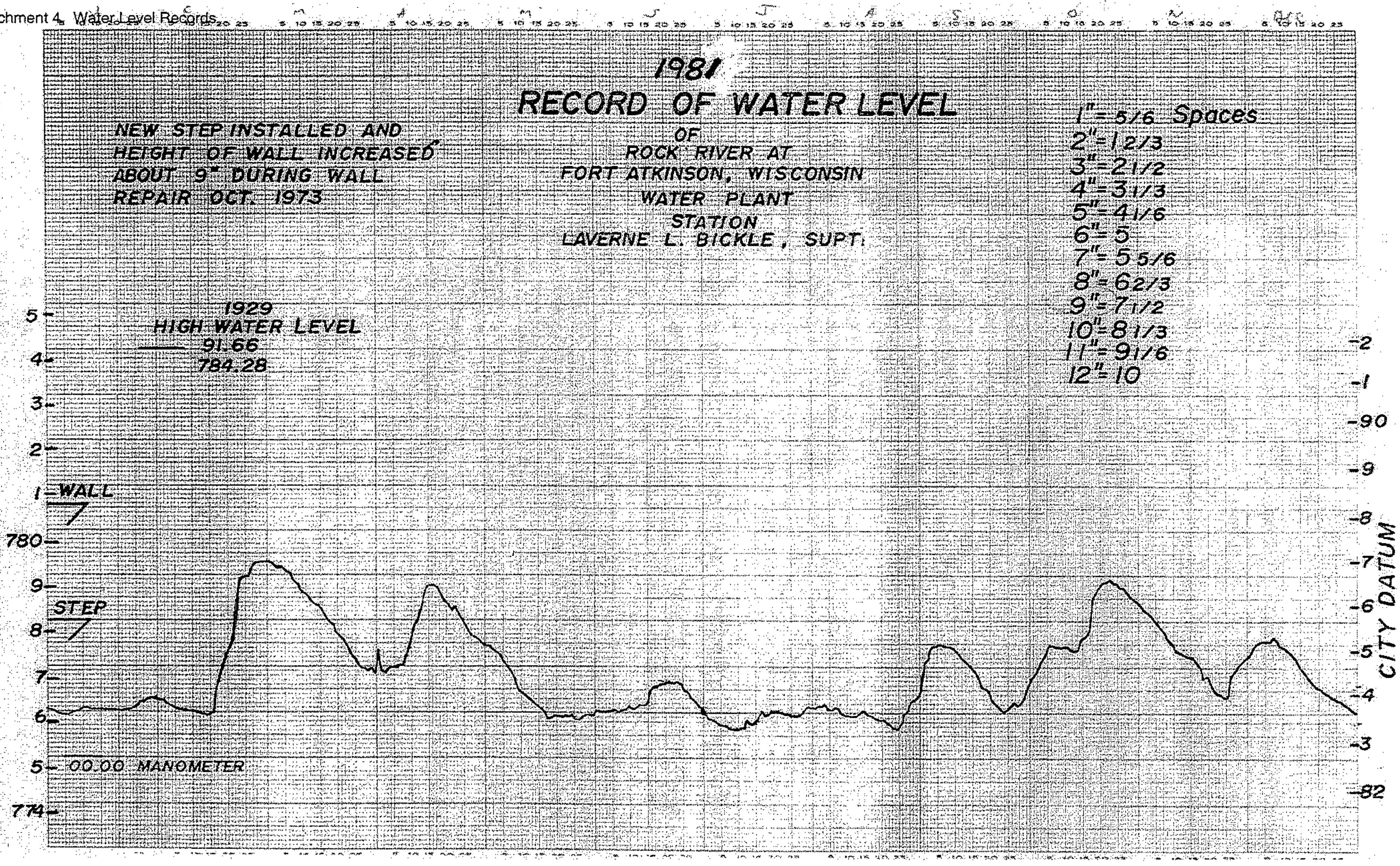
82



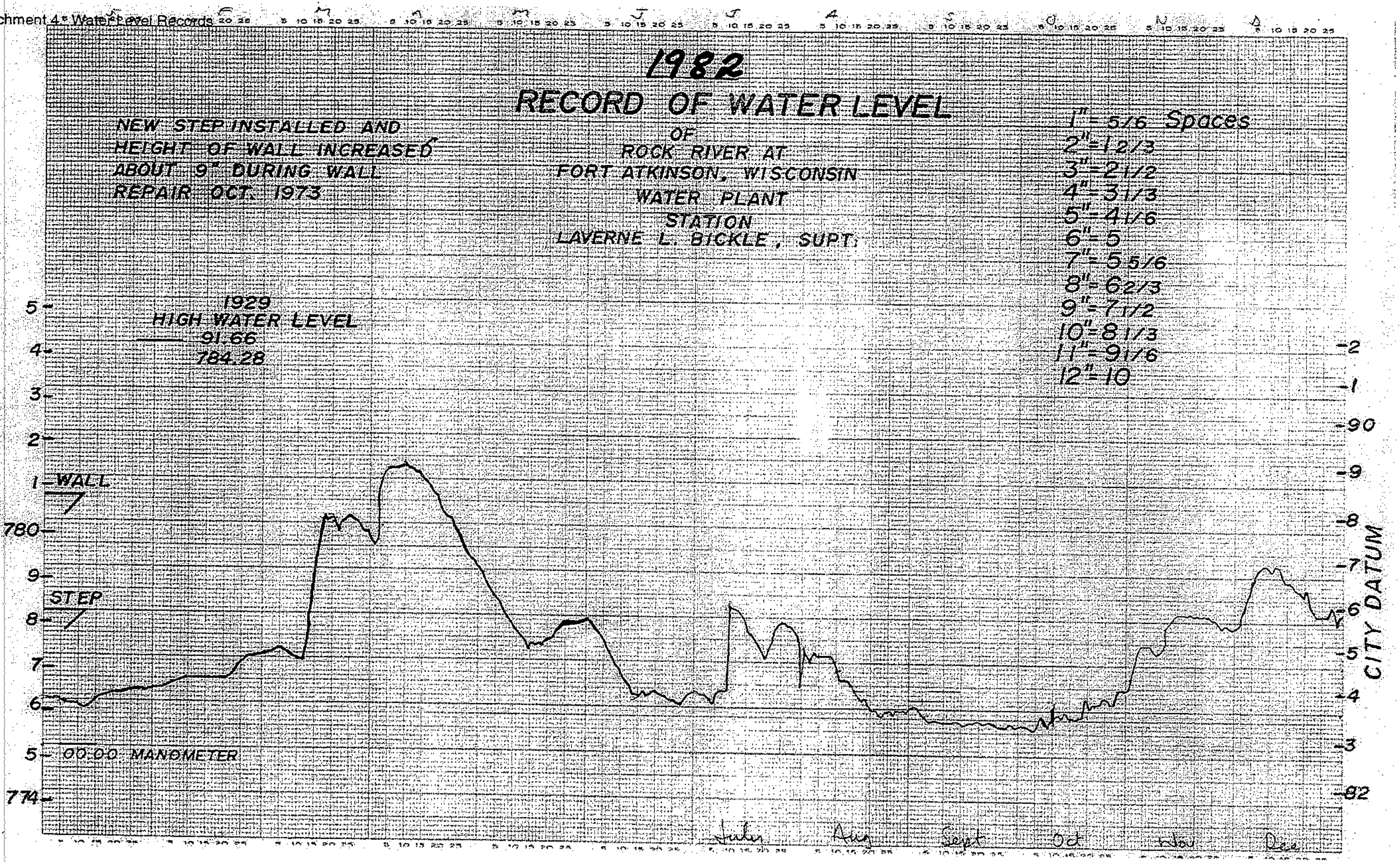
1981

RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973

1929
HIGH WATER LEVEL
91.66
784.28

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10



1982

RECORD OF WATER LEVEL

OF

ROCK RIVER AT

FORT ATKINSON, WISCONSIN

WATER PLANT

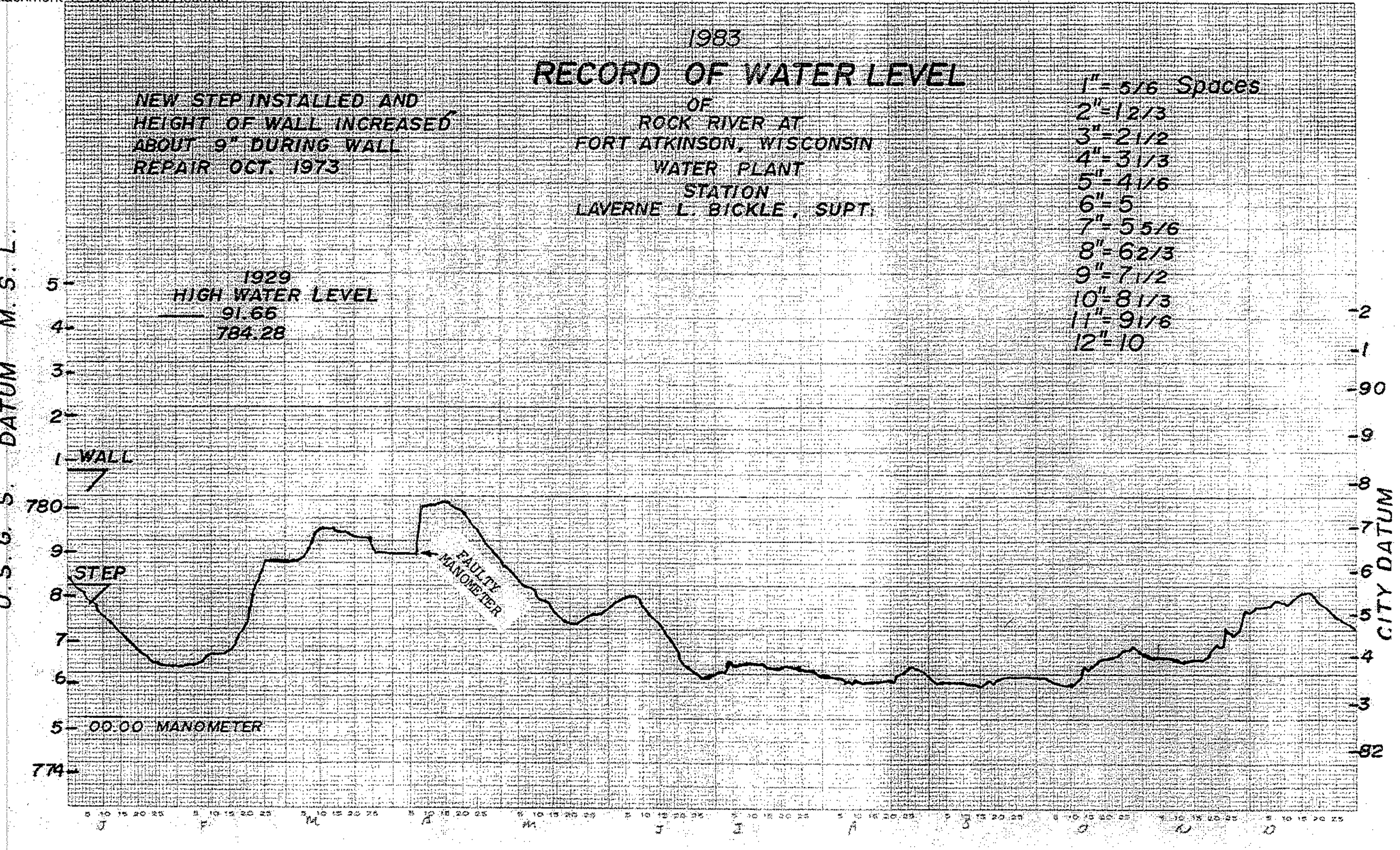
STATION

LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10

1929
HIGH WATER LEVEL
91.66
784.28



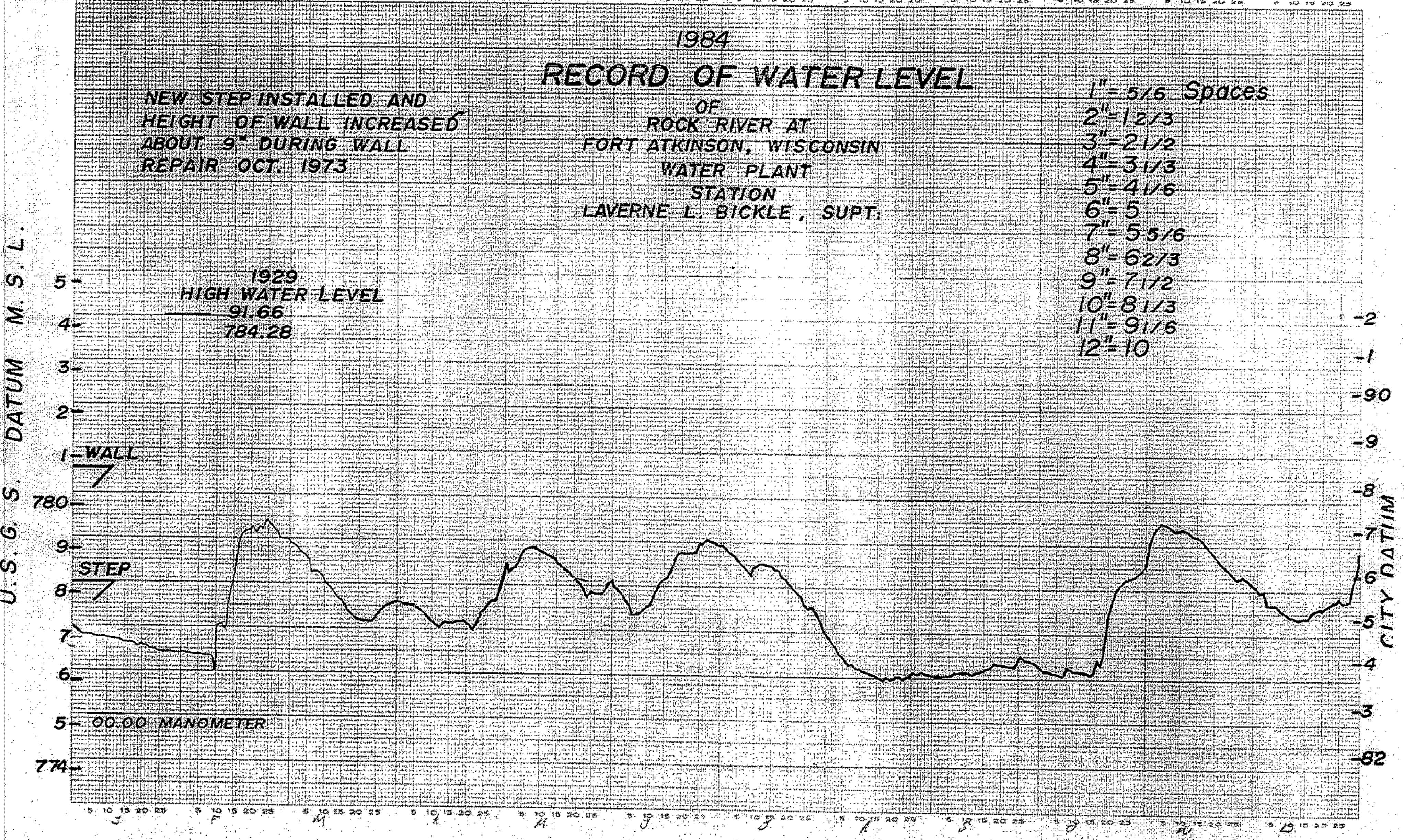
1983

RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973

1929
HIGH WATER LEVEL
91.66
784.28

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10


1984
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.
NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973
1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10
1929
HIGH WATER LEVEL
91.66
784.28
WALL
STEP
00.00 MANOMETER
U. S. G. S. DATUM M. S. L.
5
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5
774
CITY DATUM
-2
-1
-90
-9
-8
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-5
-4
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-82
5 10 15 20 25
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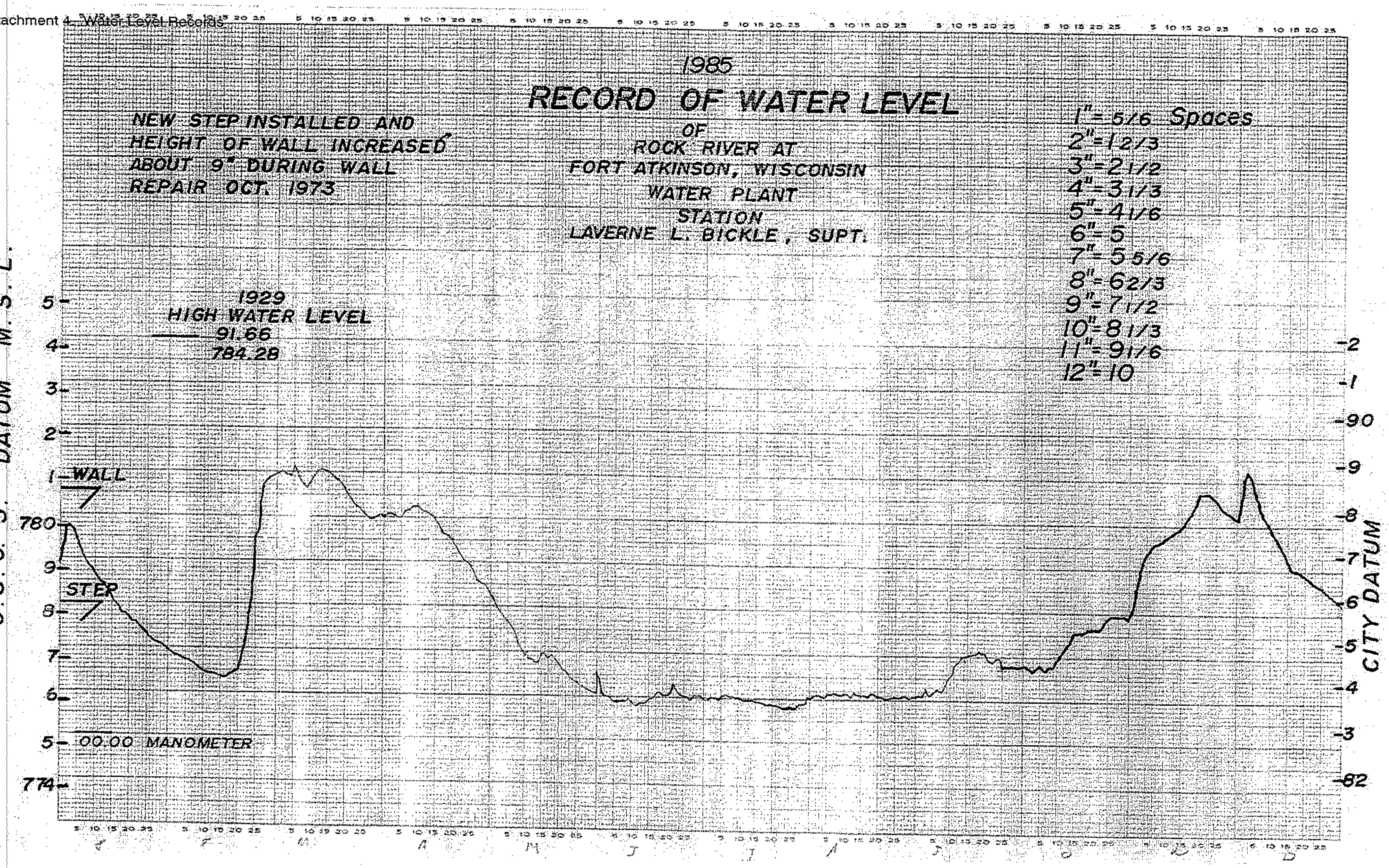


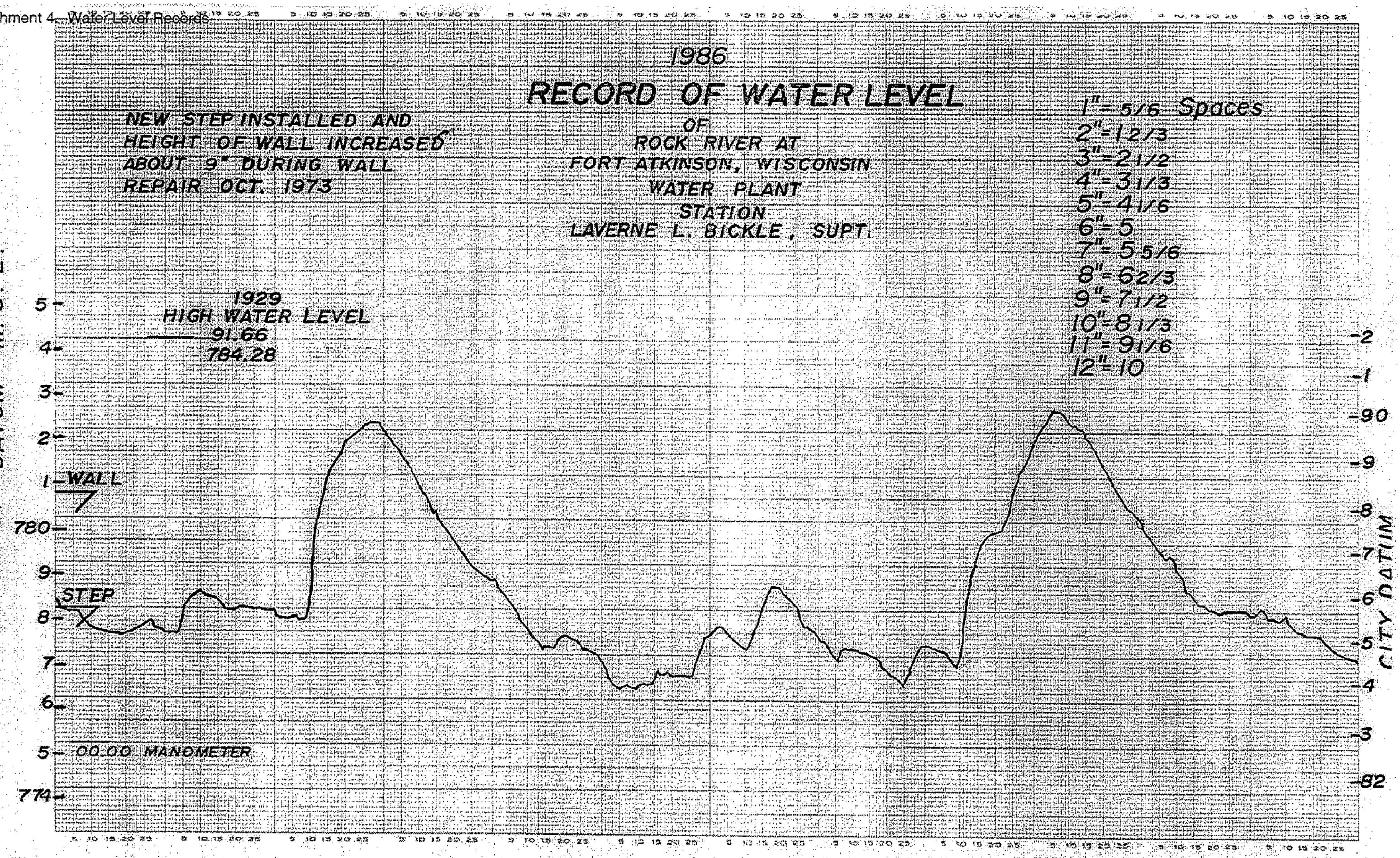
1985

RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973

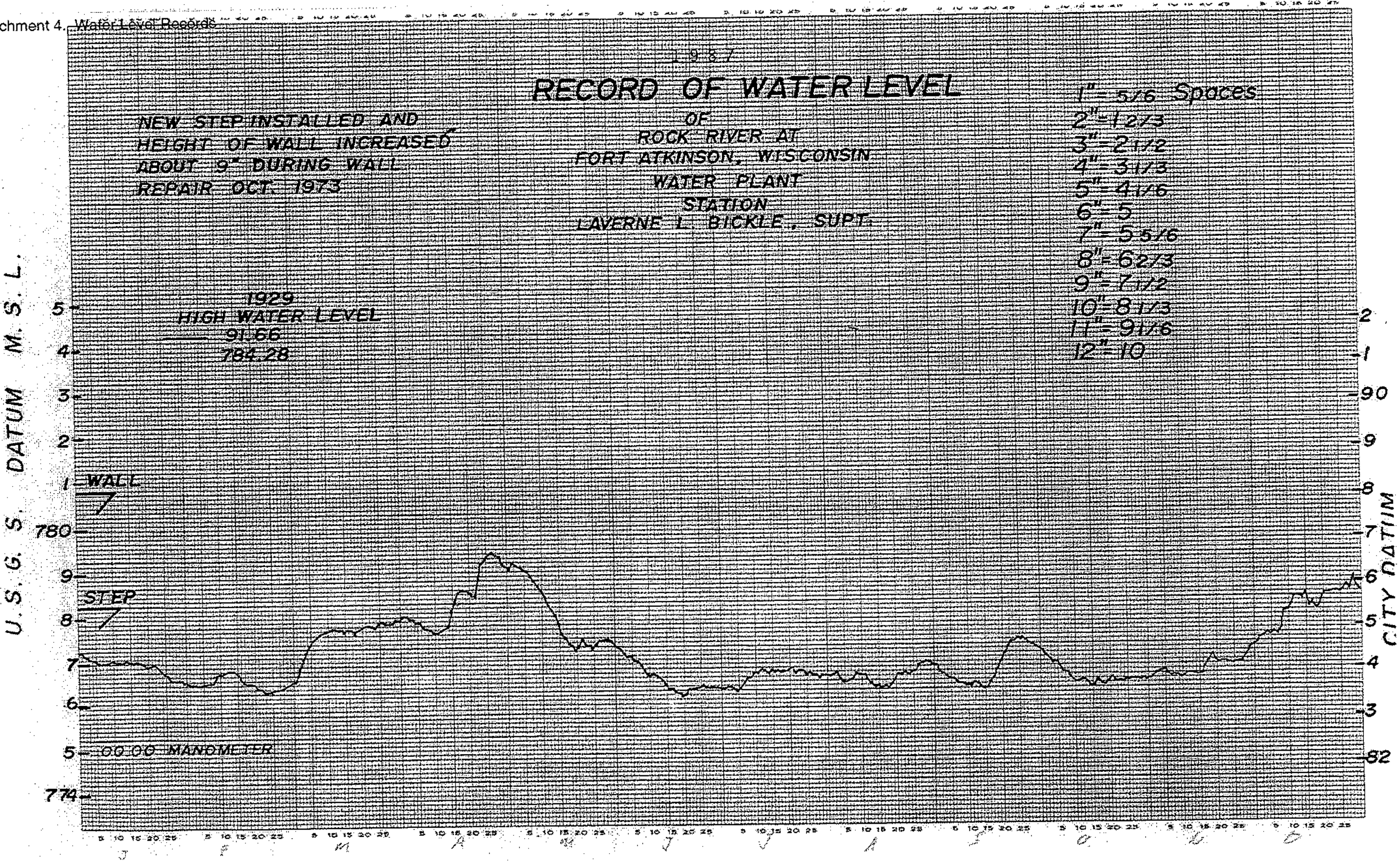
1929
HIGH WATER LEVEL
91.66
784.28

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10



1986
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973



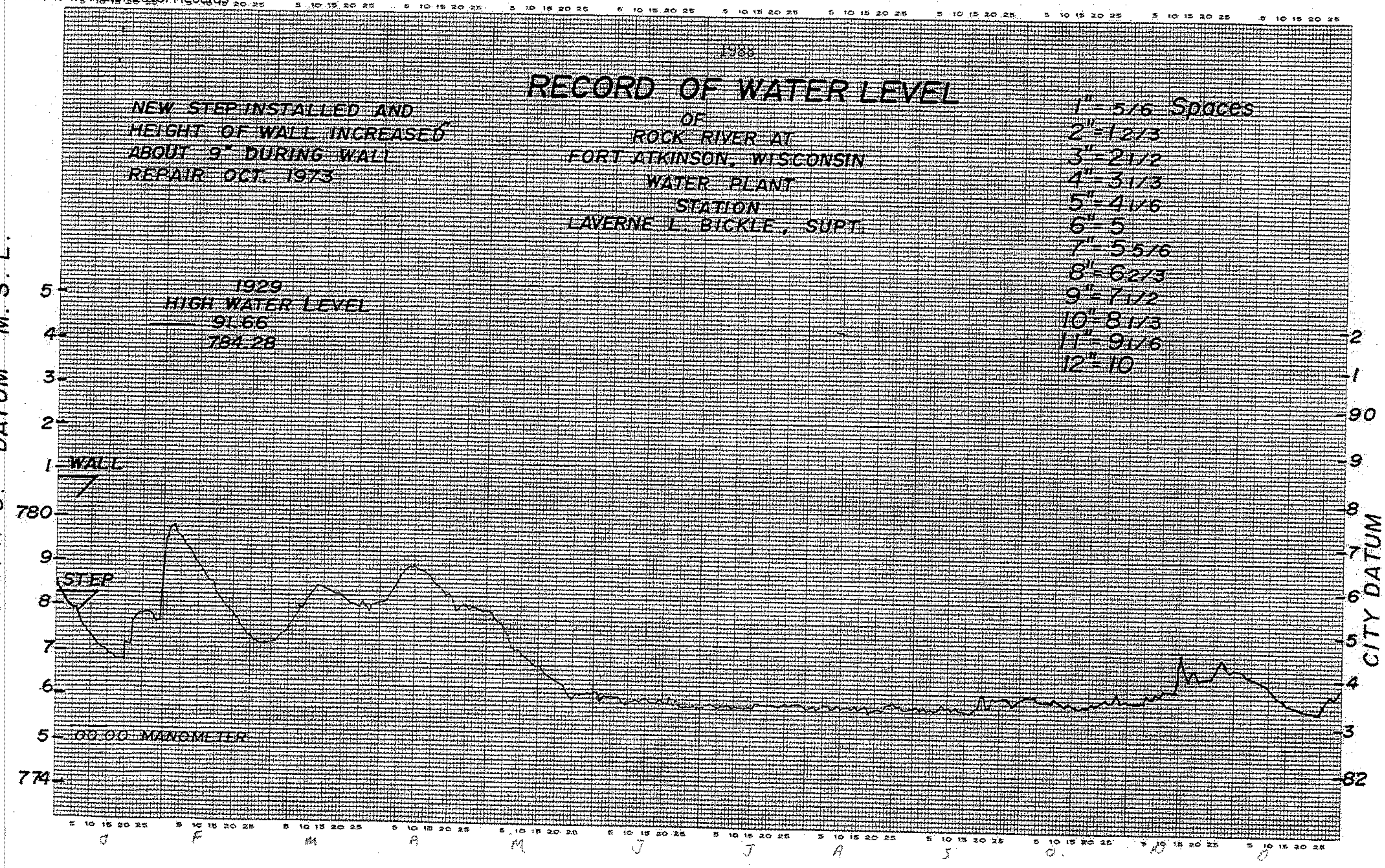
1987

RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973

1929
HIGH WATER LEVEL
91.66
784.28

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10



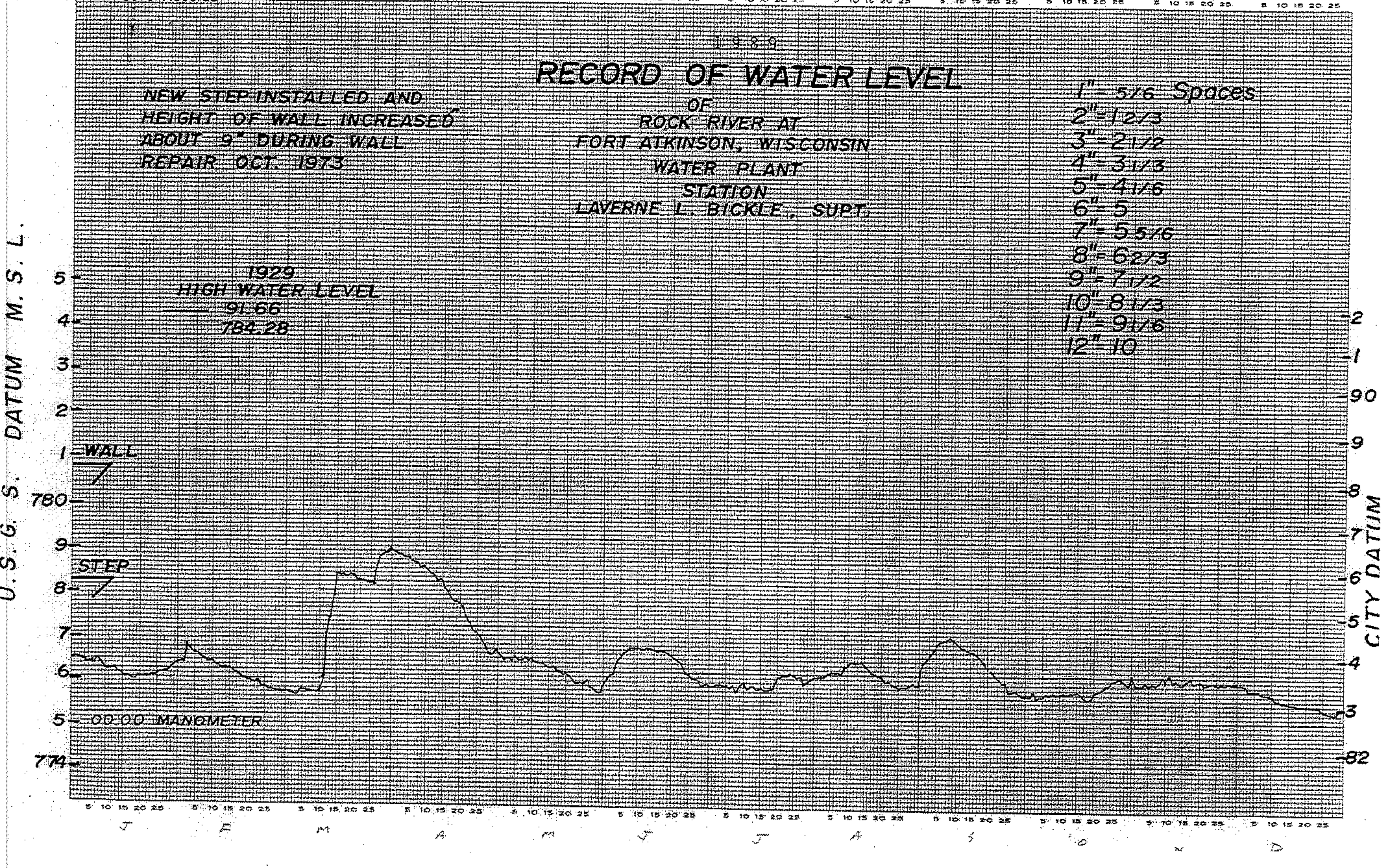
1988

RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.

NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973

1929
HIGH WATER LEVEL
91.66
784.28

1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10


1989
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.
NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973
1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
9" = 7 1/2
10" = 8 1/3
11" = 9 1/6
12" = 10
1929
HIGH WATER LEVEL
91.66
784.28
WALL
STEP
00.00 MANOMETER
U. S. G. S. DATUM M. S. L.
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CITY DATUM
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82
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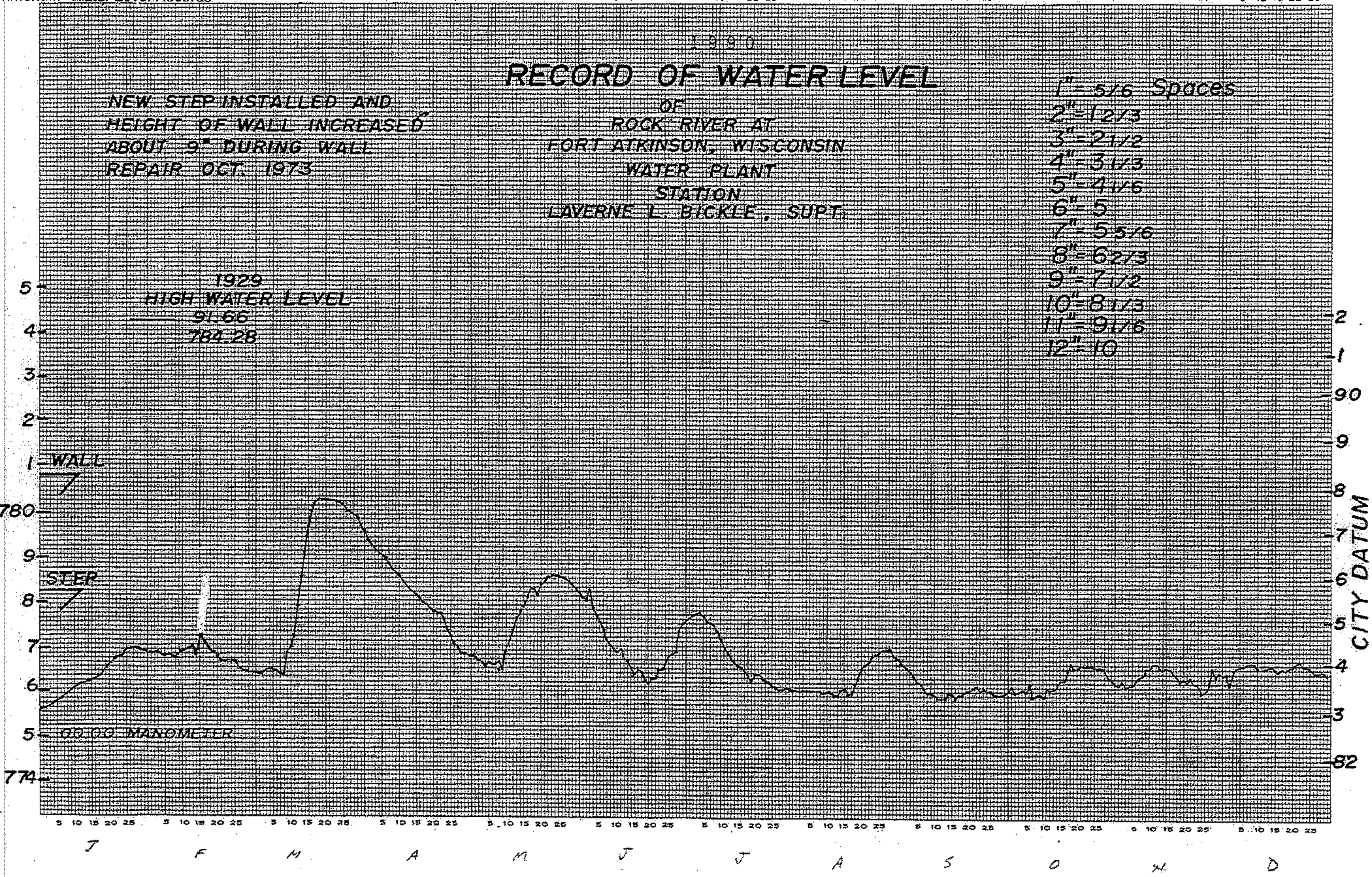
1990
RECORD OF WATER LEVEL
OF
ROCK RIVER AT
FORT ATKINSON, WISCONSIN
WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.
NEW STEP INSTALLED AND
HEIGHT OF WALL INCREASED
ABOUT 9" DURING WALL
REPAIR OCT. 1973
1" = 5/6 Spaces
2" = 1 2/3
3" = 2 1/2
4" = 3 1/3
5" = 4 1/6
6" = 5
7" = 5 5/6
8" = 6 2/3
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12" = 10
1929
HIGH WATER LEVEL
91.66
784.28
5
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WALL
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STEP
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CITY DATUM
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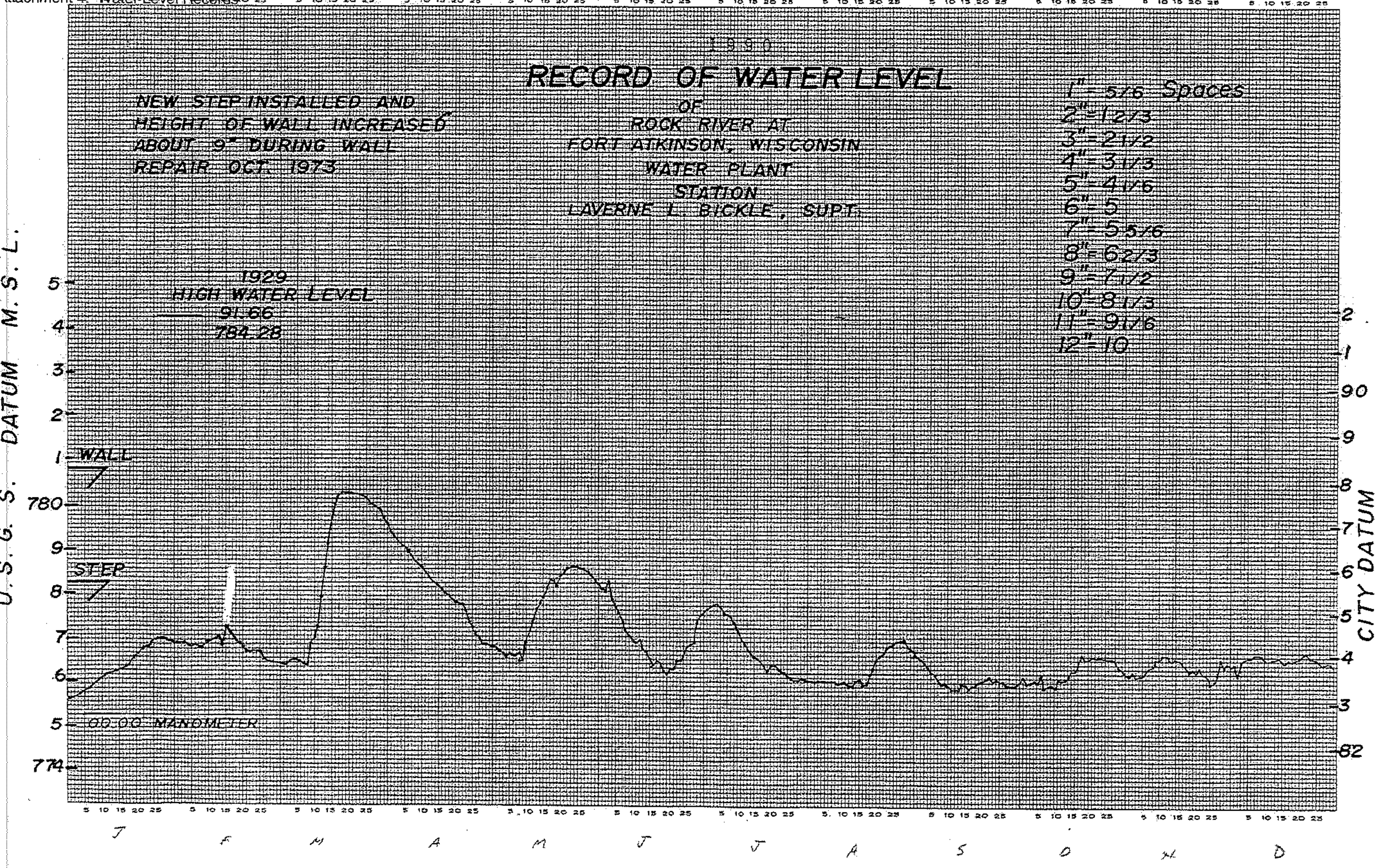
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WATER PLANT
STATION
LAVERNE L. BICKLE, SUPT.
NEW STEP INSTALLED AND
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ABOUT 9" DURING WALL
REPAIR OCT. 1973
1929
HIGH WATER LEVEL
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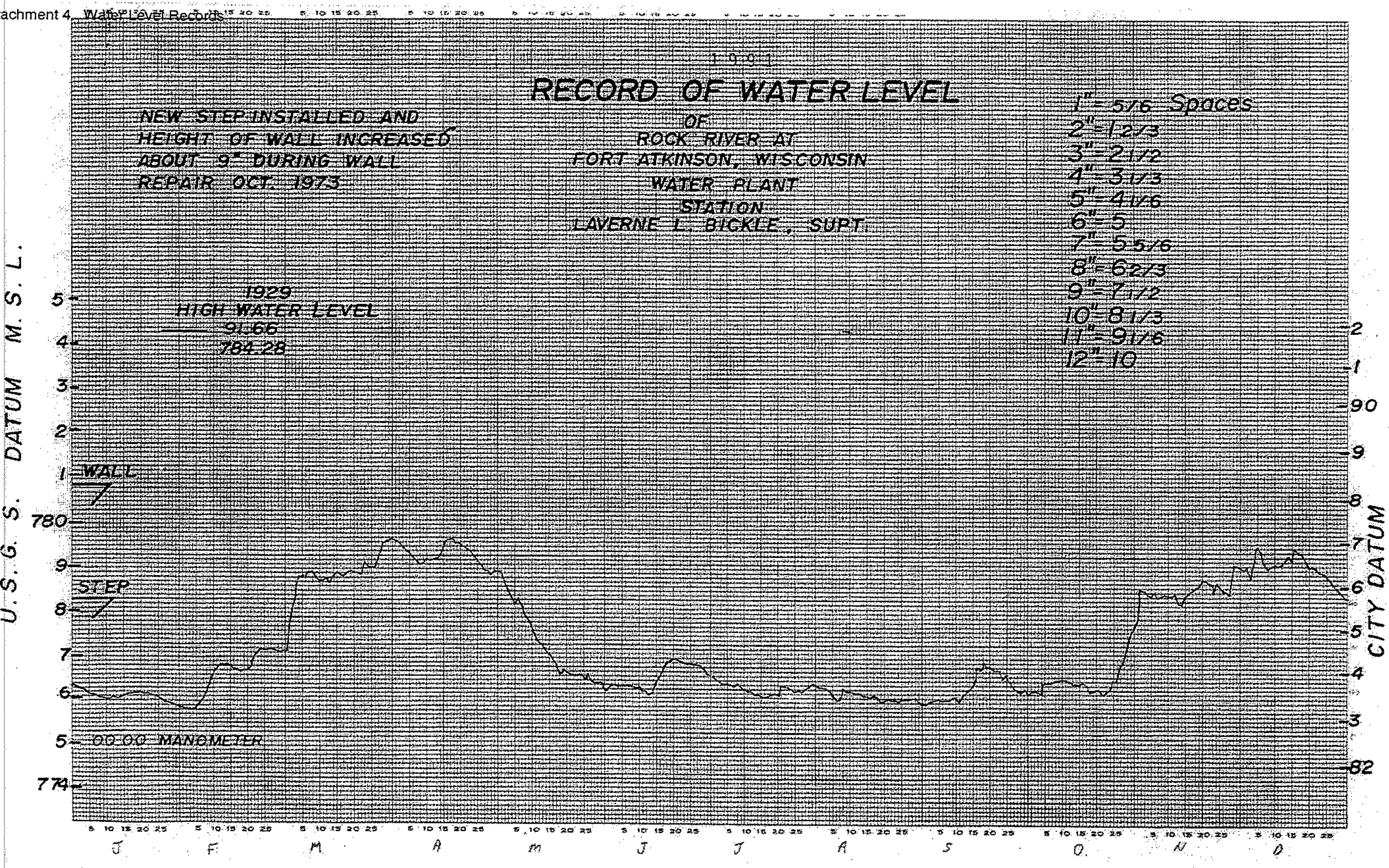

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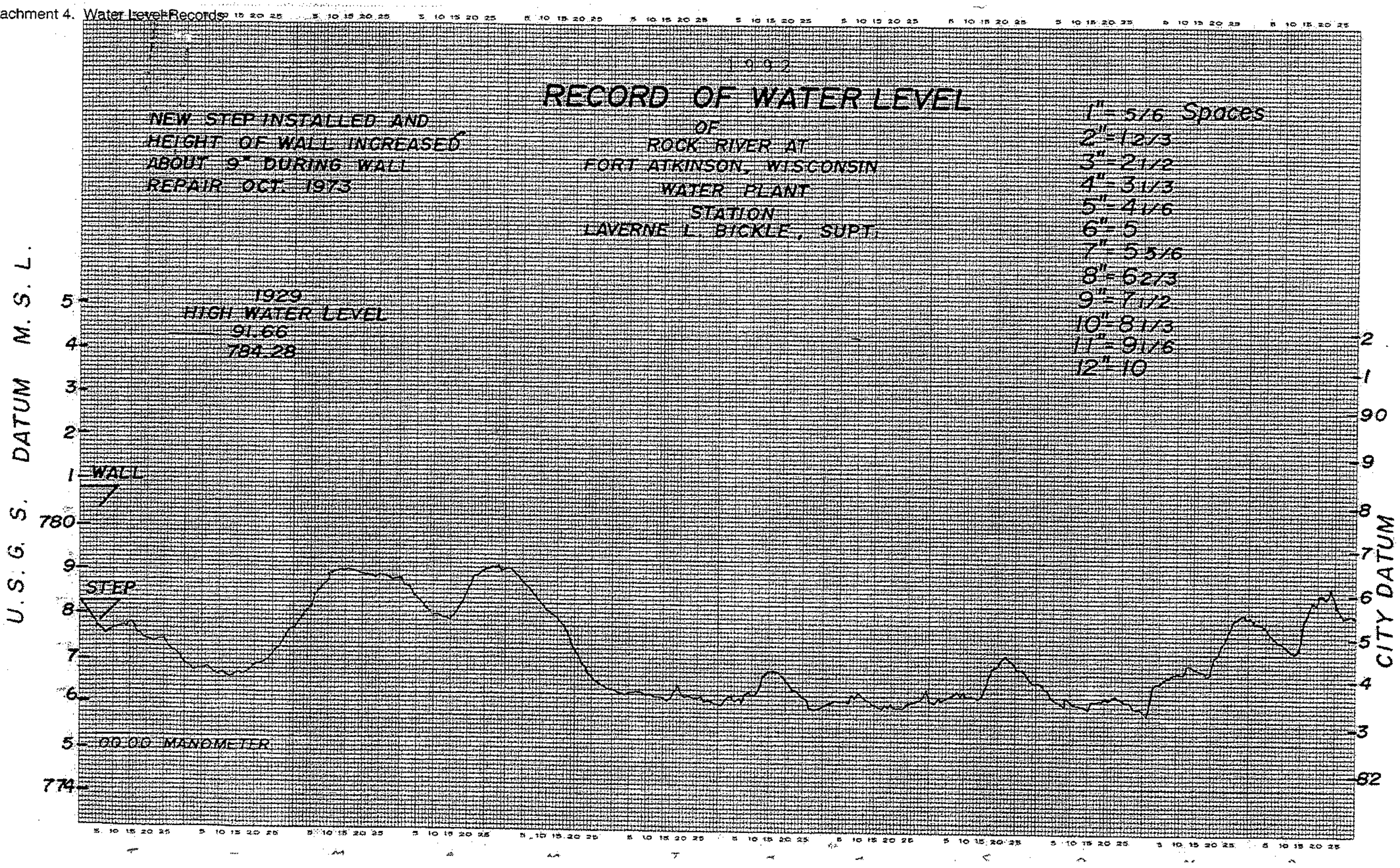
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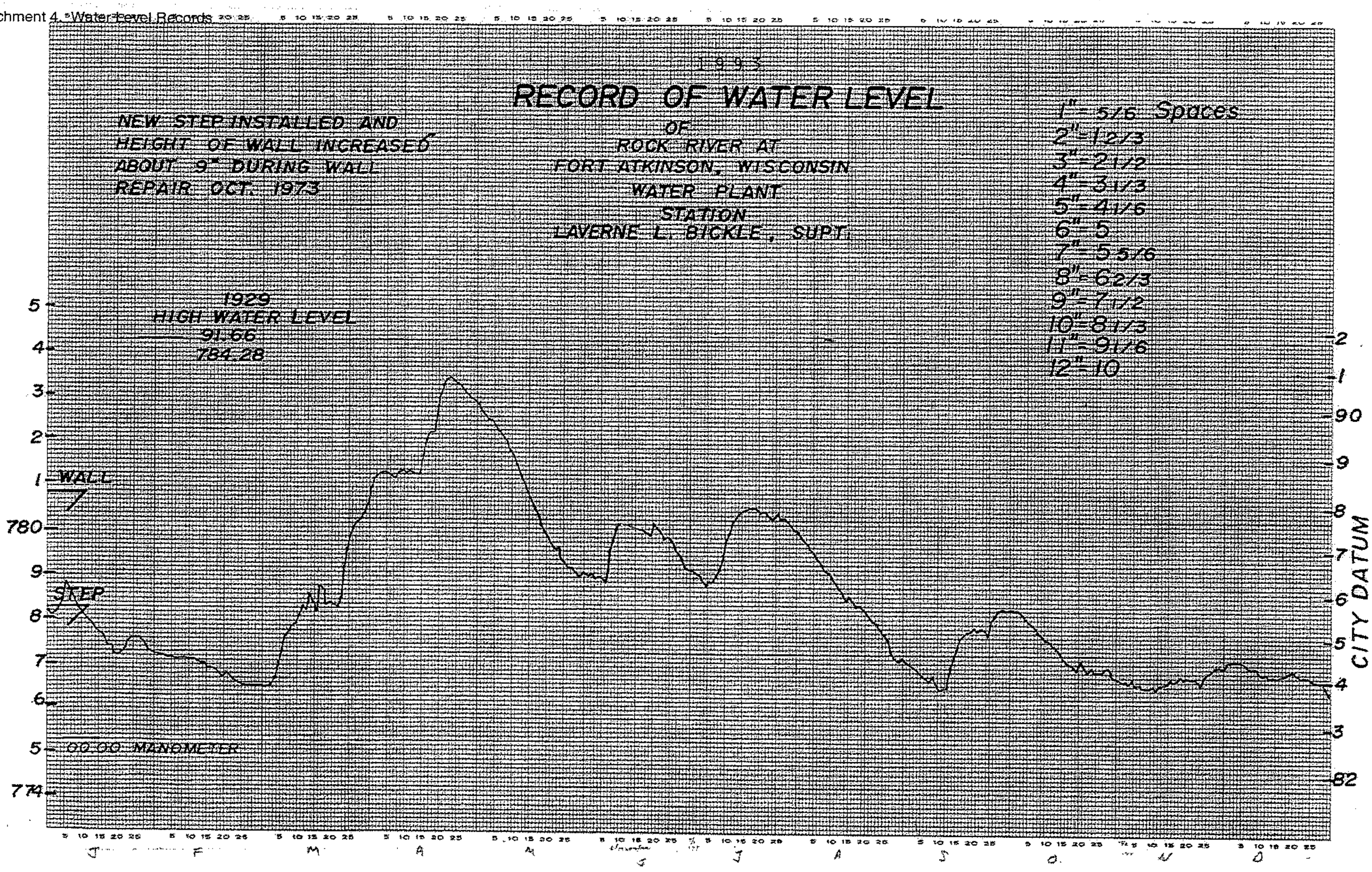

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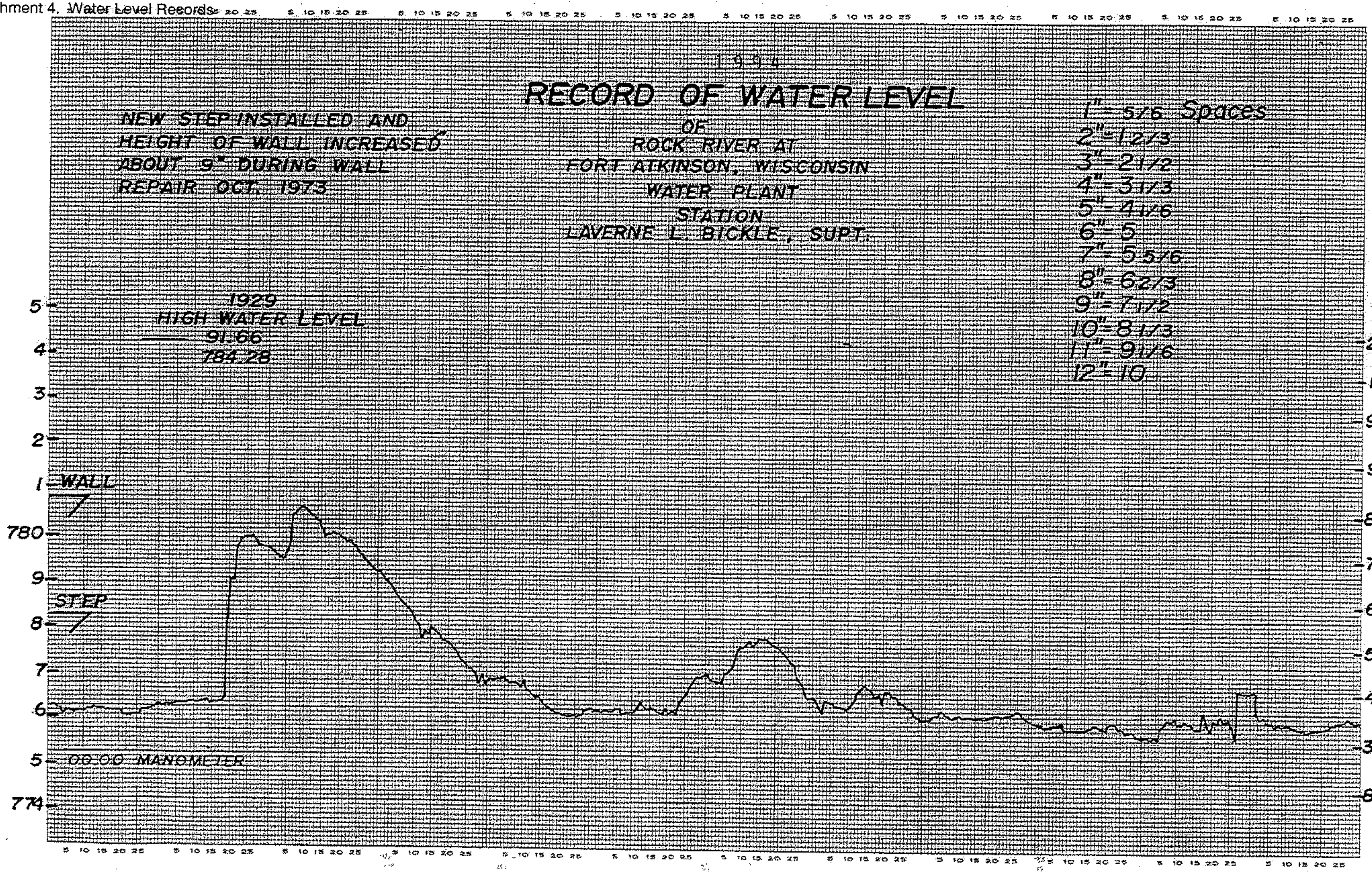
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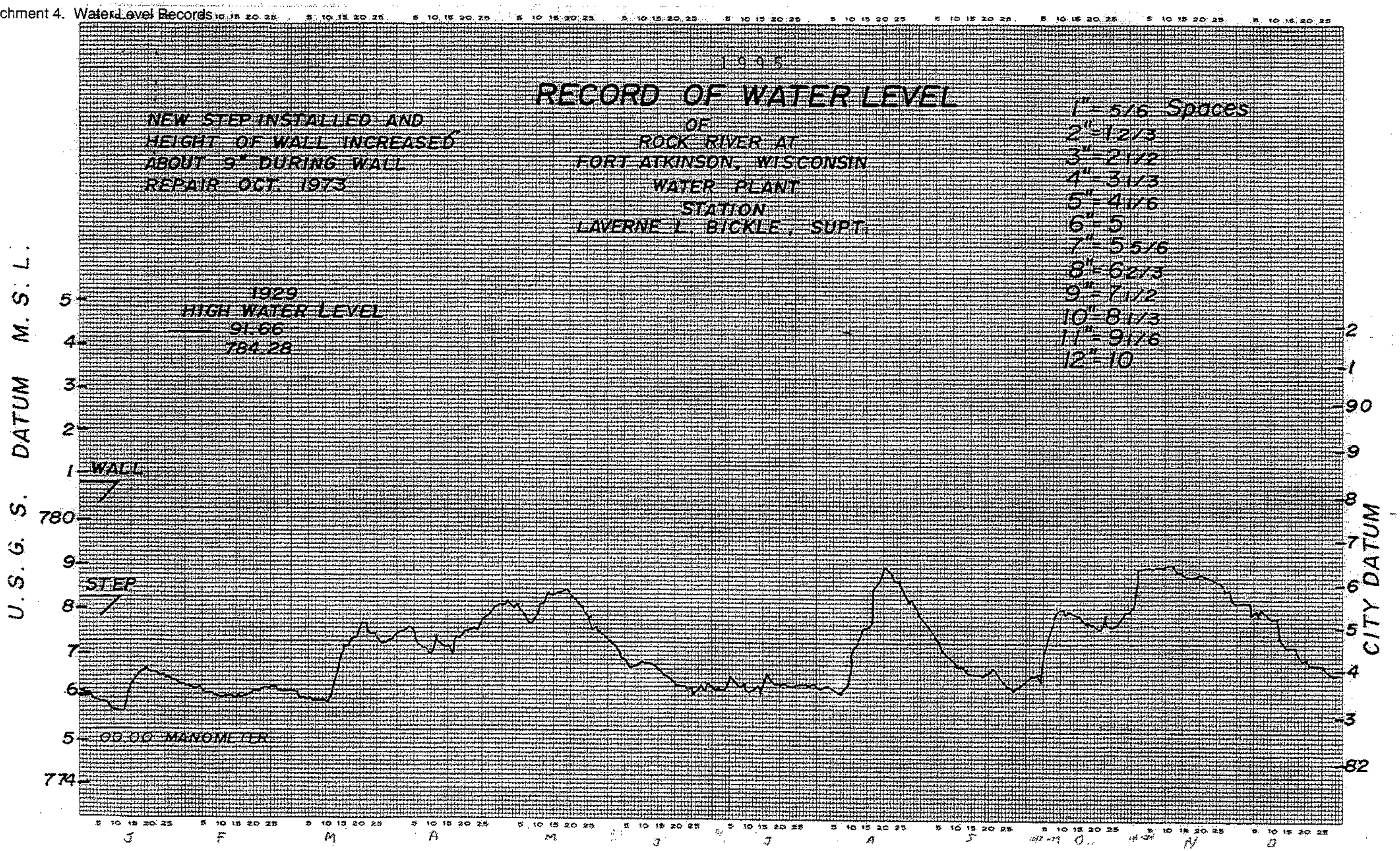
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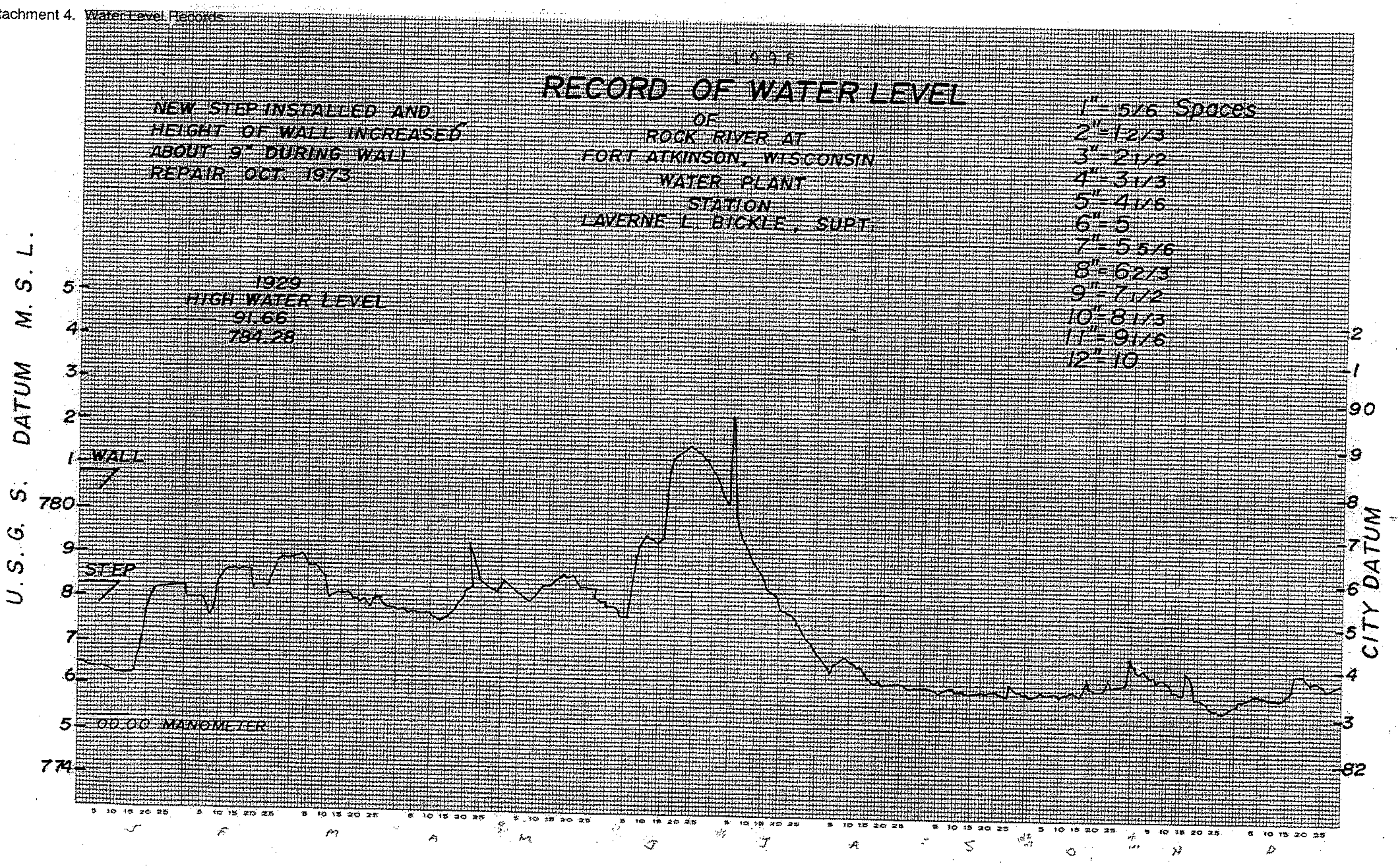
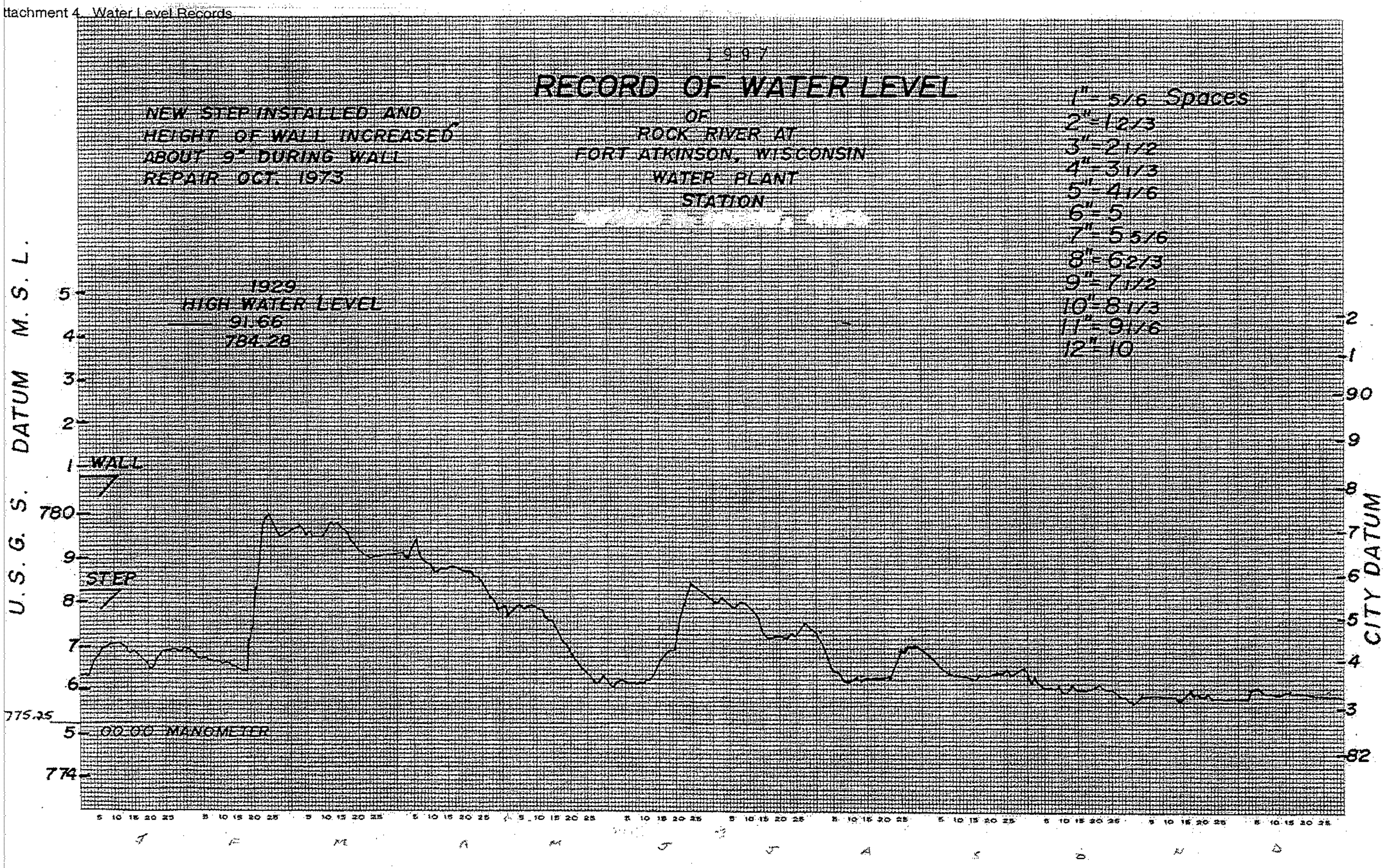
Attachment 4. Water Level Records

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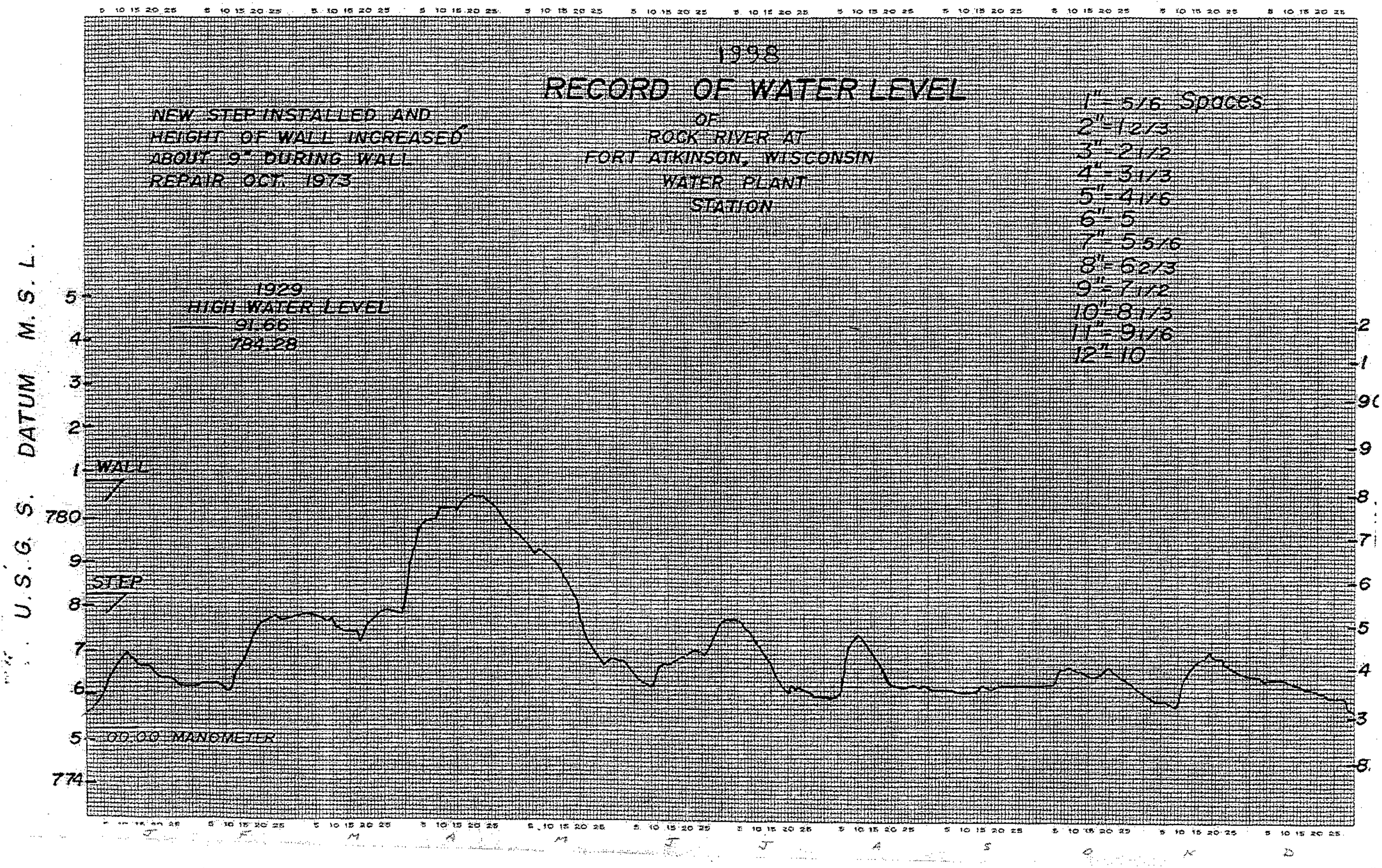

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Time Series Analysis of Lake Koshkonong Water Levels

Data Validation

The USGS in cooperation with Rock County operates a water-stage recorder for Lake Koshkonong (USGS 05427235 LAKE KOSHKONONG NEAR NEWVILLE). However, the period of record for this station is limited to recent years (July 1987 to current).

However, Fort Atkinson Water Plant staff has recorded daily water levels of the river adjacent to the plant since 1932. DNR staff received detailed annual graphs (1932-1998) of these water level records (Appendix 4).

USGS 05427235 LOCATION.--Lat 42°51'27", long 88°56'27", in NW 1/4 NE 1/4 sec.34, T.5 N., R.13 E., Jefferson County, Hydrologic Unit 07090001, 80 ft east of Pottawatomi Trail Bridge at Bingham Point Estates, and 4.5 mi northeast of Newville. DRAINAGE AREA.--2,560 square miles, at lake outlet. Area of Lake Koshkonong, 16.3 square miles. PERIOD OF RECORD.--July 1987 to current year. GAGE.--Water-stage recorder. Datum of gage is 770.00 ft above sea level. REMARKS.--Lake level regulated by dam at Indianford. Gage-height telemeter at station.Station operated in cooperation with Rock County

The reach of river between the water plant and Lake Koshkonong is very low gradient. Because of its extremely low gradient, changes in water levels recorded upstream at Fort Atkinson may be reflective of the lake levels and accurately track annual trends in water levels of the lake. To examine the utility of the Fort Atkinson water level data we compared Lake Koshkonong daily water levels found at the Lake Koshkonong gage to those recorded at the Fort Atkinson gage for the period October, 1998 though September, 2003.

Water level records at Fort Atkinson correspond to and track water levels recorded for Lake Koshkonong (Figure 1). Water levels recorded at Fort Atkinson average 0.177 feet higher than those reported for Lake Koshkonong (Figure 2). The magnitude of the difference between water levels is a function of river flows/discharge, and is described by a linear regression function where: Difference (Fort-Lake (ft.)) = 0.000169139*(FTDISCHARG) - 0.065917605. FTDISCHARG is the flow (cfs) reported for the Rock River at Fort Atkinson (Figure 3; P<0.001 Table 1).

Figure 2.

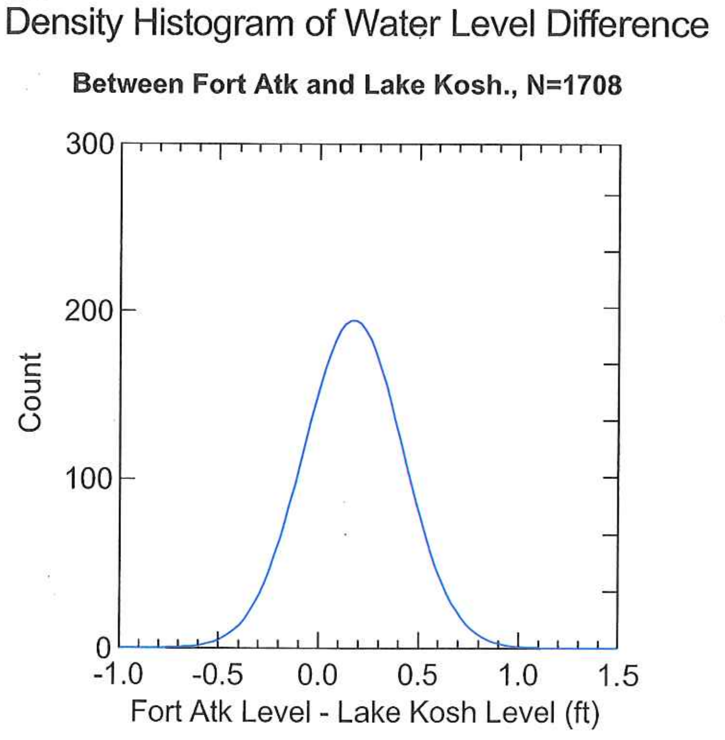


Figure 1. **1987-2004 Rock River, Water Level Data from Fort Atkinson and Lake Koshkonong**

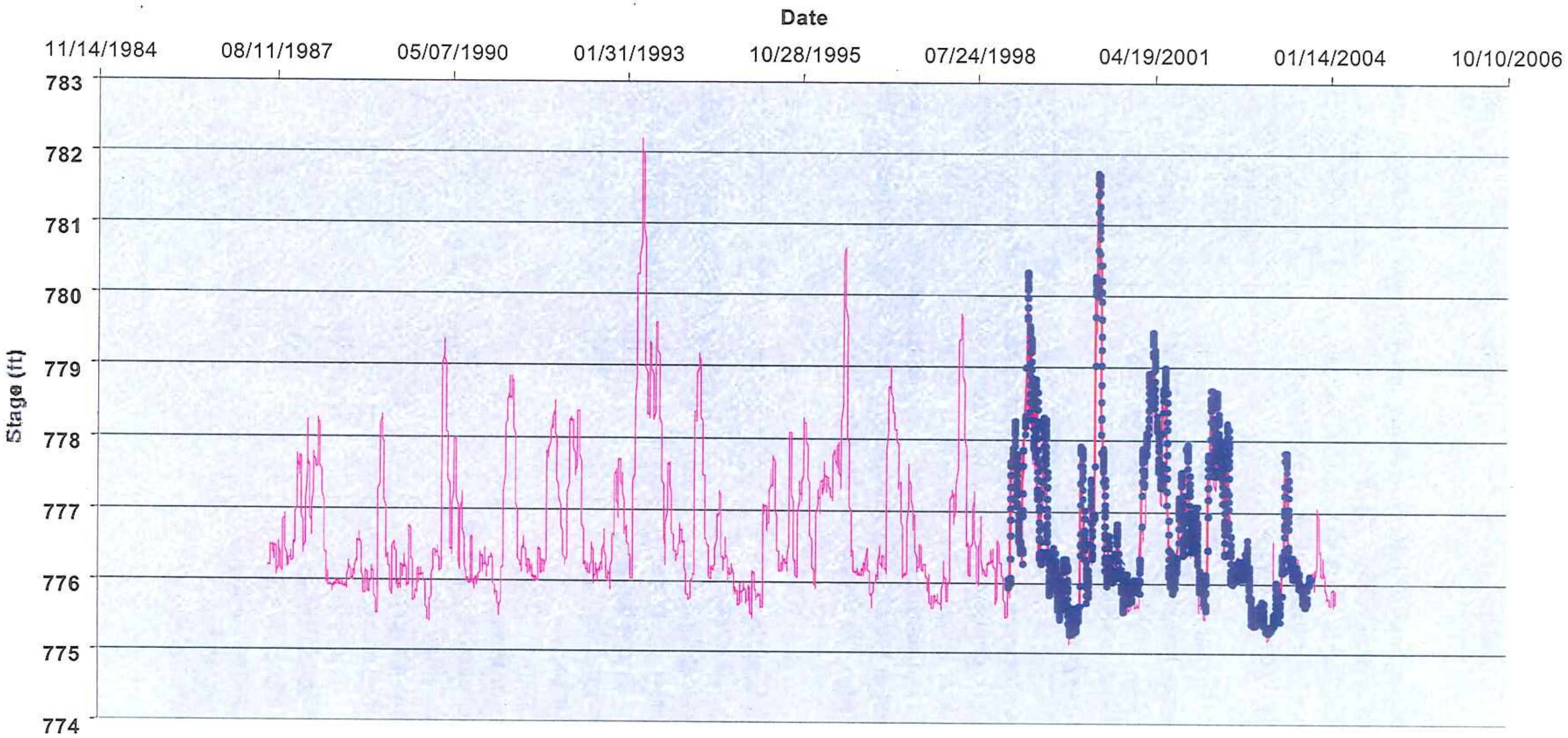


Table 1.

```
Dep Var: FORTMSLK    N: 1688    Multiple R: 0.815166549    Squared multiple R: 0.664496502

Adjusted squared multiple R: 0.664297508    Standard error of estimate: 0.146024709

              Effe( Coefficient       Std Error       Std Coef           Tolerance                t
             CONSTAI   -0.065917605    0.005504569     0.000000000              .             -1.19E01
           FTDISCHAI    0.000169139    0.000002927     0.815166549          1.00E+00          57.78653

Analysis of Variance

              Source  Sum-of-Squares                   df    Mean-Square     F-ratio              P
          Regression      7.12042E+01          .        1    7.12042E+01   3.33928E+03   0.00000000C
            Residual      3.59509E+01                1686    0.021323216
```

Water Level Time Series Analysis

Our primary objective is to examine long term trends in water level during the summer period, when flow is reflective of base levels and is not so strongly affected by the extreme runoff events that occur in spring. Data points from the Fort Atkinson Water Plant graphs were systematically interpolated on days 1,5,10, 15,20, and 25 of each month and entered into a database for analysis. For data after 1998, daily water level records were electronically available. Mean water levels were calculated by month and by season (spring, summer, fall winter) for each year.

The individual observations in a time series such as this are frequently not independent of one another. Because water level changes in a continuous manner, observations closer together in time will be more highly correlated with one another than are those far apart (and this was confirmed by the autocorrelation function values computed; Figure 4.). This type of correlation pattern must be accounted for in data analysis because many standard statistical methods assume that observations are independent. An additional complication with this series is that there appears a seasonal pattern.

Figure 3.

Difference in Station Levels by Discharge

Lines show linear regression and the 90% confidence interval of the regression, N=1708, data from 1/16/99 to 9/30/03.

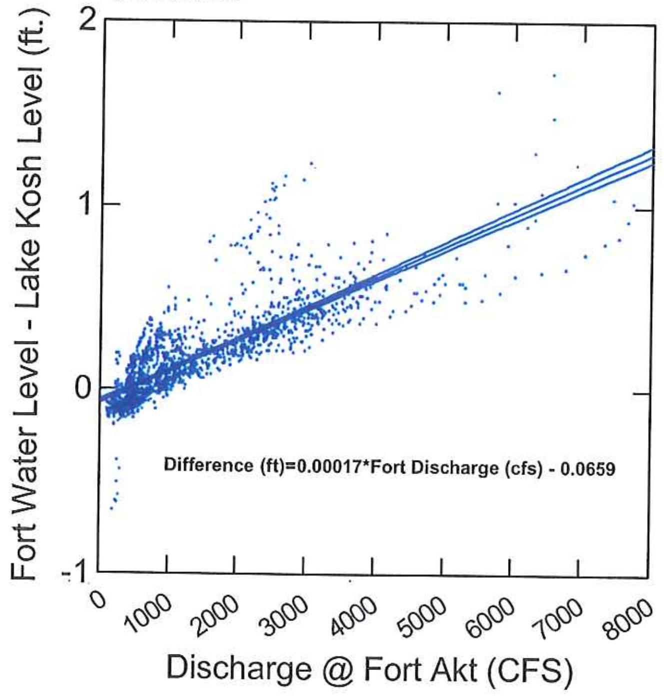
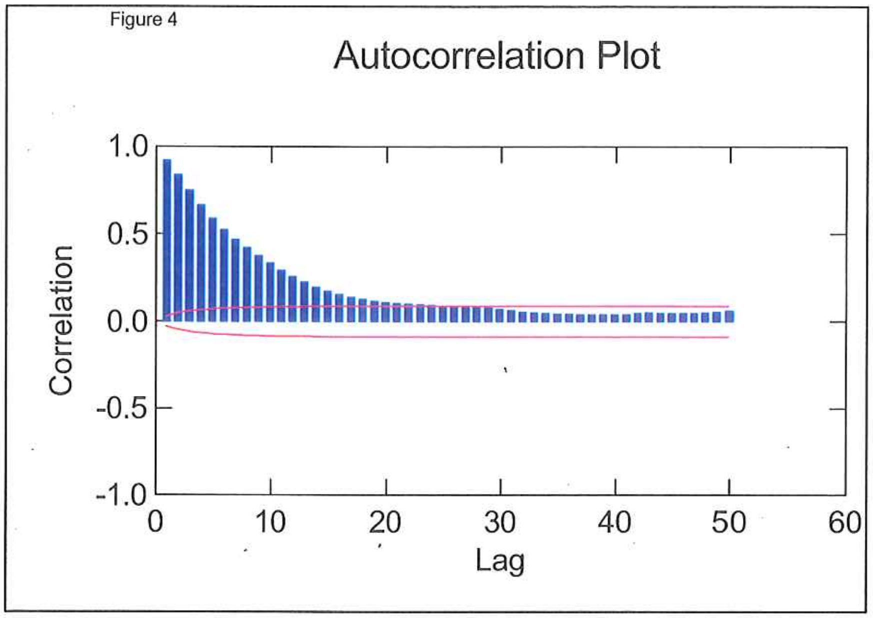


Figure 4


Autocorrelation Plot

An approach that addresses our objective and avoids problems with autocorrelation and seasonality is to compute the average summer elevation (the average of all measurements during the summer period for each year) and base trend analyses on these annual averages. Seasonality is eliminated by this procedure and autocorrelation is at least greatly reduced. These annual averages for one season are based on 18 observations at taken at 5 day intervals, and represent a good summary of water level in each season. We used interpretations of Indianford seasonal discharge data (Figure 5) to aid in segmenting the year into seasons. All records for dates in March-May, June-August, September-November, December-February were respectively identified as spring, summer, fall, and winter. We tested for significant changes in water levels for the whole period (ANOVA; 1932-2003). Next, we used analysis of covariance to test for differences in slopes of water level changes for two distinct periods: We considered years 1932-1960 as a period of more intensive dam operation for maximize power generation, and after that (1961-2003), less intensive power generation and period of less intense gate manipulation. Finally, we investigated annual trends for the remaining seasons; spring, fall, and winter.

Data Subset Method-Elimination of Wet Summers

Our objective is to determine whether a pattern in dam management for water levels exists in the time series data. A review of the data indicates that the changes in Indianford Dam operational procedures may be able to produce noticeable effects on Lake Koshkonong at relatively low flow conditions. Because the dam controls water levels during base-flow conditions during the summer period, we rated the water-level years for the purpose of eliminating variable and high precipitation years from the data. Detailed annual graphs (1932-1998) of water levels recorded by Fort Atkinson Water Plant staff (Appendix_4) were individually examined. Each year of the summer water level record for the period 1932-1998 was classified by the following criteria:

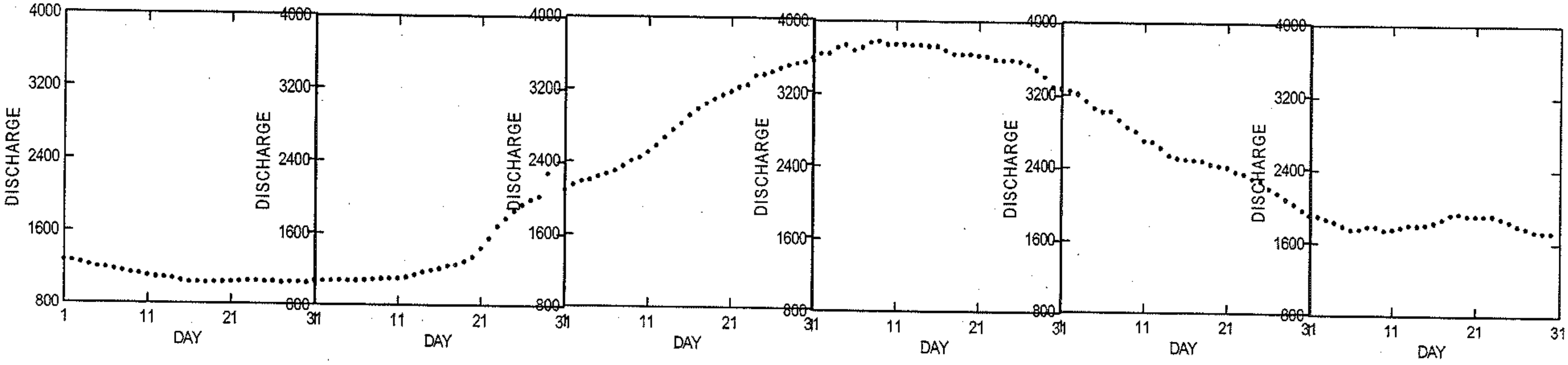
1 = level nearly constant during the summer
2 = some variablility (usually June) but level had a long stable period
3 = much variability, but a some constant level periods remaining
4 = highly variable with no constant level periods

The peak water-level was recorded for each year. We then eliminated class 4 summers and examined trends in among the remaining years (summer-peak value). Next, we eliminated class 3 and 4 summers and investigated trends in remaining years for summer peak levels.

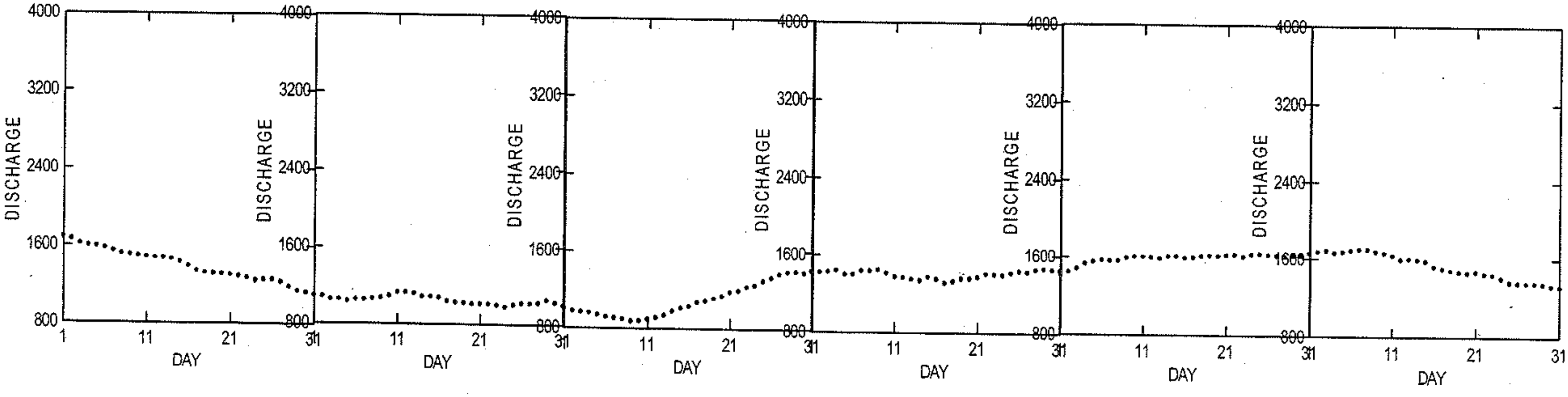
Figure 5.

USGS 05427570 ROCK RIVER AT INDIANFORD, WI . Daily Mean Discharge for the period 05/07/1975 through 09/30/2003.

January through June



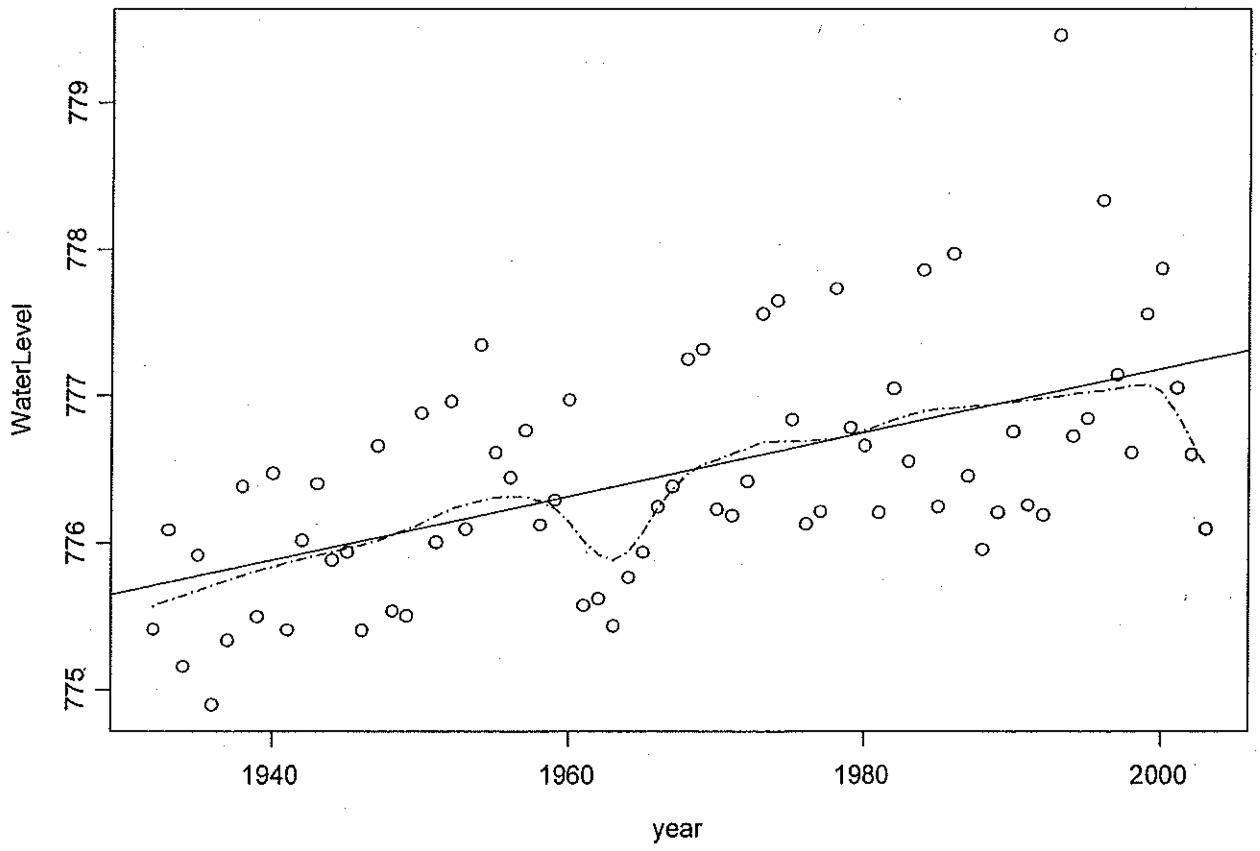
July through December



Annual Trends in Summer Water Levels

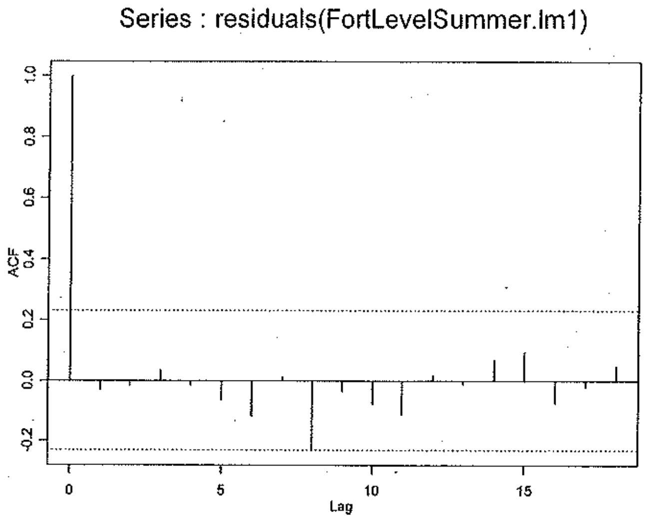
Mean summer water levels have markedly increased through the years 1932-2003 by 1.532 feet. Mean summer water levels for the period 1932-2003 is shown in figure 6. The solid line in figure 6 is the simple linear regression line (water level = 734.0195 + 0.02158*year, SE of the intercept is 7.506, SE of the slope is 0.00381, $P < 0.001$ for both, residual standard error is 0.6727). The change in water level predicted by this model for the period 1932-2003 is 1.532 feet (predicted level of 775.709 in 1932 and of 777.241 in 2003). The estimated slope indicates that water level has changed by 0.02158 feet per year over this period. There is no indication of autocorrelation in the residuals (fig. 7). Roughly speaking, the smoothed line in figure 6 shows the middle of the distribution of water levels for each small range of years. Smoothed lines are useful in showing how the empirical distribution of water levels changes over the years, without imposing a linear model or some other parametric model on the data. This smoothed line parallels the linear regression line closely except in the period just after 1960 and 2000. This suggests a short-term drop in average summer water level after 1960 and also a drop at the end of the period (2000-2003). Otherwise this smoothed line follows the linear regression line remarkably closely, thus the linear regression model appears to be a reasonable representation of the long term trend in water level.

Figure 6.



There was no difference in the slopes (ANCOVA; p=0.270) or intercepts (ANCOVA; p=0.161) of summer water levels between the two time periods,1932-1960 and 1961-2003.

Figure 7.



Annual Trends in Spring, Fall, and Winter Water Levels

Water levels have significantly increased through the years 1932-2003 (Figure 8; P<0.001) for all seasons. Trends for spring, fall, and winter mean water levels are somewhat similar to summer water-levels trends, although less variance is explained by year. Annual variation in water levels is greatest in the spring, followed by fall, winter, and spring (Figure 8). R^2 values for the seasonal relationships were 0.099 for spring, 0.314 for summer, 0.179 for fall, and 0.236 for winter.

There were no differences in the slopes or intercepts of mean water levels between the time periods 1932-1960 and 1961-2003, for any of the seasons (Table 2).

Table 2. ANCOVA-Test of slopes and intercepts between periods 1932-1960 and 1961-2003.

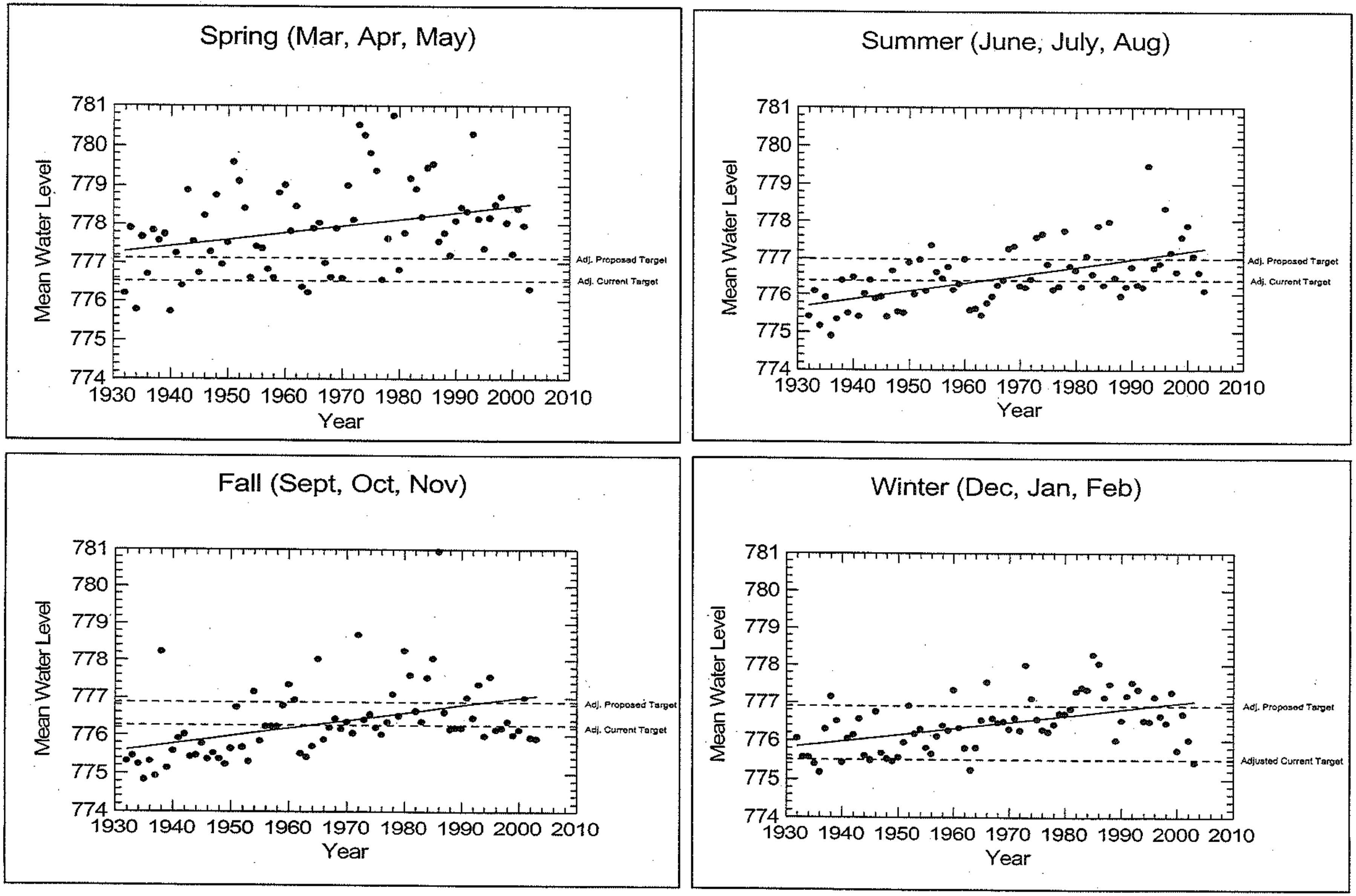
Test for difference in slopes

season	error df	F-statistic	P-value
Spring	68	1.56	.215
Summer	68	1.24	.270
Fall	68	2.85	.096
Winter	68	0.52	.474

Test for difference in intercepts

season	df	F-statistic	P-value
Spring	69	0.02	0.883
Summer	69	2.01	0.161
Fall	69	0.91	0.342

Figure 8. Annual Trends in water levels (Fort Atkinson reported) by season. Line shown is linear regression function. Dashed lines show both current and proposed flow-adjusted target levels. To calculate the adjusted levels, mean flows were calculated for each season, then mean flows were applied to the regression model in figure 3 to calculate average seasonal difference between the Fort Atk. gage and Lake gage. This difference was used to adjust the targets accordingly. Current target shown in the winter season plot reflect the winter drawdown



Data Subset Method-Elimination of Wet Summers

The following years were classified as level four, meaning highly variable with no constant level periods; 1935, 1938, 1940, 1950, 1952, 1954, 1955, 1960, 1968, 1968, 1978 1982, 1986, 1990, and 1997. The following years were classified as level three, meaning much variability but a some constant level periods remaining; 1942, 1943, 1947, 1972, 1979, 1980, 1984, 1993, 1994, 1996, 1998. Peak summer water levels containing class 1-3 years and class 1-2 years are shown in figures 9 and 10, respectively. After elimination of wet/variable summers increasing trends are apparent for "base-flow" condition summers (Figs. 9-10). A linear regression of peak summer level on year for class 1-2 years is described by the following equation: **Peak Summer Level (ft.)= 0.0208(Year) + 735.** Linear regression model predicts a peak summer level of 775.19 in 1932 and a peak summer level of 776.56, representing 1.37 ft. increase over the period (Figure 10).

Figure 9. Peak summer water levels for class 1, 2, and 3 years.

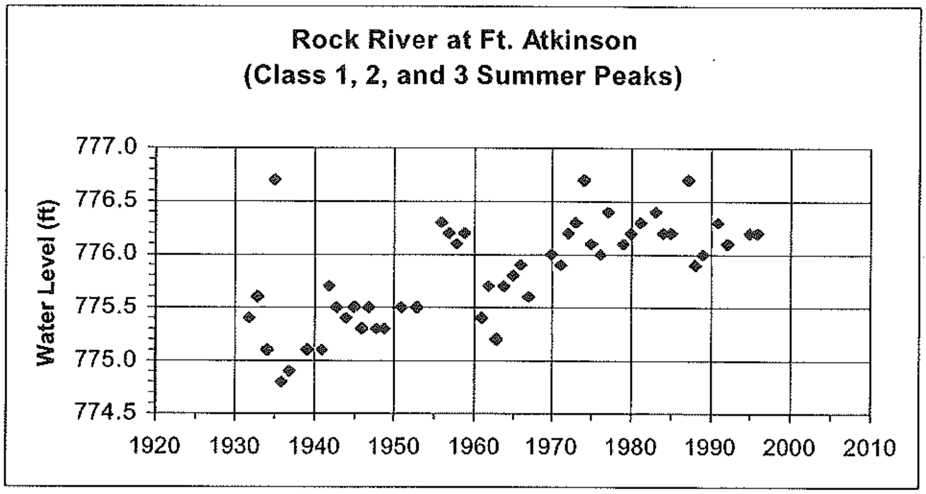
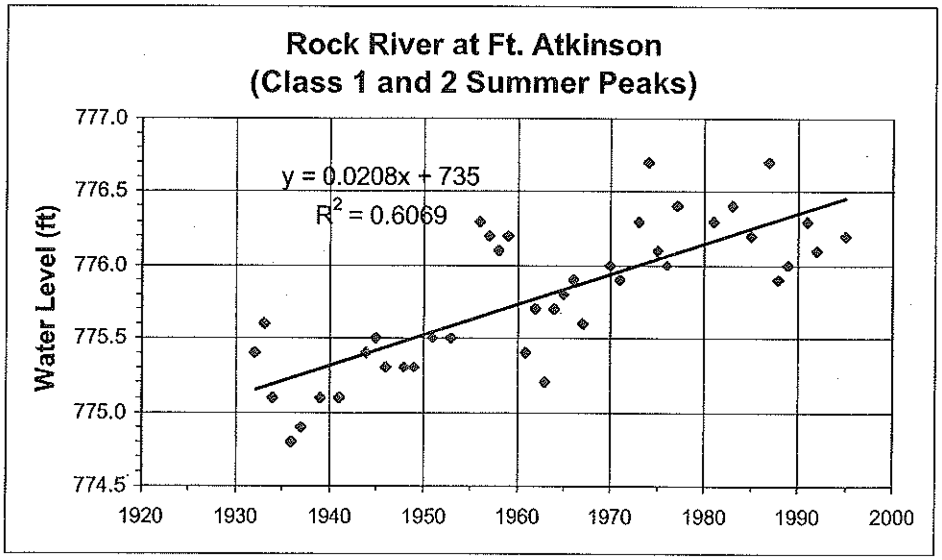


Figure 10. Peak summer water levels for class 1 and 2 years.



Time Series Analysis of Lake Koshkonong Receiving Flows

From our earlier analysis, average summer water levels at the Fort Atkinson (reflective of Lake Koshkonong levels) has increased by approximately 1.5 feet between 1932 and 2003. We sought to explore whether the increase in Lake Koshkonong water levels could be explained solely by increases in flow upstream from Lake Koshkonong. We primarily analyzed river flow information from two USGS gauging stations; the Rock River gaging station at Watertown, and the Crawfish River near Milford. We analyzed data from two gaging stations because of their valuable long-term records; these two stations contain data for the period 1931 to present, which is nearly identical to our water level records available just upstream of Lake Koshkonong at Fort Atkinson (1932 to present). These two gages have separate drainage areas and they both contribute flows to Rock River and comprise 65.8% of the drainage area upstream of the Indianford gage. For the period 1975 to present, combined flows (Watertown flows+Crawfish flows) account for 62% of the mean total flow on the Rock River at Indianford. Analysis of Watertown gage records and Milford gage records well represent receiving flows and have the advantager of much longer datasets, comparable to our Fort Atkinson water level dataset.

The Indian Ford gage accounts for a drainage area of 2,630 sq. miles

LOCATION.--Lat 42°48'15", long 89°05'25", in SW 1/4 SW 1/4 sec.16, T.4 N., R.12 E., Rock County, Hydrologic Unit 07090001, on right bank 50 ft upstream from bridge on County Trunk Highways F and M,250 ft upstream from dam in Indianford, and 1.8 mi upstream from Yahara River.DRAINAGE AREA.--2,630 square miles. PERIOD OF RECORD.--May 1975 to current year. REVISED RECORDS.--WDR WI-79-1: Drainage area. GAGE.--Water-stage recorder and crest-stage gage. Datum of gage is 763.84 ft above sea level (Rock County Surveyor bench mark). Prior to Oct. 1, 1990, at datum 0.10 ft lower. REMARKS.--Natural flow of stream affected by dam in Indianford. Discharge is adjusted for flow through wicket gates. Gage-height telemeter at station.

The Watertown gage (Rock River) accounts for a drainage area of 969 sq. miles.

LOCATION.--Lat 43°11'17", long 88°43'34", in SW 1/4 sec.4, T.8 N., R.15 E., Jefferson County, Hydrologic Unit 07090001, on left bank, 700 ft downstream from Milwaukee Street bridge, 1.1 mi downstream from Silver Creek, at Watertown. DRAINAGE AREA.--969 square miles. PERIOD OF RECORD.--June 1931 to September 1970, October 1976 to current year. REVISED RECORDS.--WSP 1438: 1933,1935(M), 1937(M), 1938-39, 1945(M); WDR WI-79-1: Drainage area. GAGE.--Water-stage recorder. Datum of gage is 792.58 ft above sea level. Prior to Sept. 26, 1933, nonrecording gage at site 700 ft upstream at different datum.

The Crawfish River gage accounts for a drainage area of 762 sq. miles.

LOCATION.--Lat 43°06'00", long 88°50'58", in SW 1/4 sec.4, T.7 N., R.14 E., Jefferson County, Hydrologic Unit 07090002, on left bank near upstream side of highway bridge in Milford, 1.4 mi downstream from Rock Creek and 9.8 mi upstream from mouth.**DRAINAGE AREA**.--762 square miles.**PERIOD OF RECORD**.--June 1931 to current year.**REVISED RECORDS**.--WSP 975: 1937-38. WSP 1438: 1932-33(M), 1935(M), 1937, 1938-41(M),1943-44(M),1947-48(M).WDR WI-79-1: Drainage area.**GAGE**.--Water-stage recorder. Datum of gage is 779.40 ft above sea level. Prior to July 28, 1966, nonrecording gage at present site and datum.

Annual Trends in Spring, Summer, Fall, and Winter Flows

Annual Trends of increasing flow are apparent during summer and fall periods, whereas trends are not as evident during winter and spring seasons (Table 3; Figures 11-18). For both the Rock River and Crawfish River there was a significant increase in summer flow (5.07 per year for the Rock R., 5.29 per year for the Crawfish R.). In both rivers the variance of flow also appeared to increase over time. This suggests it may be more appropriate to log transform flow before carrying out the regression. There was a significant increase in log of flow for both rivers as well (these convert to a 1.71% increase in flow per year for the Rock R., and a 2.05% increase in flow per year for the Crawfish R.).

Note that the R-squared values are often quite low (Table 3; Figures 11-18); expectedly there's a lot of variability about the regression line that's not explained by the regression on year. Across all seasons, year explains less of the variability of the flow data compared to water level data. In some cases, the trend with respect to time (year) is significant, in others it's not significant.

Table 3. Summary of Regression Results

Season	Station	Data Metric	Significant Trend	R^2
Spring	Rock River @ Watertown	Log Mean Flow	No	0.045
	Crawfish River @ Milford	Log Mean Flow	No	0.045
	Fort Atkinson	Water Level	Increase	0.099
Summer	Rock River @ Watertown	Log Mean Flow	Increase	0.138
	Crawfish River @ Milford	Log Mean Flow	Increase	0.199
	Fort Atkinson	Water Level	Increase	0.314
Fall	Rock River @ Watertown	Log Mean Flow	Increase	0.167
	Crawfish River @ Milford	Log Mean Flow	Increase	0.136
	Fort Atkinson	Water Level	Increase	0.179
Winter	Rock River @ Watertown	Log Mean Flow	No	0.05
	Crawfish River @ Milford	Log Mean Flow	Increase	0.08
	Fort Atkinson	Water Level	Yes, Increase	0.236

Interactions Among Water Levels and Receiving Flows

We know that increasing flows in the watershed has confused our interpretation of changes in water levels for Lake Koshkonong. If both the flow into the lake and the water level of the lake have increased since 1932, is the increase in water level of Lake Koshkonong solely explained by increasing flows? Multiple regression is useful analytical approach that enables us to remove the effects of increasing flows and understand whether water levels are increasing independent of flow. Multiple regression uses multiple independent variables, in our model the three independent variables are: year, Crawfish River flows, and Rock River flows. We fit the summer flow and water level data to a multiple regression model of the following general form: **$\text{Waterlevel} = \beta_0 + \beta_1(\text{Year}) + \beta_2(\text{Rock\_flow}) + \beta_3(\text{Crawfish\_flow})$.**

Multiple regression results indicate that after accounting for differences in seasonal flows for each year, we still observe significant year effect for summer water levels (Table 4). Flow does affect downstream water level, but once the flow effects are accounted for there still remains a significant linear increase in water level over time. Results from this model indicated that there was a significant positive relationship between upstream flow and downstream lake level, and that even when the upstream flow was accounted for, there was still an increase in downstream level over time (slope = 0.00854, $P < 0.001$).

Table 4. Multiple Regression Results for Summer Period

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	38.61452	12.87151	172.82	<.0001
Error	62	4.61777	0.07448		
Corrected Total	65	43.23230			

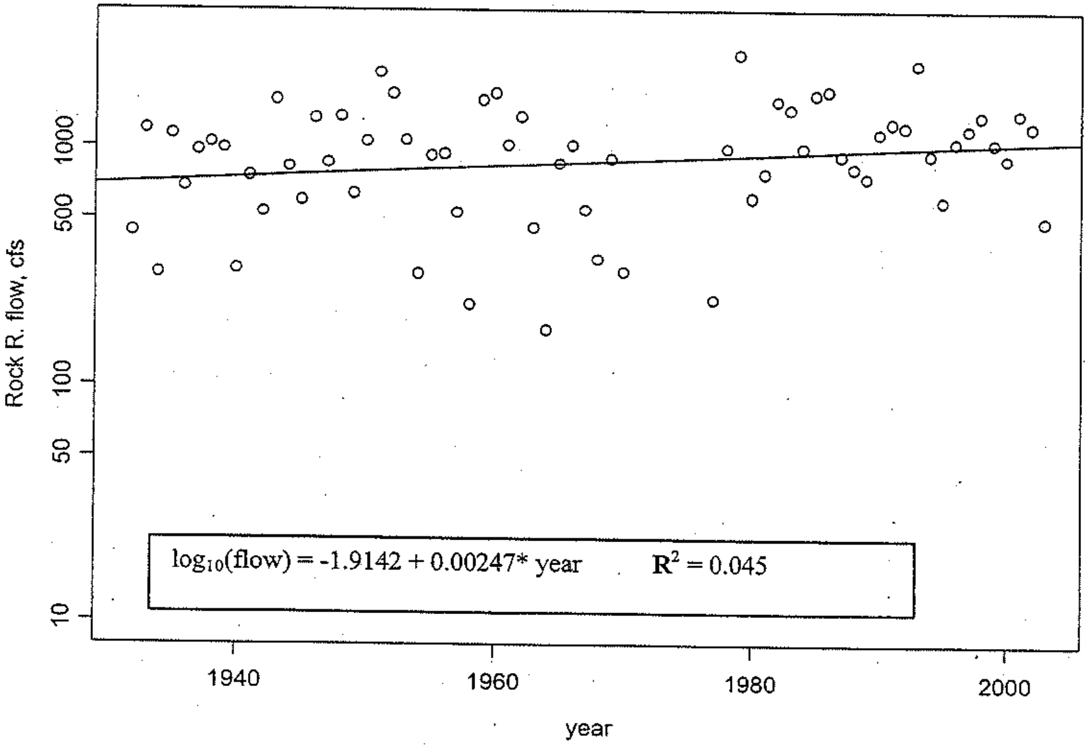
Root MSE	0.27291	**R-Square**	0.8932
Dependent Mean	776.44621	**Adj R-Sq**	0.8880
Coeff Var	0.03515		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	758.83960	3.38712	224.04	<.0001
ME1WATERTOWN	1	0.00090102	0.00025145	3.58	0.0007
ME2CRAWFISH	1	0.00158	0.00029504	5.35	<.0001
YEAR	1	0.00854	0.00173	4.94	<.0001

Conclusions

- **In summary, average summer water levels of Lake Koshkonong (as recorded at Fort Atkinson) has increased by approximately 1.5 feet between 1932 and 2003.**
- **Linear regression results of time series data of water levels predicts (after Fort vs Lake differential adjustments) a mean summer water level of 775.52 ft in year 1932, which is 0.68 feet below the water level target in the current order.**
- **Linear regression results of time series data of water levels predicts (after Fort vs Lake differential adjustments) a mean summer water level of 777.05 ft in year 2003, which is 0.8 feet above the water level target in the current order.**
- **Trend analysis of summers typified by "base-flow" conditions (Elimination of Wet and Variable Summers--data Subset Method) predicts a peak summer level of 775.19 in 1932 and a peak summer level of 776.56 in 1998; an increase of 1.37 ft. in summer water levels during the period.**
- **This increase cannot be explained solely by increases in flow in the Rock and Crawfish Rivers upstream from Lake Koshkonong.**
- **After upstream flow was accounted for, there was still an increase in summer water levels of Lake Koshkonong over time (slope = 0.00854, P < 0.001).**
- **A comparison of the slopes of the time series among seasons indicates that water level increases during the summer and fall has been greater than those for spring and winter periods.**

Figure 11. Mean spring (Mar, Apr, May) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

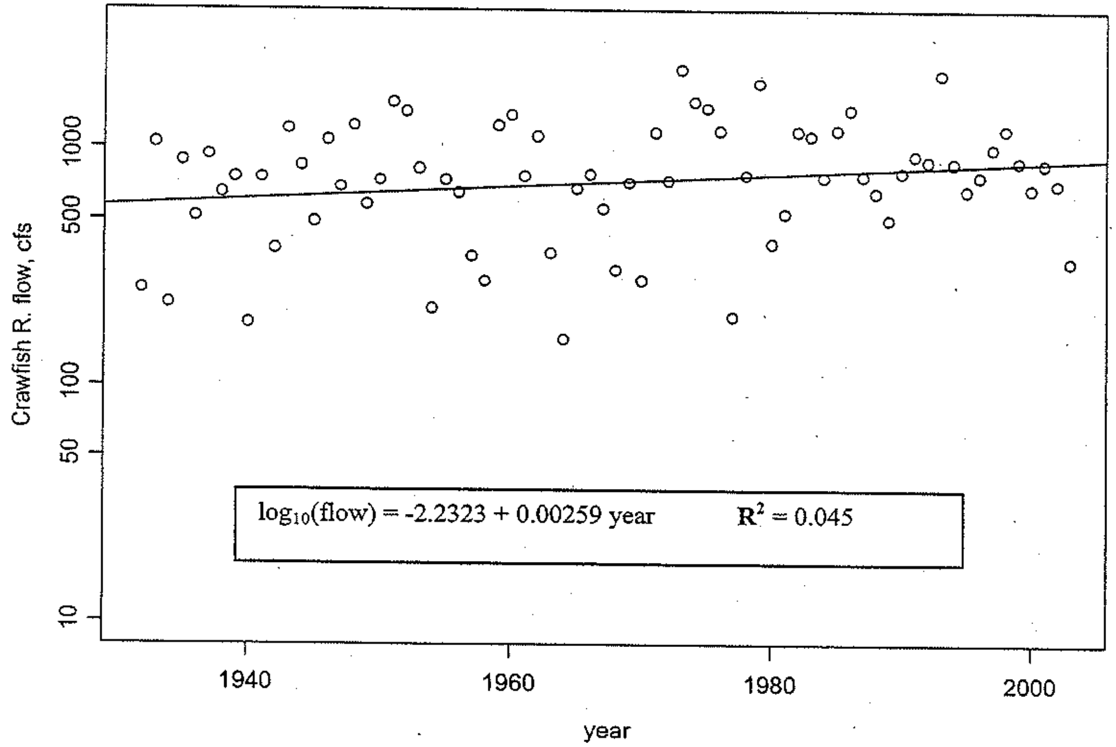


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.18744	0.18744	3.02	0.0869
Error	64	3.96916	0.06202		
Corrected Total	65	4.15660			

Root MSE	0.24903	R-Square	0.0451
Dependent Mean	2.93452	Adj R-Sq	0.0302
Coeff Var	8.48637		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.91425	2.78926	-0.69	0.4950
YEAR	1	0.00247	0.00142	1.74	0.0869

Figure 12. Mean spring (Mar, Apr, May) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

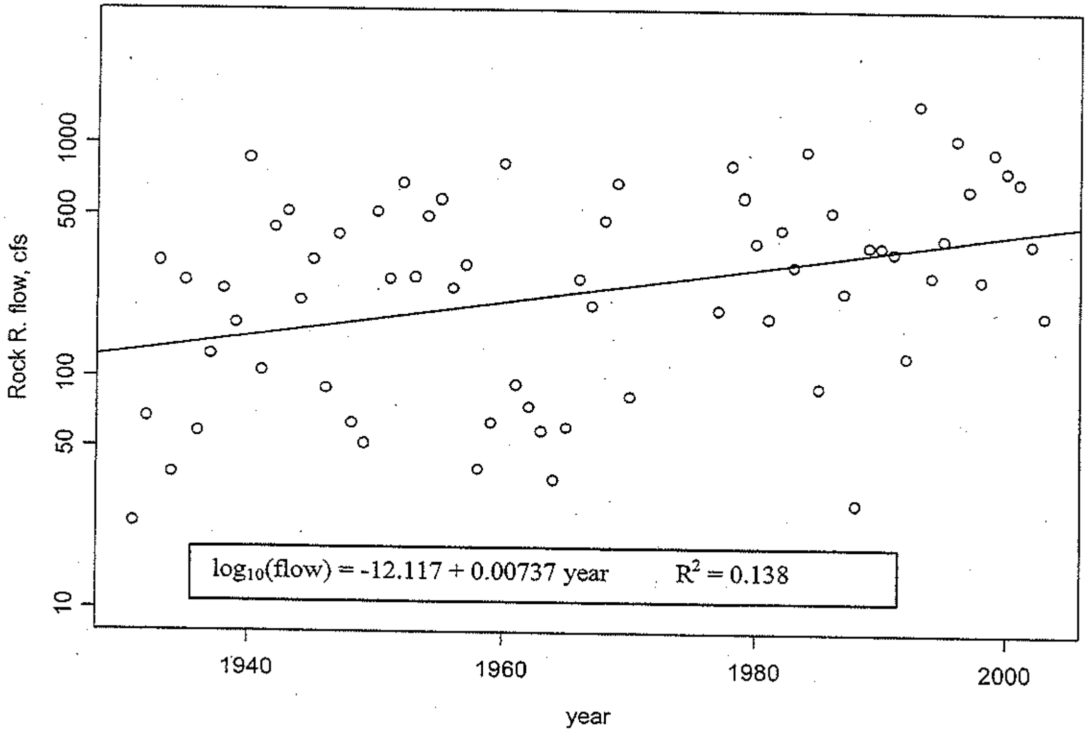


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.20798	0.20798	3.31	0.0732
Error	70	4.40038	0.06286		
Corrected Total	71	4.60836			

Root MSE	0.25072	R-Square	0.0451
Dependent Mean	2.85594	Adj R-Sq	0.0315
Coeff Var	8.77904		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.23226	2.79749	-0.80	0.4276
YEAR	1	0.00259	0.00142	1.82	0.0732

Figure 13. Mean summer (June, July, Aug) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

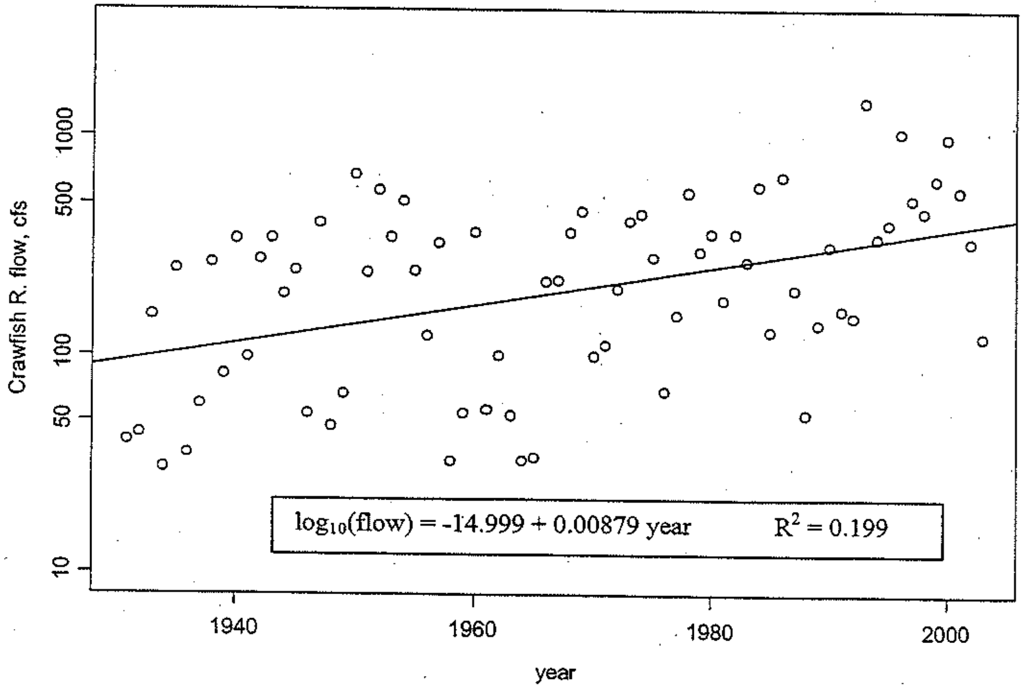


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.74421	1.74421	10.37	0.0020
Error	65	10.93199	0.16818		
Corrected Total	66	12.67620			

Root MSE	0.41010	R-Square	0.1376
Dependent Mean	2.37366	Adj R-Sq	0.1243
Coeff Var	17.27726		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-12.11737	4.50007	-2.69	0.0090
YEAR	1	0.00737	0.00229	3.22	0.0020

Figure 14. Mean summer (June, July, Aug) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\ (10^b - 1)$.

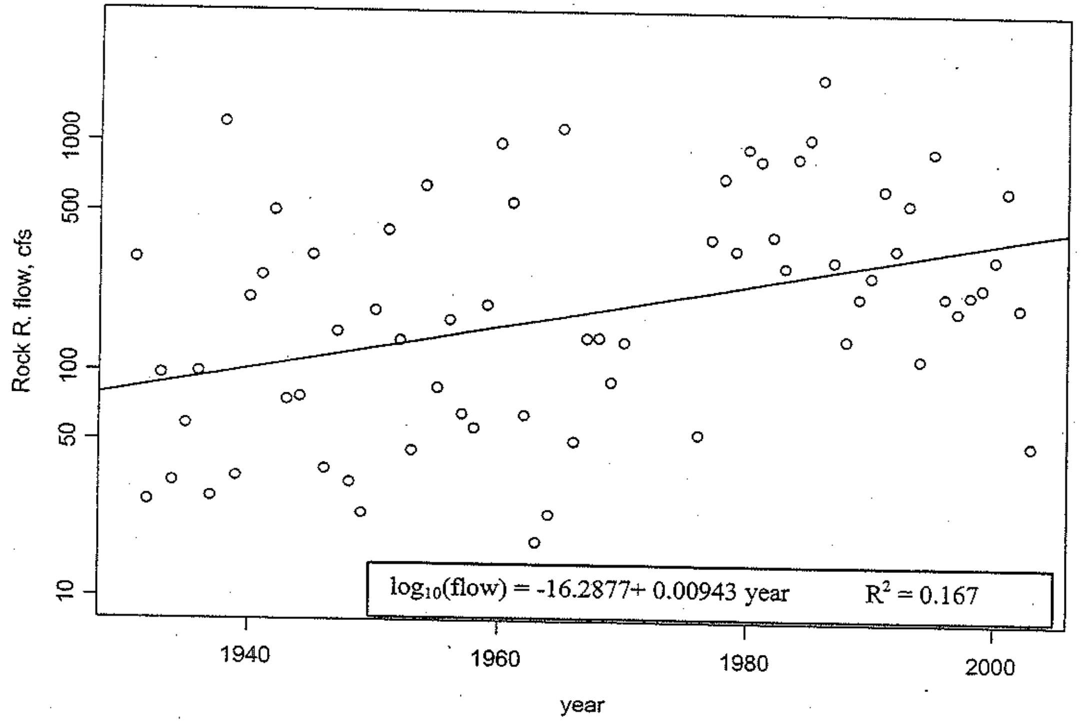


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.50555	2.50555	17.63	<.0001
Error	71	10.09048	0.14212		
Corrected Total	72	12.59603			

Root MSE	0.37699	R-Square	0.1989
Dependent Mean	2.29515	Adj R-Sq	0.1876
Coeff Var	16.42535		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-14.99916	4.11911	-3.64	0.0005
YEAR	1	0.00879	0.00209	4.20	<.0001

Figure 15. Mean Fall (Sept, Oct, Nov) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^{b} - 1)$.

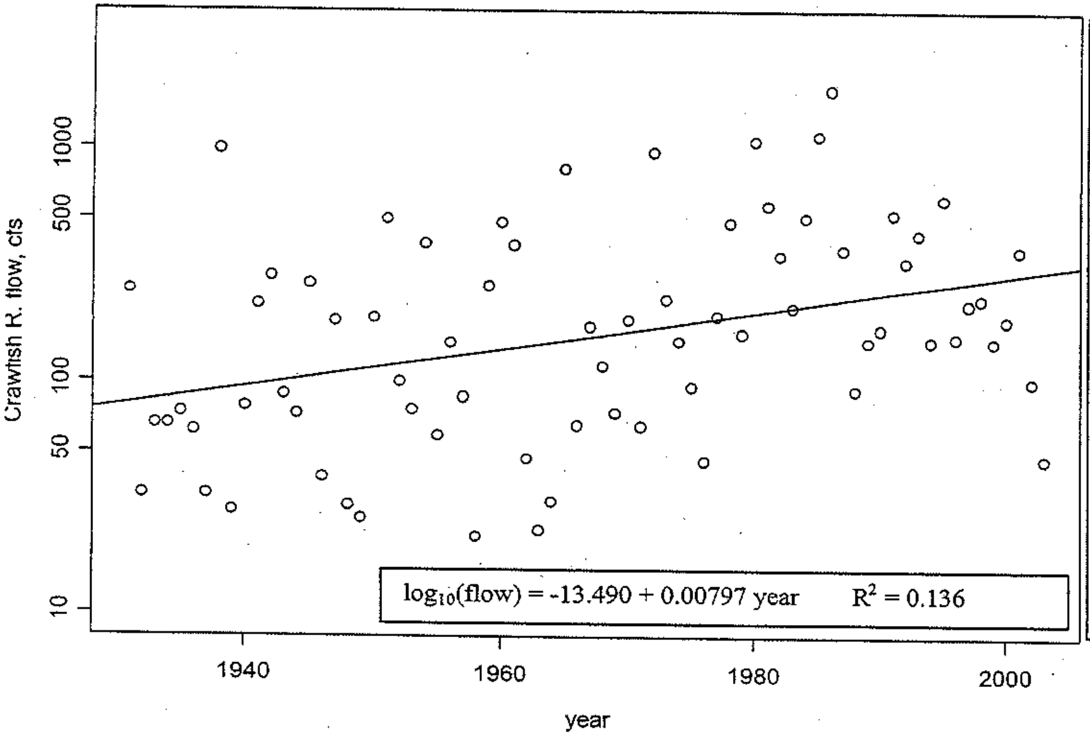


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.86564	2.86564	13.23	0.0005
Error	66	14.29803	0.21664		
Corrected Total	67	17.16367			

Root MSE	0.46544	R-Square	0.1670
Dependent Mean	2.26175	Adj R-Sq	0.1543
Coeff Var	20.57891		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-16.28769	5.10050	-3.19	0.0022
YEAR	1	0.00943	0.00259	3.64	0.0005

Figure 16. Mean Fall (Sept, Oct, Nov) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^b - 1)$.

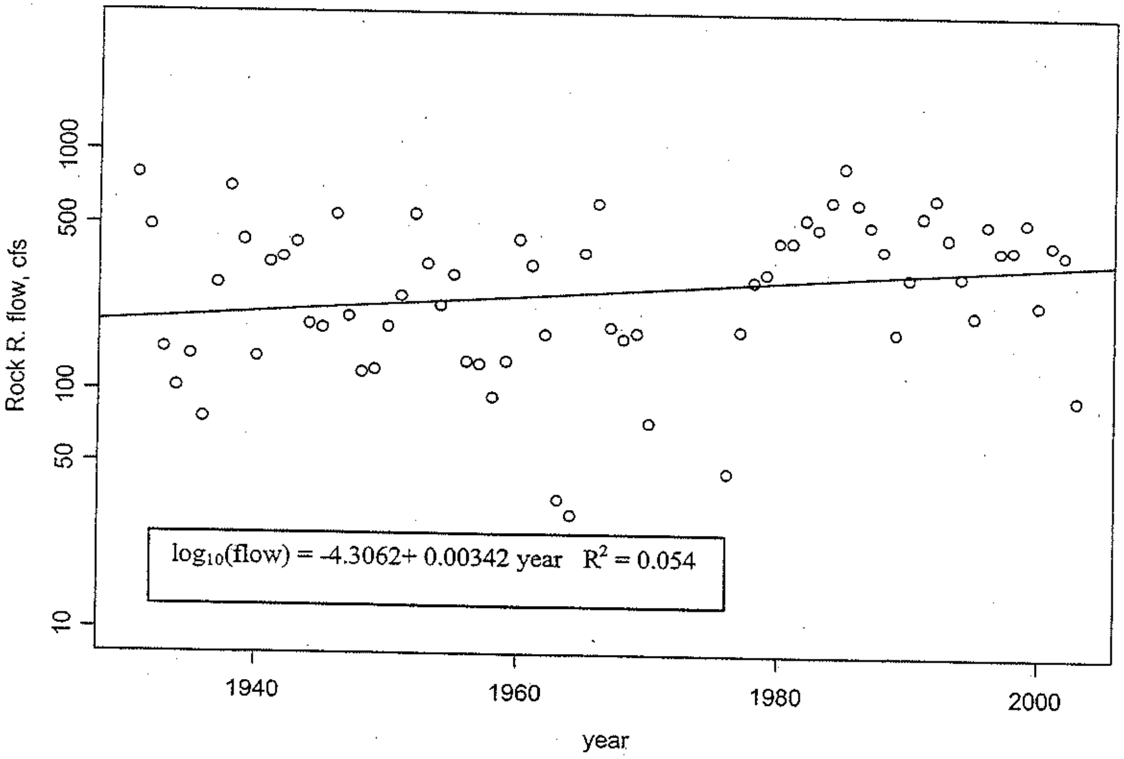


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.06020	2.06020	11.21	0.0013
Error	71	13.04739	0.18377		
Corrected Total	72	15.10759			

Root MSE	0.42868	R-Square	0.1364
Dependent Mean	2.19202	Adj R-Sq	0.1242
Coeff Var	19.55639		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-13.49014	4.68392	-2.88	0.0053
YEAR	1	0.00797	0.00238	3.35	0.0013

Figure 17. Mean Winter (Dec, Jan, Feb) log-transformed flows reported from the Rock River at Watertown. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = 100 $(10^b - 1)$.

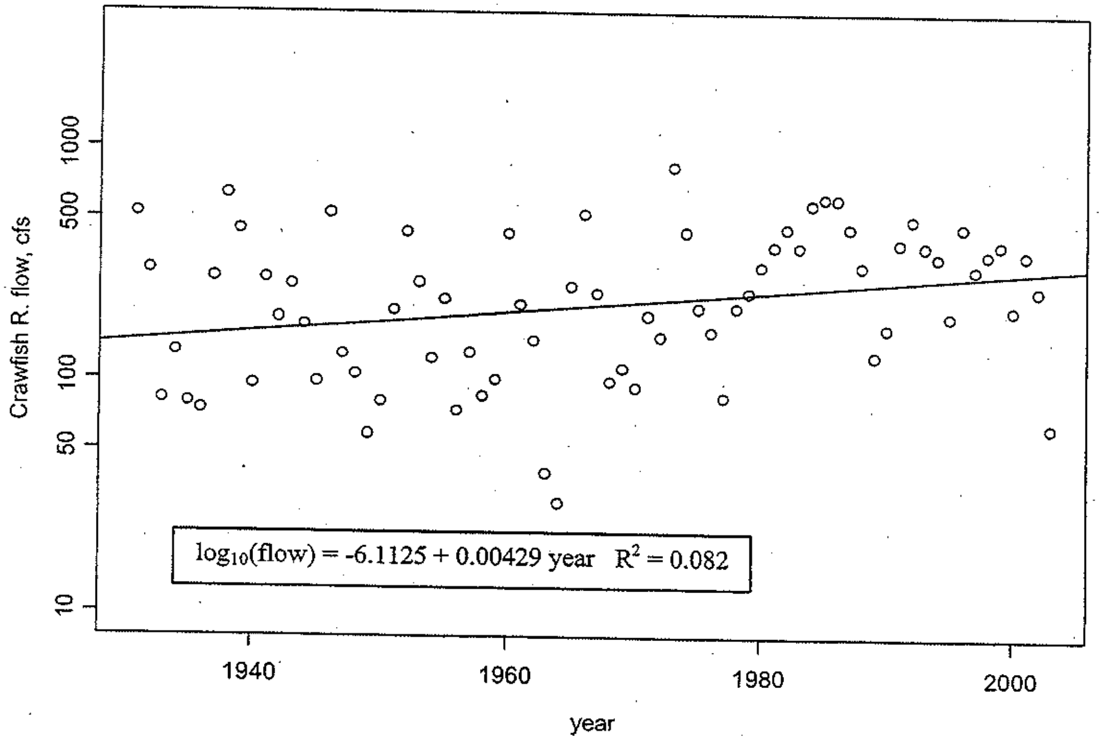


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.37642	0.37642	3.75	0.0570
Error	66	6.62087	0.10032		
Corrected Total	67	6.99728			

Root MSE	0.31673	R-Square	0.0538
Dependent Mean	2.41669	Adj R-Sq	0.0395
Coeff Var	13.10585		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-4.30618	3.47082	-1.24	0.2191
YEAR	1	0.00342	0.00176	1.94	0.0570

Figure 18. Mean Winter (Dec, Jan, Feb) log-transformed flows reported from the Crawfish River at Milford. NOTE: To convert the slope from a model with $\log_{10}$ transformed response variable to a percent change, use the following formula (let b = slope estimate) – percent change = $100\,(10^{b} - 1)$.

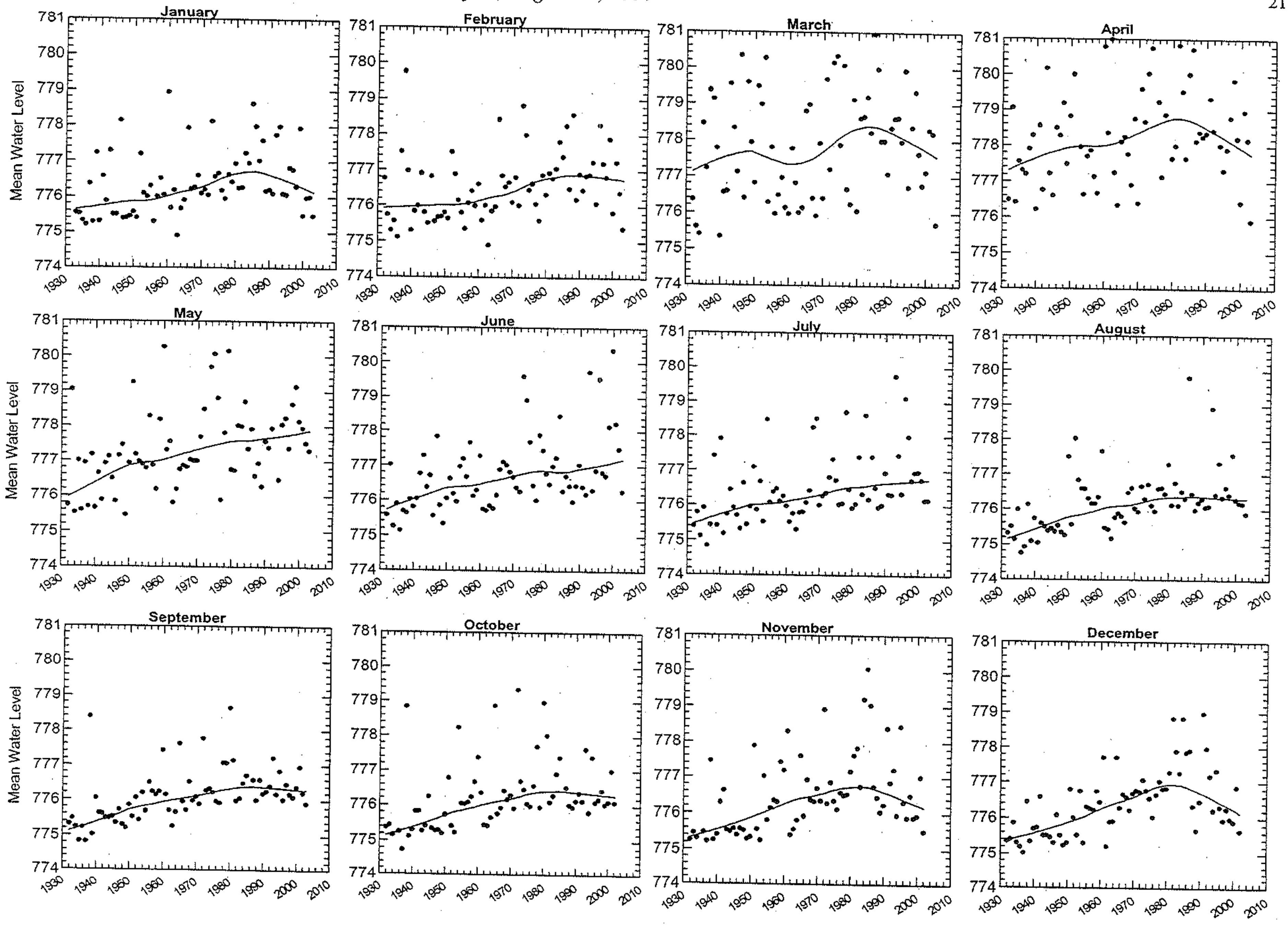


Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.59637	0.59637	6.30	0.0144
Error	71	6.72399	0.09470		
Corrected Total	72	7.32036			

Root MSE	0.30774	R-Square	0.0815
Dependent Mean	2.32494	Adj R-Sq	0.0685
Coeff Var	13.23646		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-6.11246	3.36249	-1.82	0.0733
YEAR	1	0.00429	0.00171	2.51	0.0144

Attachment 5. Water Level Time Series Analysis, August 12, 2004



Where nutrient control is not the answer: Lake Apopka and Lake Okeechobee, Florida

R. Bachmann, D. Canfield, and M. Hoyer

Ecology and Management of Shallow Lakes Symposium, 134th Annual Meeting of The American Fisheries Society, August 22nd – 26th 2004

Hundreds of millions of dollars have been spent on nutrient control as the dominant management strategy for two large, shallow, eutrophic lakes in Florida with little or no improvement in their water quality or fisheries. Starting in 1947 Lake Apopka switched from a macrophyte-dominated deepwater marsh with an outstanding largemouth bass fishery to a turbid, algae-dominated lake. The resuspension of a layer of flocculent sediments has prevented the reestablishment of the macrophyte habitat. A $100,000,000 program to reduce phosphorus inputs shows little sign of restoring the lake and its fishery. We propose an alternative to restore the largemouth bass fishery. The open waters of Lake Okeechobee, the largest shallow lake in the US, maintain a turbid state due to wave-driven sediment resuspension that results in no correlation between phosphorus concentrations and algal chlorophylls in the pelagic zone. A massive nutrient control program resulted in reductions in phosphorus inputs to the lake, yet phosphorus concentrations have increased rather than decreased. An experimental lowering of the water level in 2000 demonstrated that water level controls could rejuvenate macrophyte habitat important to the fisheries and seemed to be a more effective management technique for this lake than stringent phosphorus controls in the watershed.

Role of water level fluctuation in Meditteranean shallow lakes: case Turkish shallow lakes.

M. Beklioglu

THE 7th INTECOL INTERNATIONAL WETLANDS CONFERENCE IN UTRECHT, THE NETHERLANDS (JULY 25-30, 2004)

Functioning of shallow lakes is expected to be very sensitive to water level fluctuation (WLF) which is an influential element of hydrology. Relationship between the WLFs and occurrence of alternative stable states were investigated in five Anatolian shallow lakes of Turkey, which are under the influence of semi-arid to arid Mediterranean climate. Four of the study lakes shifted to submerged plant dominated state whilst the water levels were lower than that of the long-term average. In these lakes, the low water level periods created a flatter bottom with an increased morphometry index (Zmean/Zmax). One of the study lakes shifted to submerged plant dominated state at significantly high water level occurring winter. Furthermore, the same lake had increased morphometry index and lake surface area by 20% at the high water level period. In all the study lakes, shift to the submerged plant dominated state coincided with a significant decrease in the amplitude of the intra-annual fluctuations. Moreover, in all the study lakes, vegetated state was characterized by the presence of significantly high density of waterfowl, especially coot (Fulica atra) and the low biomass of carp (Cyprinus carpio). With the recovery of the vegetation, the lakes supported internationally important number of waterfowls, hence, conservation value of the lakes boosted. Consequently, the lakes received different protection status including Ramsar site, A-class wetland and Important Bird Area. In conclusion, water level fluctuations may have a profound impact in affecting bottom profile through determining the extent of littoral zone and the subsequent ecological interactions.

The roles of water level fluctuations and nutrients in determining macrophyte dominated state of Turkish shallow lakes: Lake Mogan a case study

M. Beklioglu and C. Tan.

International Conference on Limnology of Shallow Lakes, Balatonfüred, Hungary 25-30 May 2002

Lake Mogan is a large shallow lake (surface area: 550 ha, Zmax: 3.9 m; Zmean: 1.99 m).During the period of 1998–2001, the concentrations of total phosphorus (TP) and chlorophyll-a increased significantly (87±014 and 18.1±2.1 mg l-1, respectively) compared to the concentrations recorded in 1997 (73±10 and 9±1.1 mg l-1,respectively). However, the Secchi depth transparency remained high that in turn may have maintained the high coverage of submerged plants. Even though there was sign of deteriorations, the submerged plants persisted that can be attributed to 38 cm drop in the mean water level. Lake Mogan previously also had a shift from turbid water to macrophyte dominated clear water 30 years ago through the implementation of the flood control which led to 47 cm drop in the mean water level and 4–7 folds decrease in the amplitude of the water level fluctuations. This shift took place regardless of any significant change in the concentrations of nutrients. The shift to the submerged plant dominated clear water state increased the conservation value of Lake Mogan that 180waterfowl species were recorded and were dominated by coot and diving duck. Consequently, the lake qualifies as an Important Bird Area (IBA). Bey°ehir, Marmara and Uluabat Lakes also provided evidence for the structuring role of the water level draw down through which lakes shifted to exclusively submerged plant dominated clear water state. In these lakes, 0.5 to 2 m drop in the spring water level due to sporadic drought, and decrease in the amplitudes of the water level fluctuations appeared to be the main reason behind the shift since the sparse vegetation state was recorded at low availability of phosphorus. Through the shift to the submerged plant dominated state, ecological and conservation value of these lakes increased especially due to 10–15 folds increase in the waterfowl density that all the lakes qualify as IBAs and A class wetlands and Lake Uluabat has also been designated as a RAMSAR site since 1998. In sum, water level changes appear to play a structuring role in the ecology of Turkish shallow lakes.

Restoration of Lake Eymir, Turkey by biomanipulation and water level draw-down
M. Beklioglu,
International Conference on Limnology of Shallow Lakes,Balatonfüred, Hungary 25-30 May 2002
Over 25 years of raw sewage effluent discharge shifted Lake Eymir from a lake that had formerly submerged plants, dominated largely by Charophytes with 6–7m of outer depth of colonization, to turbid water state. Partial sewage effluent diversion undertaken in 1995 led to some reduction in the in-lake concentration of nutrients, which remained still very high (324 mg TP l-1 and 0.1 mg DIN l-1), and the water clarity expressed as Secchi depth was poor (111 cm). The surface coverage of submerged plants was limited (2.5 %). Domination of the fish stock by benthiplanktivorous tench and common carp and their top-down effect appeared to have been the reason for low water clarity and low vegetation cover. The removal of 57 % of the fish, which was accomplished within 1.5 years, led to 2.5 fold increase in the Secchi disk transparency. This was probably induced by the 4.5 fold decrease in inorganic suspended matter, as well as a significant reduction in the phytoplankton crop. However, a delay was recorded in the redevelopment of the submerged plants, whose coverage increased only to 6.2 % of the total surface area of the lake, probably due to the high coot biomass and their grazing effect (24±4 ind. ha-1). Nevertheless, in 2000, the coverage of submerged plants increased to about 48 % of the lake surface area with 86±22 % PVI, and this led to a major decrease in the in-lake concentrations of TP and DIN as recorded elsewhere. The Secchi depth also trebled. The density of large-bodied *Daphnia pulex & Arctodiaptomus bacillifer* increased 5 to 10-fold following the fish removal. In 2001, the signs of deterioration in the concentration of TP and DIN, and water clarity were experienced. Despite this, the submerged plants coverage increased to 90 % of the lake surface area though the PVI decreased to 47±29 % This can be attributed to 80 cm drop in the water level. The signs of instability appeared to be combated through water level draw-down.

Vegetation response to 2001 and 2002 summer drawdowns on Upper Mississippi River, pool 8
G. Benjamin and K. Kenow.
Ecology and Management of Shallow Lakes Symposium, 134th Annual Meeting of The American Fisheries Society, August 22nd – 26th 2004
After almost 70 years of impoundment the mosaic of river habitats on the Upper Mississippi River are disappearing. Investigations into the use of one tool, seasonal summer drawdowns, to increase the aquatic vegetation began in 1996 to 199 with small-scale backwater drawdowns. Positive results in density and diversity of emergent and submersed aquatic species led to a demonstration of the tool on a large-scale in Upper Mississippi River, Pool 8. An 18-inch drawdown was conducted during the summers of 2001 and 2002 resulting in about 2,000 acres of the pool substrate exposed. The drawdown likely contributed to an increase in deep marsh annual, shallow marsh perennial, wet meadow, submersed aquatic vegetation, wet meadow shrub, and shallow marsh annual communities in Pool 8. Arrowhead (Sagittaria latifolia and S. rigida), false pimpernel (Lindernia dubia), water stargrass (Heteranthera dubia), teal lovegrass (Eragrostis hypnoides), rice cutgrass (Leersia oryzoides) and chufa flatsedge (Cyperus esculentus) were the dominate species that developed on exposed substrates. Second year drawdown showed a 16-fold increase in arrowhead tuber production and a shift from annual aquatic plant communities to perennials aquatic plant communities. Submersed aquatic vegetation did not appear to be negatively effected by the two years of drawdown.

Submerged macrophytes in shallow lakes and their importance for waterfowl.
Blindow, i., G. Anderson, et al. (1990)
Wetland Management and Restoration-Proc. Workshop., Sweden.
The numbers of both breeding and resting waterfowl have fluctuated drastically in several southern Swedish lakes over the last decades. In order to determine if these fluctuations are caused by variations in food availability, we studied submerged macrophtyes, invertebrates, fish and water chemistry in two lakes. One of them, Lake Takern, had high waterfowl abundance, in the other, Lake Krankesjon, the number of waterfowl had been low since the early 1970's. In Lake Takern the submerged macrophytes and macros-invertebrates were more abundant than in Lake Krakesjon. Furthermore, the growth rates of *Rutilus rutilus* (roach) and *Perca fluviatilis* (perch) were higher. The results indicat that fluctuations in waterfowl abundance are caused by changes in food availability. During the study, food availability started to improve in Lake Krakesjon. Submerged macrophytes expanded, followed by

increased macro-inverterate abundance, less turbid water and incresed numbers of breeding and resting waterfowl. The mean length of perch increased and thus also the potential influence of predatory fish on lower trophic levels. Submerged macrophytes are considered to be important for waterfowl directly as a food resource and indirectly by improving availability of other food resources (invertebrates, fish). Suitable management of this type of vegetation is briefly discussed. Water level fluctuations are considered as on the most important factors. In Lake Krankesjon, lower water levels during spring and summer are suggested to be the most probable reason for macrophyte expansion.

Ecosystem response to changes in water level in Great Lakes Marshes.
P. Chow-Fraser
THE 7th INTECOL INTERNATIONAL WETLANDS CONFERENCE IN UTRECHT, THE NETHERLANDS, July 25-30, 2004
A general understanding of how aquatic vegetation responds to water-level fluctuations is needed to guide restoration of Great Lakes coastal wetlands. In 1997, common carp (*Cyprinus carpio*) was removed from Cootes Paradise Marsh (L. Ontario) to reduce sediment resuspension and bioturbation, and thus regenerate marsh plants that had declined dramatically since the 1930s. Data from 1934 to 1993 were assembled to reassess the nature of the relationship between percent cover of emergent vegetation and water level. Areal cover of emergent vegetation declined non-linearly as water levels increased through the six decades, and this trend was confirmed for the dominant species, *Typha latifolia*, from detailed analysis of eight sets of digitised vegetation maps from 1946 to 1979. A modest recovery of emergent vegetation in 1999 following carp exclusion could have been predicted from declining water level alone. An unusually cool spring in 1997 delayed the migration of spawning planktivores into the marsh and resulted in a grazer-mediated clear-water phase that initiated a short-lived resurgence of the submersed aquatic vegetation (SAV) community in 1997, which became inhibited by the low water levels in 1999. Light conditions had been adequate to support SAV growth in the marsh, according to a published relationship between maximum depth of SAV colonization and light extinction coefficient. Since there had been no significant differences in the environment other than water depth and clarity, I suggest that wave disturbance and propagule burial associated with shallow water depths was the main reason for the disappearance of SAV in 2000.

Lake Puckaway Fishery Restoration Project—1978-1992.
Congdon, J. (1993)
Wisconsin Department of Natural Resources
Lake Puckaway was known as one of the finest hunting and fishing lakes in Wisconsin until the late 1960's. Anglers used the lake heavily year round coming long distances to try their luck on its near legendary fishing. Waterfowl hunter came after the abundant diving ducks, particularly the canvasback, that stopped to rest on the lake and feed during the fall southern migration. By the1950's, carp were recognized to be a serious problem, but as late as the early 1970's, fishing quality was still fairly good and lake use was heavy. However, the fishery began to decline precipitously as the carp population expanded. By 1976, the once abundant aquatic vegetation was nearly gone, the water was muddy brown, and angler use had declined to nearly nothing. Concerned lake users and residents as the Wisconsin DNR to develop a plan to restore the fishery waterfowl resource and water quality in Lake Puckaway. Implementation of a three phase plan involving partial drawdown of the lake, mechanical and chemical carp removal, and restocking of game fish species was begun in 1979. This report is a summary of the management program that was implemented and the results that have been achieved to restore the quality of the fishery and waterfowl resource on Lake Puckaway.

Significance of water level fluctuations for lake management
H. Coops
International Conference on Limnology of Shallow Lakes Balatonfüred, Hungary 25-30 May 2002
The regulation of water levels in Dutch lakes has been very extensive, leaving extremely little space for natural fluctuations. It is argued that the regulation has had a strong impact on ecological functioning of shallow lakes. We evaluate a number of probable impacts of a restored water-level regime. These impacts include effects on shoreline stability en emergent vegetation succession, biogeochemical processes, foodweb interactions, and biodiversity. The timing of low and high water levels and the morphology of the littoral zone are key factors. An assessment was made of the potential ecological effects of an enhanced water-level range in the Veluwemeer, a shallow eutrophic lake in the Netherlands.

Water-level management as a tool for the restoration of shallow lakes in the Netherlands
Coops, H. and S.H. Hosper 2002.
Lake and Reservoir Management 18(4):293-298.
Water-level fluctuations are among the major driving forces for shallow lake ecosystems. In the low-lying parts of tf the Netherlands, the water-level regime of lakes is strictly regulated. This is need for reducing risks of flooding and economic purposes, including maximum agricultural benefit. The fixation of water-level fluctuations, considering the functioning of (semi-)aquatic ecosystems. We review the benefits of natural water-level fluctuations, considering the impacts on nutrient inputs, nutrient concentrations, phytoplankton development and turbidity. In particular, the mediating role o submersed and emergent vegetation and filter feeders is addressed. The present government policy, to allow more space for water, presents a major challenge for combining flood prevention measures and ecological restoration. Restoration of natural water-level regimes, which is likely to lead to enhancement of water quality and biodiversity, may occur in two ways: (1) expanding the critical limits between which the water level is allowed to fluctuate annually, and/or (2) incidental recessions of the water level. It is stressed that ecologically-based water-level regimes should be incorporated into the context of multiple use of lakes.

Nutrient content and biomass of *Phragmites australis* in Lake Fertő/Neusiedlersee
M. Dinka
International Conference on Limnology of Shallow Lakes Balatonfüred, Hungary 25-30 May 2002
The production of vigorous and die -back sites of the same reed belt, the reed growth and nutrient content of reed were studied to detect possible causes for reed degradation. Samples were collected from three vigorous and three die -back sites of Lake Fertő/Neusiedler See from March to November in 1996 and 1997. Reed stands are compared when the biomass was maximal (August) in both years. Shoot density, total aboveground and underground biomass and their C, N, S, P contents were determined. Reed shoots were significantly shorter, thinner and had less internodium at the die -back sites than at the vigorous sites, where the aboveground biomass was 1.5–2.0, the LAI 1.7–2.5 times higher. The underground biomass was nearly the same at the vigorous sites and the die -back sites (except at site 5., which is covered by deep water). The amount of decaying underground biomass was less than 50 % of the total underground biomass at the vigorous sites, while it reached 75 % at the die -back sites. Different N, C, P and S concentrations were found on the studied reed organs (leaves, culms, rhizome, and roots). The N concentration of leaves, culms and rhizome was higher at the die -back sites, where the P concentration was the lowest. The N, P, C and S standing stock of the aboveground biomass was significantly lower at the die -back sites than at the vigorous sites. The P standing stock was significantly lower, the N standing stock significantly higher in the underground biomass of the die back sites than at the vigorous sites. Not more than 17 % of the total dry mass estimated from a given 1 m2 unit, 17 % of the C, 24 % of the N, 14 % of the S and 27 % of the P standing stock was found in the aboveground phytomass produced in the actual year. The aboveground biomass of the individual site was different between the years while the underground biomass remained relatively constant. The results indicate that not only biomass ratios but also nutrient cycling (biogeochemical processes) is characteristically different between the vigorous and the die -back sites.

Changes in the water-cover and macro-vegetation of the lower Zala valley over the last two centuries: a GIS perspective
Z. Dömötörfy, D. Reeder, P. Pomogyi
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002
Cartographic surveys of Austro-Hungary began in earnest in the second half of the Eighteenth Century and provided the essential framework for planning the river regulation and land reclamation of the vast wetlands then existing in the Carpathian Basin. The level of Lake Balaton was lowered in 1863 and the first drainage works in the lower Zala valley were completed in 1865; the combined effect was that the waterbalance of the Kis-Balaton wetlands was dramatically changed and the macrovegetation profoundly affected. By the end of the Nineteenth Century the surface waters of the area had almost disappeared. Following further extensive channel works and levee construction, completed in 1925, all that remained was a large reed-bed with two small water-bodies lying at the deepest point. It was soon realized that these wetlands played a vital role in maintaining the water-quality of Lake Balaton, by trapping sediment and excess nutrients: thus siltation and eutrophication in the western basin of the lake began to be a serious problem. Also the importance of the rich natural environment of the Kis-Balaton, with its large populations of water-birds, was recognized: however it was also obvious that the areas of surface water, on which these natural assets depended, were constantly becoming smaller. In the 1950s the central part of the area was established as the Kis-Balaton nature reserve and by the 1980s it was decided to re-create the wetlands through artificial flooding. This had further profound effects on the macro-vegetation. Our research is an attempt to

summarize the quantitative and qualitative changes in the macro-vegetation of the study-area over the past two centuries. Water-level data are extant from the early 19th Century onwards and by applying these values, from selected historical times, to a digital elevation model it is possible to demonstrate the extent of the water-covered area and in many places its depth. Thus we can make assumptions on the nature and extent of the vegetation at various points in time and compare these with the results of contemporary physical surveys, from the earliest concise cartographic attempts, through the first aerial surveys of the 1930s to modern infra-red photographic technology.

Relationship Between Abundance of Largemouth Bass and Submerged Vegetation in Texas Reservoirs

P.P. Durocher, W.C. Provine, and J.E. Kraai.

Survey data from 30 Texas reservoirs, collected between 1976 and 1978 as part of the Dingell-Johnson Reservoir Management Project, were analyzed to determine which factors affected largemouth bass (Micropterus salmoides) standing crops and their recruitment to harvestable size. A highly significant, positive relationship ($P < 0.01$) was found between percent submerged vegetation (up to 20%) and both the standing crop of largemouth bass and numbers being recruited to harvestable size. The relationship seemed to be linear within the range of values observed. Any reduction in submerged vegetation below 20% of the total lake coverage resulted in a decrease in recruitment and standing crop of largemouth bass. Conversely, to increase standing crop and recruitment of largemouth bass more than 10 in long in reservoirs having little or no cover, a program to increase submerged vegetation either through introductions or water-level manipulation should be implemented.

Aquatic macrophyte growth in a turbid windswept lake.
Engel, S. and S.A. Nichols (1994).
Journal of Freshwater Ecology 9(2):97-109.
The water turbidity developed when high water destroyed wild rice beds (*Zizania palustris* var. *palustris*), allowing winds to suspend soft sediment, uproot surviving plants, and circulated nutrients. Suspended sediment and phytoplankton blooms reduced secchi disk visibility to less than 30 cm. These conditions left 61% of the water surface barren of rooted plants and forced surviving pondweeds to grow in peculiar ring or loop formations. With ice-out in mid-April and dense phtoplankton blooms by June, Rice Lake macrophytes had just 4-6 week to sprout and reach the water surface—a growth window too short for most northern species.

Restoring Rice Lake at Milltown, Wisconsin.
Engel, S. and S.A. Nichols (1994).
Madison, Wisconsin, Wisconsin Department of Natural Resources.

Wind and high water, after decades of erosion and runoff from farms and municipal wastewater treatment plant, converted a clear lake bordered by wild rice into a turbid one dominated by phytoplankton. Rice Lake at Milltown, a 52 ha (128 acre) kettle in northwestern Wisconsin, had northern wild rice (*Zizania palustris var. palustris*), waterfowl, and panfish until the mid-1970's. Then the rice almost disappeared and people up fishing and swimming. Now wind, bullheads (*Ameirus spp.*), and green algae (Chlorophyceae) keep the water turbid. How these changes occurred in Rice Lake was studied from August 1987 through October 1991. Water turbity created a depauperate macrophtye flora offshore, dominated by water lilies (*Nuphar variegatum* and *Nympaea tuberosa*), sago pondweed (*Potamogeton pectinatus*), and floating-leaf pondweed (*P. natans*). Because secchi disk transparency decrease each June to about 32 cm, macrophytes had bare 4-6 weeks to sprout and float leaves befor being shaded. Under such poor conditions, dry weight staning crop of all submersed macrophyte clumps averaged just 6-12g/m^2. Wild rice planted each fall from (0.5 acres in 1988; 2.0 acres in 1989) sprouted well and formed emergent shoots by July. But muskrates (*Ondatra z. zibethicus*) nipped most shoots ad must be controlled for wild rice to set seed and return. Then wild rice can blunt wind that creates turbidity and can store nutrients that would otherwise wash into downstream Balsam Lake.

Effects of carp, *Cyprinus carpio* L., on communities of aquatic vegetation and turbidity of waterbodies in the Lower Goulburn River Basin.
Fletcher, A.R., A.K. Morison, et al. (1985)
Aust. J. Mar. Freshw. Res. 36:311-327.

Densities of carp, ranges of turbidity, and details of communities of aquatic vegetation from 1979 to 1982 are given for several waterbodies in the Goulburn River valley including the Broken River, near Shepparton, Victoria. The turbidity values at all sited were high, typical of Austalian inland waterbodies. There was no association between high carp densities and high turbidity, and population of carp did not appear to increase turbidity. Observed turbidity increases at each site appeared to be related to hydrological changes. Fluctuation of water levels was also an important factor determining the extent of aquatic vegetation communities. However circumstantial evidence is present that shallow-rooted and soft-leaved aquatic vegetation such as *Potamogeton spp.* have been reduced by carp.

Wetland and Riparian Habitats; A non-game management overview. In Management of Nongame Wildlife in the Midwest: A Developing Art.
Fredrickson, L.H. and F. Reid (1986).
North Central Section, The Wildlife Society:59-96.
The authors discuss wildlife use of wetlands wher water is drawn down for management. Drawdowns attract a diversity of foraging birds and increase food availability by concentrating foods in smaller areas and at water depth within the foraging range of target wildlife. As dewatering progresses, deep water species are replace by those adapted to exploit foods in shallow water. For example, waterfowl like shovelers and pintaails use marshes with water that is 8-10 inches deep, whereas sandpipers, rails, snipe, yellow legs, and bitterns use water about three inches deep.

The Fox Lake experience: can hypertrophic lakes be restored?
P. Garrison, and L. Stremick-Thompson
Ecology and Management of Shallow Lakes Symposium, 134th Annual Meeting of The American Fisheries Society, August 22nd – 26th 2004
Fox Lake, a large shallow lake in southern Wisconsin, has experienced various restoration efforts during the last 4 decades. During the early 1950s, the lake shifted from a clear water macrophyte dominated phase to a turbid one dominated by algae. In 1966 the fishery was completely eradicated and for about ten years water clarity improved. Most recently, a drawdown of about 1.5 feet was conducted in 1997, without eradication of the existing fishery. The 1997 drawdown resulted in an increase in emergent vegetation for about 2 years but there was not an improvement in submergent vegetation or water clarity. A comprehensive fishery survey was conducted after the drawdown. In addition, efforts to remove benthivorous carp, control harvest of predatory gamefish, and increase recruitment of gamefish populations through stocking were also addressed as part of this project. Overall, post-drawdown catch-per-effort (CPE) for all game, pan, and rough fish decreased from pre-drawdown fish surveys. The panfish fishery remains dominated by planktivorous crappie, and the carp population was not significant reduced by the efforts of this project. The whole lake fish eradication conducted in 1966 was most beneficial for improving water quality. The 1997 drawdown may have been less successful because it was not severe enough to stimulate submergent vegetation growth, and high levels of nutrients delivered from the watershed may have been a confounding factor.

Effects of stabilized water levels in Lake Manitoba on the natural history of Delta Marsh in south-central Manitoba, Canada
G. Goldsborough and D. Wrubleski
Ecology and Management of Shallow Lakes Symposium, 134th Annual Meeting of The American Fisheries Society, August 22nd – 26th 2004.
Delta Marsh, on the shore of Lake Manitoba in south-central Manitoba, has become highly turbid over the past four decades. The shift from a former clear state is due, in part, to the stabilization of lake water levels in 1961. Our studies over the past six years have documented other changes, including a loss of submersed macrophytes and emergent plant islands from marsh bays, deteriorating water quality, and encroachment of hybrid cattails into shallow inshore areas. We have quantified gross morphometric changes in ponds around the periphery of the marsh, over a 50-year period, using a time series of aerial photographs. Temporal changes in the distribution of marsh vegetation were mapped using high-resolution infrared imagery. In 2003, dramatic seed bank recruitment coincided with the lowest water levels in nearly a century. A proposal by a multi-stakeholder group is presently advocating the partial deregulation of Lake Manitoba as a remedial measure for Delta Marsh and other coastal wetlands; the process by which consensus was achieved will be discussed.

Limnology of temperate shallow lake in last stage before dry up
A. Górniak, M. Baranowski, P. Zieliński
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002

Gorbacz Lake (area 44 ha), situated in the regional water divide in NE Poland, was mires shallow lake. Lake completely dried up cause of catchment melioration and climatic condition consequence in year 2000. Surrounding bög and fen areas created dystrophic lake ecosystem with pH < 6 and EC < 100 µS/cm. In the last stage of lake existence, macroions and nutrient concentrations were posit ively correlated with the water column thickness. High DOM concentration, relatively aliphatic, was accompanied by low water colour. The chlorophyll a concentrations increased with decreasing lake water level caused by benthos algae enrichment. Cyanobacteria and Chlorophycea dominated in phytoplankton with a strong space diversity. Zooplankton (mean 47 ind./L) was represented by 13 taxons, mainly detritovories *B. longirostris* and *Asplanchna* sp. It is interesting that in the dystrophic lake with low calcium concentrations and dy type of bottom sediments *Anadonta cygnea* was noticed. Our investigations have documented that in the last stage, dystrophic lake represents specific ecosystem with taxons mixture originated from different trophic statues and not being evolved to eutrophic system as previously presented in lakes ontogeny schemes.

Aquatic vegetation and largemouth bass population responses to water level variations in Lake Okeechobee, Florida (USA)

K. Havens, D. Fox, S. Gornak, C. Hanlon

THE 7th INTECOL INTERNATIONAL WETLANDS CONFERENCE IN UTRECHT, THE NETHERLANDS, July 25-30, 2004

A five-year study examined responses of submerged aquatic vegetation (SAV), emergent vegetation, and largemouth bass (*Micropterus salmoides*) to variations in water level in a large subtropical lake. Water levels initially were high and the SAV and emergent vegetation had low spatial extent and biomass. Largemouth bass had low density and failed to recruit age-0 fish. In spring 2000, the lake was lowered by discharging water from major outlets, and this was followed by a regional drought. Water levels dropped by 1 m, and there was widespread development of *Chara* lawns and increased water clarity. Complexity of the SAV was low and there was no substantive improvement in bass recruitment. In 2001 the SAV continued to be dominated by *Chara* and again there was no fish response. In 2002, water levels increased to a moderate depth, vascular SAV increased in biomass and spatial extent, and the community developed high structural complexity. Emergent aquatic plants developed dense stands along the shoreline. These conditions were favorable to largemouth bass, which displayed a 3-fold increase in density, and a strong recruitment of age-0 fish for the first time in over five years. Bass recruitment success declined slightly in 2003, when high water returned and SAV was reduced by 30%.

Impact of water level fluctuations on St. Lawrence River aquatic vegetation

Christiane Hudon

Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat. 54(12): 2853-2865 (1997)

Historical records of average seasonal water levels in the St. Lawrence River over the past 80 years reveal cyclic variations of up to 1 m above (1976) and 1 m below (1965) present levels. These variations are probably related to climatic conditions in the basin. Over the same period, the vertical range of seasonal water levels decreased from 2.2 to 1.5 m because of discharge regulation. Exposure of new substrate during periods of extreme low water levels may facilitate the invasion of aggressive and (or) exotic species. In Lake Saint-Pierre, a strong negative relationship was observed between seasonal water level and the percentage of emergent plant cover. Under low water levels, the lake becomes a large (387 km^2) marshland that could support a high plant biomass (286 times 10^3 t) whereas under high water levels, the lake shifts to a vast (501 km^2) open-water body with a lower predicted plant biomass (117 times 10^3 t). A model of the major anthropic and climatic forces acting on water levels is also presented; it describes aquatic plant biomass allocation and species diversity under different water level conditions.

A Model Study on the Role of Wetland Zones in Lake Eutrophication and Restoration .

Janse, J.H.; Ligtvoet, W.; Van Tol, S.; Bresser, A.H.M.

The Scientific World Journal, 1(S2):605-614 2001

Shallow lakes respond in different ways to changes in nutrient loading (nitrogen, phosphorus). These lakes may be in two different states: turbid, dominated by phytoplankton, and clear, dominated by submerged macrophytes. Both states are self-stabilizing; a shift from turbid to clear occurs at much lower nutrient loading than a shift in the opposite direction. These critical loading levels vary among lakes and are dependent on morphological, biological, and lake management factors. This paper focuses on the role of wetland zones. Several processes are important: transport and settling of suspended solids, denitrification, nutrient uptake by marsh vegetation (increasing nutrient retention), and improvement of habitat conditions for predatory fish. A conceptual model of a lake with surrounding reed marsh was made, including these relations. The lake-part of this model consists of an existing lake model named PCLake[1]. The relative area of lake and marsh can be varied. Model calculations revealed that nutrient concentrations are lowered by the presence of a marsh area, and that the critical loading level for a shift to clear water is increased. This happens only if the mixing rate of the lake and marsh water is adequate. In general, the relative marsh area should be quite large in order to have a substantial effect. Export of nutrients can be enhanced by harvesting of reed vegetation. Optimal predatory fish stock contributes to water quality improvement, but only if combined with favourable loading and physical conditions. Within limits, the presence of a wetland zone around lakes may thus increase the ability of lakes to cope with nutrients and enhance restoration. Validation of the conclusions in real lakes is recommended, a task hampered by the fact that, in the Netherlands, many wetland zones have disappeared

Influence of water level changes on the spawning migration of pikeperch (*Sander lucioperca*) in Lake Võrtsjärv, Estonia
A. Järvalt, T. Feldman, A. Kangur, and P. Nõges
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002
L. Võrtsjärv is a large (area 270 km2) shallow (average depth 2.8 m) eutrophic lake. The mean annual amplitude of fluctuation in the water level of L. Võrtsjärv has been 1.34 m, the absolute long-term range is 3.08 m. In a long-term period the water level of L. Võrtsjärv has shown a sinusoidal fluctuations alternated with a duration of 25–30 years. The main inflow, the Väike Emajõgi River, enters the narrow southern end of lake. During 1992–1997 2–3 % of the spawning stock of pikeperch L. Võrtsjärv migrated upstream to Väike Emajõgi River. Due to the extremely low water level in 1996–1997 the area of macrophytes has extended remarkably. The shallow western part and especially the southern end of lake was fully grown with *Nuphar lutea* and *Potamogeton lu cens.* In the end of April when the water temperature is risen over 8 C0 pikeperch starts to migrate to the river via the traditional migrating route alongside western shore and narrow southern end to Väike Emajõgi River. In 1998–2001 the abundance of migrating fish decreased up to 3 times (gill-nets CPUE). Pikeperch as a pelagic fish prefers open water and common migrating route is closed by dense vegetation.

Development of the cladoceran community in Dallund Sø, Denmark, during the last 7000 years – based on macrofossils in the sediment
L. Sander Johansson, E. Bradshaw, E. Jeppesen, and P. Rasmussen
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002
The historical changes in lake ecosystems, caused by human activities, can be elucidated by palaeoecological analyses of the sediment. A sediment core of 13 m (representing approx. 7000 years) from Dallund Sø, a lake impacted by human activities for at least the last 6000 years, was thoroughly analyzed for several physical and biological variables. We present the analysis of cladoceran fragments and relate it to the data from terrestrial pollen, diatoms, diatom-inferred P-level and the minerogenic input (a proxy for soil erosion). The cladoceran fragments indicate, that the ecosystem of the lake was rather stable until 1000 BC. Hereafter, the absolute number of fragments and the share of macrophyte associated cladocerans increased. These results correspond well with other parameters, showing that high erosion led to a dramatic decline in the water level at 1000 BC, and an expansion of aquatic macrophytes. Later, from 1200 AD to the present, the total number of fragments increased further, and the macrophyte associated cladocerans almost disappeared. This coincides with a period of increasing P-concentration, and is an indication of a decline in the water quality. Moreover, a shift occurred from a large proportion of *Daphnia* to exclusive dominance by *Bosmina*, indicating an increase in fish predation at this time.

Effects of a drawdown on a waterfowl impoundment.
Kadlec, J. A. (1962)
Ecology 43(2):267-281.
This report covers an evaluation of pilot drawdown of the Backus Lake flooding project in north-central lower Michigan and its effect on vegetation, waterfowl, soil, water, and bottom fauna. A marked increase on soil nitrate occurred during the drawdown as a result of aerobic nitrification. Invertebrate populations, a potential food supply for waterfowl, were considerable reduced after the drawdown. The plant species composition was not notably affected. Most emergent species spread and increased in abundance as a result of the drawdown. Waterfowl utilization of the area increased in the late summer of 1959. Use by breeding waterfowl increase in 1960 when the newly developed emergent cover was available.

Restoration of Canvasback Migrational Staging Habitat in Wisconsin.
Kahl, R. (1991)

Madison, Wisconsin, Wisconsin DNR

Throughout the 1900's degradation of staging habitat in the Upper Midwest, including several sites in the southeastern half of Wisconsin, led to large concentration of migrating canvasbacks on limited habitat alone the Upper Mississippi River (UMR) from the mid-1960's to the late 1980's. This reliance on just a few habitats left a major segment of the North American population of canvasbacks susceptible both to catastrophic events affecting the health of the birds and to the degradation of the last remaining quality habitats. Thus the development of alternative staging habitats must be addressed if this segment of the North American population is to remain secure. This report: (1) assesses present status of canvasback staging populations and habitat in Wisconsin, (2) describes goals for management of canvasback staging populations and habitat, (3)outlines the research strategy necessary to formulate management plans for restoration of staging habitats in the southeastern half of Wisconsin, and (4) outlines an ecosystem approach to managing large, shallow lakes, which typify canvasback staging habitat. Information was compiled during 1985-1990. Primary sources of information included a literature review, discussion with natureal resource personnel from several agencies, a review of Wisconsin DNR file data, and preliminary results of a DNR Bureau of Research study on the status of canvasback staging populations and habitats, which began in 1985.

Historical accounts indicated that Lakes Koshkonong and Puckaway atracted large numbers of migrating canvasbacks in the late 1800's and early 1900s. Census data indicated that lake Poygan, Winneconne, and Butte de Mortes hosted peak fall population ranging from 8,000 to 77,000 in the 1950's and early 1960's. Lake Mendota attracted 61,000 in 1954. These sites apparently fulfilled the critical habitat requirement of migrating canvasbacks; large littoral areas supporting an abundance of readily accessible foods, especially American wildcelery, sago pondweed, and macrobenthos, as well as large open-water areas providing refuge from disturbance. Most canvasbacks stopped using these lakes after habitat quality decline due to nonpoint and point source pollution, high and fluctuating water levels, wave action, introduction of common carp and resulting unbalanced fish communities, and human disturbance. Although North America's eastern population of canvas backs declined during the mid-1980's to levels below those occurring in the mid-1960's, staging populations using lakes in the southeastern half of Wisconsin declined much more precipitously. From the late 1960's to the mid-1980's no site survey in the south eastern half of Wisconsin had peak fall population greater than several hundred to several thousand. Peak weekly populations for 15 sites in the southeaster half of Wisconsin ranged from 160 to 2,198 in fall and 4,850 to 10,215 in spring, 1985-1990. Lake Poygan typically attracted the most canvasbacks during this period. In contrast Pools 7-8 of the UMR attracted peak fall populations exceeding 60,000 during 1973-84, and this trend continued into the late 1980's.

From 1979-1984, canvasback use-days on Pools 7-9 of the UMR averaged about 2.5 million annually. In the southeastern half of Wisconsin, annual use-days for the 15 sites averaged about 1000,000 and ranged from 45,000 to 159,000 from 1986-89. Based on federal and state collaboration, a regional goal was proposed that called for redistributing about 50% of the use-days from Pools 7-9 to other staging habitats. Wisconsin DNR established the goal of providing for 625,000 use-days and redistributing about 20% of the annual use-days from the UMR Pools. Wisconsin's goal requires the provision of about 240 ha of wildcelery, 180 ha of sago pondweek, or 1,815 ha of macrobenthos beds on each of the 3 sites. Furthermore, management strategies should address boating disturbance where necessary through lake-use restrictions. Sites apparently having the greatest potential for management and restoration include Lakes Poygan, Winneconne, Butte des Morts, Koshkonong, Puckaway, and Beaver Dam. Of these sites, only Lake Poygan, with 355 ha of wildcelery presently provides more than 10-20 ha of relatively dense wildcelery of sago pondweed. Limit data and circumstantial evidence suggests that Lake Poygan, Winneconne and Butte des Morts support relatively low populations of the macrobenthos species important to canvasbacks, while Lakes Koshkonong and Beaver Dam may support moderate to high densities of macrobenthos.

Due to inadequate baseline data and uncertainty about the source of factors contributing to habitat degradation on these sites, specific management plans cannot be developed with additional research. The proposed research strategy includes acquiring data on present status of canvasback populations and habitat quality; determining limiting factors (and their sources) for aquatic macrophytes, macrobenthos, and disturbance; and evaluating restoration techniques for each of the 6 study sites. Most of the suggest factors limiting the abundance of submerged macrophytes and macrobenthos have system-wide and often watershed-wide causes that also affect fish, other wildlife, and water resources. Many of these limiting factors and their management strategies are outlined in an appendix on shallow lake management. The information present in this report should be useful to managers formulating plans for managing canvasbacks as well as any other species associated with shallow lake ecosystems.

An addendum briefly describes a significant decline in wildcelery and macrobenthos that occurred in most pools of UMR in 1988-89 after this report was prepared. This decline reinforces the need for Wisconsin to quickly achieve the goals for restoration of staging habitat and to expand the goals and restoration strategy to include the UMR.

Aquatic macrophyte ecology in the Upper Winnebago Pool Lakes.
Kahl, R. (1993)
Madison, Wisconsin, Wisconsin DNR

The primary factors limiting overall abundance of macrophytes during this study likely included high spring-summer water levels, abnormal timing and magnitude of water level fluctuations and turbidity. Consistently high water levels in May and June of 1975-84 probably controlled abundance of most emergent macrophytes system-wide. Rapidly rising water levels during the floating-leaf stage through June and early July apparently determine system wide abundance of wildrice. A revised water level management plan implemented in 1982 failed to reduce late spring and early summer water levels. Low light availability (restricted by water turbidity and epiphyte communities) apparently was the ultimate limiting factor determining long-term system-wide abundance of submerged macrophytes to maximum depths of 55-61 inches in Lake Poygan and 47-53 inches in Lake Butte des Morts. These maximum depth limits approximated the 5% photic zone for Lake Poygan (57-67 inches) and the 5-10 photic zone for Lake Butte des Morts (46-60 inches). However, because of consistently high turbidity through the study, late spring, and early summer water levels determined the amount of lake bottom within the photic zone, and thus the annual abundance of submerged macrophytes. Primary sources of turbidity for Lake Butte des Morts included the Fox River, the Wolf River at Winneconne, lesser tributaries, and in-lake phytoplankton populations. For Lake Poygan, in-lake sources and lesser tributaries accounted for most turbidity.

Sediments and undesirable fish-primarily carp and freshwater drum – may be important sources of nutrient than external sources leading to high phytoplankton and epiphytic communities. Wave action and undesirable fish probably have a greater impact on submerged macrophytes in the UWPL by contributing to turbidity than through direct physical damage to plants. Injure to new shoots and rhizomes by wave action, boats, and undesirable fish may restrict expansion of establish stands or prevent re-establishment of perennial emergents in some locations. Furthermore, wave action severely erodes unprotected shorelines, adjacent marshes, and shallow littoral sediments. Management recommendations are (1) revise the water level management plan by establishing a new spring-summer target level under 2.5 ft. at the Oshkosh gage, but allow periodic seasonal and anuual fluctuations above and below this level to simulate seasonal and longer-term drought and flooding phases of a natural hydrologic cycle; also moderating winter-drawdowns; (2) continue research to identify sources of turbidity and nutrients, especially from nopoint sources including tributaries, lakeshore and side-channel developments, sediments, wave action, and undesirable fish; (3) determine factors limiting expansion of existing emergent macrophyte stands, especially long-term and short-term fluctuations, wave action, boats, and undesireable fish; (4) develop and implement watershed and lake management plans, including large-scale breakwater projects to reduce water turbidity and improve water level management; (5) monitor water quality, macrophytes, and shoreline erosion to evaluate management efforts; and (6) evaluate harvest and planting techniques for propagules of macrophyte species important to these lakes.

The effects of the long dry periods on the water quality of Lake Velence (Hungary)
István Kóbor, Erzsébet Takács
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002
Lake Velence is a 10–12 thousand years old, mosaic -like lake shallow lake in Hungary. The lake area is 24.5 km2, 10.2 km2 is covered by reed. The upsilting lake was recovered between 1960 and 1987, large open waters (recreational areas) and natural reservation area were created. To stabilize water level, two reservoirs were constructed on the major inflow. Due to this measures the trophic level of the lake has been decreased, became much better for meeting recreational purposes. In the early 90's the water level dramatically decreased according to a long dry period. It also caused a significant water quality change. At the same time toxic blue-green algal blooms occurred in the lake, the dominant species was *Microcystis aeruginosa.* We investigated the effects of the hydrological, meteorological and other factors and parameters on the water quality, and on the occurrence and bloom formation of *Microcystis.* Some parameters of the sediment, like phosphorous forms and number of

Microcystis colonies were also measured. We found that the water quality changes were mainly associated with the evaporation and increasing salt content. The inflow water quality affected only a relatively small part of the lake. The bloom formation of *Microcystis aeruginosa* was independent from the water quality, except the nutrient load. The algal biomass and the frequency of bloom did not correlate, only the short term meteorological conditions were relevant.

Top-down control and alternative buffer mechanisms promoted by *Egeria densa* in a subtropical shallow lake

G. Lacerot, M. Meerhoff, L. Rodríguez-Gallego, J. Gorga, C. Kruk, F. Quintans, N. Mazzeo, M. Loureiro, and D. Larrea.

International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002

Submerged plants are thought to affect negatively phytoplankton crops by a number of mechanisms, including nutrient and light limitation, enhancement of top-down control by offering diurnal refuge for zooplankton against visual predation and by favouring piscivores. In 1998, Laguna Blanca, a yellow-brownish shallow lake in Uruguay, suffered a severe water level reduction that determined a massive fish kill and an extensive colonisation by *Egeria densa*. Nowadays, a clear water phase is established in the system despite the fish community being restricted to two small omnivorousplanktivorous fish: *Jenynsia multidentata* and *Cnesterodon decemmaculatus*. The analysis of sites with and without macrophyte coverage allowed us to propose alternative direct or indirect mechanisms associated to *E. densa* for the maintenance of clear water. The water column had low to intermediate nutrient concentrations, whereas phytoplankton community was highly diverse with a moderate biomass (mean Chl a = 10.6 µg l-1). The zooplankton community was dominated by copepods and low algal biomass values were associated to the highest cladoceran abundance in spring (*Diaphanosoma birgei* and *Chydorus* spp.). Macrophyte PVI represented 28–39 % of the lake volume (annual mean biomass = 174 gDW m-2), and fish and mediumsized zooplankton (except for the calanoid copepod *Notodiaptomus incompositus*) were significantly associated to submerged macrophyte beds. In spite of the high biomass and density of omnivorous-planktivorous fish (11.5 gFW m-2, 13 fish m-2), zooplankton explained most of phytoplankton variation. The medium-sized zooplankton decline coincided with fish reproductive events and the concomitant density increase during summer. The following stronger predation pressure by juvenile omnivorous fish seemed to diminish the macrophyte efficiency as zooplankton refuge. As chrolophyll a was non-detectable in periods when cladocerans had less importance, *E. densa* "bottom-up" mechanisms would also be present contributing to the clear water maintenance. Besides the usually described nutrient and light limitation by shade, the internal production of coloured dissolved organic matter could enhance the observed "top-down" effect.

The Heron Lake restoration project: big watersheds, big lakes, tough challenges.

R. Markl

Ecology and Management of Shallow Lakes Symposium, 134th Annual Meeting of The American Fisheries Society, August 22nd – 26th 2004.

Heron Lake is a large 3,238 ha (8,000 acre) shallow lake with a 1,178 square kilometer (455 square mile) watershed. Over 90% of the watershed is intensively drained agricultural land. Water depths, in the lake, average 0.8 meters (2.5 feet), though there can be regular sustained bounces to depths of over 2.4 meters (8 feet). Historically, Heron Lake has had considerable use by migrating diving ducks (reported 700,000 Canvasbacks (Aythya valisineria)). Changes in watershed land uses, nutrient discharges, flood flows, water level management (higher water levels), climatic conditions, dominant in-lake vegetation species, and carp introduction, among other things, have lead to a serious decline in water quality, desirable vegetation, and bird use. Around 1989, dissenting factions agreed that something must be done. Support and funding started traditional mending processes, including watershed treatments (buffer strips, wetland restorations, permanent vegetation plantings, best management practices, etc), wastewater treatment plant improvements, improved water level management (lower water levels), control of undesirable fish and stocking of desirable fish. Though some success has been observed, the road is long. Often times, the opinions/desires/needs of the human factions do not agree with each other, the wildlife needs, or the applied management practices.

Effects of water level regulation on littoral vegetation of Lake Bourget (France)

André Miquet

THE 7th INTECOL INTERNATIONAL WETLANDS CONFERENCE IN UTRECHT, THE NETHERLANDS, July 25-30, 2004

As in most Alpine lakes, reedbeds have strongly declined over the last century in area (about 50 % in the last 50 years in Lake Bourget), physiognomy and sanitary condition. This was due to an addition of factors, all of which have been magnified by the recent (1982) Water Regulation Program. Lower level during vegetation season has permitted brush encroachment, which is accelerated by the restriction of fluctuation, causing floating wastes to accumulate constantly on the same shoreline. Higher water level in early autumn inhibits the mineralization of organic matter, the germination of *Phragmites* (but not of *Schoenoplectus*), and also reed vegetative horizontal extension. Overall, lower mean level and smaller water fluctuation concentrate erosion both on sediments by wave action, and on reed stems by floating objects. Due to water stability storms always occur at the same waterlevel, which aggravates erosion impact and impedes the cicatrization of littoral vegetation. A re-negociation of the Water Regulation Program is initiated in regard to the Water Directive: while the elevation of spring-summer level seems impossible, for hydraulic and political reasons, the lowering of autumn levels could be achieved, but limited for the sake of navigation and dependent on rainfall. However, the social demand for scheduled water-calendars prevents any yearly adaptation to climatic conditions; thus, in spite of the historic opportunity given by the draught in summer 2003, and due to a "perfusion" from the Rhône River, Lake Bourget did not lose a single millimeter.

Climate-driven phytoplankton changes in a large shallow temperate lake
T. Nõges, and P. Nõges
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002
In Lake Võrtsjärv (270 km2, mean depth 2.8 m) cyanobacteria build up 2/3 of theaverage phytoplankton biomass (B) during the ice-free period (May–October). On average 75 % of the cyanophyte biomass is formed by 4 filamentous species: *Limnothrix planktonica, L. redekei, Planktolyngbya limnetica* and *Aphanizomenon skujae.* Centric diatoms from the genera *Aulacoseira* and *Cyclotella* dominate in the biomass of diatoms. The 35-year database revealed that phytoplankton biomass was quite closely correlated with lake depth (D), and North Atlantic Oscillation index in winter (NAOw) was positive ly correlated with D. Spring B of major phytoplankton groups were positively correlated with NAOw and winter air temperature, and negatively with the end of the ice-cover. The spring B was not related to D. The duration of the ice-cover was crucial for filamentous cyanophytes, but for diatoms the relationship was weak and insignificant as diatom blooms started to develop in sufficient light conditions already under the ice. In summer and autumn, D determined the biomasses of major phytoplankton groups. This can be considered as and indirect effect of NAOw which determined the water level throughout the whole year. The percentage of *L. redekei* among other filamentous cyanophytes was related with winter temperature, ice-cover duration and NAOw generally in the same way as the biomasses of major phytoplankton groups. However the strong positive correlation with D throughout all seasons was most remarkable. As a dim light species *L. redekei* is favoured by steep light gradients. In L. Võrtsjärv its biomass increased from year to year since the late 1970s and reached its maximum at high water period at the end of the1980s. In L. Võrtsjärv where the light conditions as well as phosphorus availability get worse in deeper water, filamentous *Limnothrix* species are most successful in competition for light and phosphorus while the share of nitrogen fixing species (mainly *A. skujae*) among cyanobacterial filaments decreases together with the increasing D. During low water periods, *A. skujae* is clearly favoured by improved phosphorus availability (decreased N/P ratio) and better light conditions.

The extreme flood of 1999 at Lake Constance: starting point of a new reed die-back?
W. Ostendorp, M. Diens, K. Schmieder
International Conference on Limnology of Shallow Lakes Balatonfüred, Hungary 25-30 May 2002
In May and June 1999 strong precipitations in the catchment area of Lake Constance caused an extreme flood in the lake. It was the third highest flood since the beginning of regular water mark records in 1816/17. Lake Constance is the only large lake in the Northern Alps whose water le vel regime is not significantly modified by man. Hence, extreme flood events are natural features in this lake, which the littoral vegetation has to cope with. In this contribution the effects of the 1999 extreme flood on lakeside *Phragmites australis* (Poaceae) reeds are discussed reporting the first results from a three years monitoring project which documents the initial damage of the reeds and the regeneration process, using aerial photo interpretations combined with GISanalyses, and field investigations on stand structure, biomass production, belowground carbohydrate storage, sediment quality, and stressor abundance. Since the flood rose five weeks earlier then under normal circumstances, the reed belts were affected in their very early growth period. The lakeside reed belt exhibited a high patchiness of stand structure types ranging from nearly unaffected stands to complete die -back sites. Five gradual degrees of damage were separated on the basis of CIR air-photos, the corresponding plots were digitised and the total areas of the different classes were calculated using GIS. Permanent quadrates were established at 50 locations, covering all degrees of damage and a wide range of environmental conditions. Many aspects of culm morphology, shoot density, bio mass production, nutrient economy, and carbohydrate storage in the rhizomes were affected in the first season after the flood. The water level curve in 1999 can be compared with the extreme flood in 1965 when ca. 74 % of the reed belt area below the mean

low water line was lost. A good part of this loss did not rehabilitate till 1998. Similar effects may be expected following the 1999 flood, and the effects on the littoral ecosystem in Lake Constance is presently a matter of speculation. The findings are discussed in context with clonal strategies of rehabilitation and re-occupation of the former stand area.

Changes in macrovegetation in the Second Stage of the Kis-Balaton Water Protection System, with a special regard to thepartial operation of the "Ingói-berek" area
P. Pomogyi, and Z. Dömötörfy
International Conference on Limnology of Shallow Lakes. Balatonfüred, Hungary 25-30 May 2002
The Kis-Balaton Water Protection System is located at the mouth of the Zala River. The main goal of its construction is the retention of nutrients from Lake Balaton. Its first part, the Hídvégi-Pond (24 km2) is operating since 1985. Construction works of the second part, the Fenéki-Pond (57 km2) started in 1985, and are ongoing. Partial operating a part of it with an area of 16 km2 (so-called Ingói-Berek) started in autumn 1992. The vegetation mapping is based on colour infrared aerial (CIR) photos, carried out annually. The vegetation maps have been preparing in the last 3 years by GIS methods based on the digital CIR orthophotos. The larger part of the original vegetation of the Hídvégi-Pond was covered by *Carex-*, *Deschampsia* - and *Solidago* dominated communities. The ditches were covered only by aquatic macrophytes. Before the implementation approximately 40 % of the Fenéki-Pond was covered by different *Phragmition,* 30 % by *Magnocaricion,* and 4 % by *Lemno-Potamea* associations, respectively, while 90 % of the Ingói-Berek was covered by aquatic and marshy vegetation. Subassociations of *Scirpo-Phragmitetum typhetosum, caricetosum,* and *thelypteridetosum* were the most dominant. These show that the reedcharacterised stands were already in a late phase of succession, indicating the presence of drier conditions. After the flooding the Ingói-Berek changes in the macrovegetation occurred rapidly. In its upper part the *Carex* dominated stands decreased during 2–3 years; their area was covered later by *Sparganio-Glycerietum – Lemno-Utricularietum – Ceratophylletum submersi* associations and at present followed by either *Polygonetum amphibii* or *Ceratophylletum submersi polygonetosum.* At the same time in the middle and the lower part of this area, the reed dominated stands have also changed: the *Scirpo-Phragmitetum caricetosum* changed to "*hydrocharetosum*" subassotiations (with different subdominance of aquatic plants), while the vegetation structure of the so-called floating-marshes has not changed. Knowledge of the earlier vegetation allows us to influence the direction of the changes. At the Fenéki-Pond the objective is to maximise the area of wetland vegetation. To achieve this it is proposed to gradually raise the water level, by 15–20 cm per year. It can be concluded that the vegetation mapping together with the study of the geographical and historical past of the region are necessary to plan any rehabilitation works, especially with a purpose to retain nutrients from Lake Balaton.

Upper Mississippi Valley Wetlands Refuges and moist-soil impoundments.
Reid, F., J. Kelley, et al. (1989)
Habitat Management for Migrating and Wintering Waterfowl in North America. L. Smith and R. Kaminski. Lubbock, Texas Tech University Press:181-202.
This paper is one of 21 chapter in this comprehensive book on wetland management for waterfowl. The chapters are presented by flyways. Fredrickson's paper was presented in the Mississippi flyway where he has a long research history working on riverine riparian wetlands. He and his co-authors write about habitat management for emergent wetlands including marsh and moist-soil techniques. Developing a good duck marsh includes using a floodwater source, flooding and dewatering to promote plant growth, controlling water with pumps and levees, impounding water in ponds of the right size, and locating ponds and marshes near habitat types that promote waterfowl use. The data on water level control relates to shallow lakes in the north central states.

Distribution and biomass of submered macrophytes in Neusiedlersee.
Schiemer F. and M. Prosser (1976).
Aquatic Botany 2: 289-307.
Within the area of the open, reed-free zone in Neusiedlersee there exists a clearly define region *with Myriophyllum spicatum* L. and *Potamogeton pectinatus* L. Phytosociological estimates, quadrant counts and direct harvest methods have been combined over a 3-year period in order to estimate the extent, density and production characteristics of the zone. Quantitative studies have been concentrated on the northern part of the lake, which the previous surveys had indicated as the major zone of macrophyte growth. Evidence is present for a distinct inshore-offshore distribution of *M. spicatum.* The interaction of wave action and sedimentation rates of fine inorganic material is consider to be principally responsible for this pattern as well as for the overall distribution of both species. However, the distribution pattern of *P. pectinatus* shows a lesser degree of dependence upon such factors.

Computation of the total biomass and annual production of macrophytes within the lake are presented and a comparison is attempted between the status of macrophyte production with Neusidlersee and that estimated for other shallow lakes. The constant reduction in extent of the macrophyte belt during the obervation period is discussed in relation to the artificial increase in water level and eutrophication phenomena (significantly increase phytoplankton and epiphytic algae) during recent years

Shallow lake restoration: Big Muskego 1996-2004
E. Schumacher, S. Beyler, and T. Zagar.
Ecology and Management of Shallow Lakes Symposium, 134th Annual Meeting of The American Fisheries Society, August 22nd – 26th 2004.
Prior to our project, 900- hectare Big Muskego Lake was mired in a turbid, algae-dominated state for decades. After elimination of treated sewage effluent in 1984, it remained turbid; generating little recreation associated with fisheries and wildlife. Intent on shifting the lake's environment to a macrophyte-dominated, clear water state, we began our project in Fall, 1995 with an 18- month water level drawdown. We removed the carp (Cyprinus carpio) dominated fish population, restocked 20 native fish species, enacted restrictive fishing regulations to promote bio-manipulation of algae-grazing zooplankton and constructed a mechanical and electrical carp barrier to prevent carp re-colonization. Post project we have seen marked improvement in Trophic State Index values and electrofishing catch per unit of effort of desirable native fish. In a hemi-marsh mosaic of interspersed cattails and open water, desirable macrophytes now dominate the environment. Despite a partial winterkill of the fish population and re-colonization by carp, the lake remains in the clear-water state. Recognizing the "new" value of the lake, Big Muskego has been designated as one of the few remaining "Land Legacy" areas in Southern Wisconsin and remaining riparian open space is being preserved cooperatively by the City of Muskego and Wisconsin Department of Natural Resources.

Effects of water level fluctuations on biogeochemical processes in littoral zones of shallow lakes
S. Sollie, J.T.A. Verhoeven, H. Coops
THE 7th INTECOL INTERNATIONAL WETLANDS CONFERENCE IN UTRECHT, THE NETHERLANDS, July 25-30, 2004
Water levels in the shallow lakes in the central part of The Netherlands (IJsselmeer and Randmeren) are maintained for agriculture, navigation and safety. The resulting water regime is counter-natural, with high water levels in summer and low levels in winter. In combination with steep slopes, this prevents the development of wide helophyte zones. Such zones are able to enhance water quality due to an increased nutrient retention. The quantitative importance of this aspect has, however, not been investigated thoroughly. The goal of this research is therefore to investigate the influence of different water levelregimes and fluctuations (and shore morphometry) on the importance of littoral zones in enhancing water quality.The set-up of the study involves a combination of correlative field surveys and causal analytical mesocosm and microcosm studies in the greenhouse and the laboratory for quantifying biogeochemical processes in littoral zones. The data collected will be used to validate existing models, like PCLake and to add new modules to these models. Finally, the models developed will be used to calculate the outcome of different scenarios in terms of water level management and morphometry of the littoral zone on water quality enhancement.

The Managed Recession of Lake Okeechobee, Florida: Integrating Science and Natural Resource Management
Steinman, A., K. Havens, and L. Hornung. 2002.
Conservation Ecology 6(2): 17.
Resource management decisions often are based on a combination of scientific and political factors. The interaction of science and politics is not always apparent, which makes the decision-making process appear arbitrary at times. In this paper, we present a case study involving Lake Okeechobee, a key environmental resource in South Florida, USA, to illustrate the role that science played in a high-profile, highly contentious natural resource management decision. At issue was whether or not to lower the water level of Lake Okeechobee. Although scientists believed that a managed recession (drawdown) of water level would benefit the lake ecosystem, risks were present because of possible future water shortages and potential environmental impacts to downstream ecosystems receiving large volumes of nutrient-rich fresh water. Stakeholders were polarized: the agriculture and utility industries favored higher water levels in the lake; recreation users and businesses in the estuaries wanted no or minimal discharge from the lake, regardless of water level; and recreation users and businesses around the lake wanted lower water levels to improve the fishery. Jurisdictional authority in the region allowed the Governing Board of the South Florida Water

Management District to take emergency action, if so warranted. Based on information presented by staff scientists, an aggressive plan to release water was approved in April 2000 and releases began immediately. From a hydrological perspective, the managed recession was a success. Lake levels were lowered within the targeted time frame. In addition, water quality conditions improved throughout the lake following the releases, and submerged plants displayed a dramatic recovery. The short-term nature of the releases had no lasting negative impacts on downstream ecosystems. Severe drought conditions developed in the region during and following the recession, however. Severe water use restrictions were implemented for several months. There also were impacts to the local economy around the lake, which depends heavily on recreational fishing; use of boat launch areas was curtailed because of the low water levels in the lake. This case study provides an example of how science was used to justify a controversial decision. Although the environmental basis for the decision was validated, unexpected or unpredictable climatic results led to socioeconomic challenges that offset the environmental successes.

Water-level fluctuations in northern prairie wetlands
Arnold G. van der Valk
THE 7th INTECOL INTERNATIONAL WETLANDS CONFERENCE IN UTRECHT, THE NETHERLANDS, July 25-30, 2004
Oscillatory water-level fluctuations are reversible changes in water levels around a longterm mean. Because there has been no standard set of terms to describe oscillatory water-level changes, some suitable terminology is proposed based primarily on their range and frequency. Long-term water-level studies in prairie wetlands and proxy data (e.g., tree rings) for them indicate that oscillatory water-level changes have occurred for thousands of years. Changes in prairie wetland vegetation caused by oscillatory waterlevel fluctuations are called wet-dry cycles. During the wet phase of the cycle, higher than normal water levels can result in the near elimination of emergent species. During the dry phase, prairie wetlands can go completely dry, a drawdown. During drawdowns, the vegetation recruited from the seed bank in areas free of standing water is dominated by terrestrial annuals and seedlings of emergent species. During the transition from the dry to wet phase of the cycle, annual species are eliminated from the vegetation and emergent species initially increase in abundance. Observational and experimental studies of individual wetland species during wet-dry cycles have focused on the seed germination requirements and the flooding tolerances of emergent species. These have confirmed observations made during field studies and have added little to our understanding of vegetation changes during wet-dry cycles. A number of assembly-rule models of wet-dry cycles have been developed. When adequate data are available, the latest quantitative models can accurately predict changes in composition and distribution of emergent vegetation during all or parts of a wet-dry cycle.

Vegetation abundance in lowland floodplain lakes: importance of surface area, age and connectivity
G. J. Van Geest, F. C. J. M. Roozen, H. Coops, A. D. Buijse, R. R. Roijackers, M. Scheffer
International Conference on Limnology of Shallow Lakes Balatonfüred, Hungary 25-30 May 2002
We analyzed the vegetation structure of 215 lakes in the floodplain of the lower river Rhine in relation to environmental variables related to hydrological connectivity, lake morphometry, lake age and land use on adjacent land. The frequency distribution of the cover of submerged macrophytes deviated significantly from the normal distribution, implying that submerged macrophytes were either almost absent or quite abundant in lakes. Multiple logistic regression indicated that the probability of submerged macrophyte dominance decreased markedly with the surface area, depth and age of the lakes. The surface area effect occurred independently of the depth. Also, a negative relationship to long-term inundation duration by the river was found. Nymphaeid cover showed a distinct optimum with respect to mean lake depth. Nymphaeids are almost absent in lakes shallower than 0.5 meter. In contrast to what was found for submerged plants, the probability of occurrence of nymphaeids increased with lake age. Nymphaeids were also positively related to the proportion of lake area drawn down in summer, and negatively related to cattle grazing and the presence of trees on adjacent land. Helophytes showed largely the same pattern as nymphaeids. The probability of helophyte occurrence increased with lake age, and decreased with presence of trees, cattle grazing, surface area, use of manure and mean lake depth. In all cases the critical level of one factor (e.g. mean lake depth) depended on other factors (e.g. surface area or age of lake). Thus, in the present study, small lakes tend to remain dominated by submerged macrophytes till a greater depth than large lakes, and helophytes colonize smaller lakes at an earlier phase. The effect of river dynamics is only modest in our data-set. This may be due to the fact that, unlike in most other floodplain systems described in the literature, most of our lakes are rarely inundated during the growing season and experience only moderate current velocities during inundation periods.

Lake Tamnaren, (Wallsten and Forsgren, 1989; Bengtsson and Hellstrom, 1992),

Lake Okechobee (Havens et. al; Steinman, A.D., K. E. Havens, A.J. Rodusky, B. Sharfstein, R.T. James, and M. C. Harwell, 2002. The influence of environmentail variable and a managed water reession on the growth of charophyte in a large subttropical lake. Aquatic Botany. 72: 297-313.),

Lake Krankesjon (Blindow, I. 1992. Long- and short-term dynamics of submerged macrophtyes in two shallow eutrophic lakes. Freshwater Biology. 28: 15-77.

Blindow, I., G. Andersson, A. Hargeby and S. Johansson. 1993. Long-term patterns of alternative stable states in two shallow eutrophic lakes. Freshwater Biology 30: 159-167),

Lagoon of the Islands (Sanger 192 and Sanger, A.C. 1994. The role of macrophytes in the dexline and restoration of Loon of Islands. Lake and Reservoir Management: 9: 111-112.

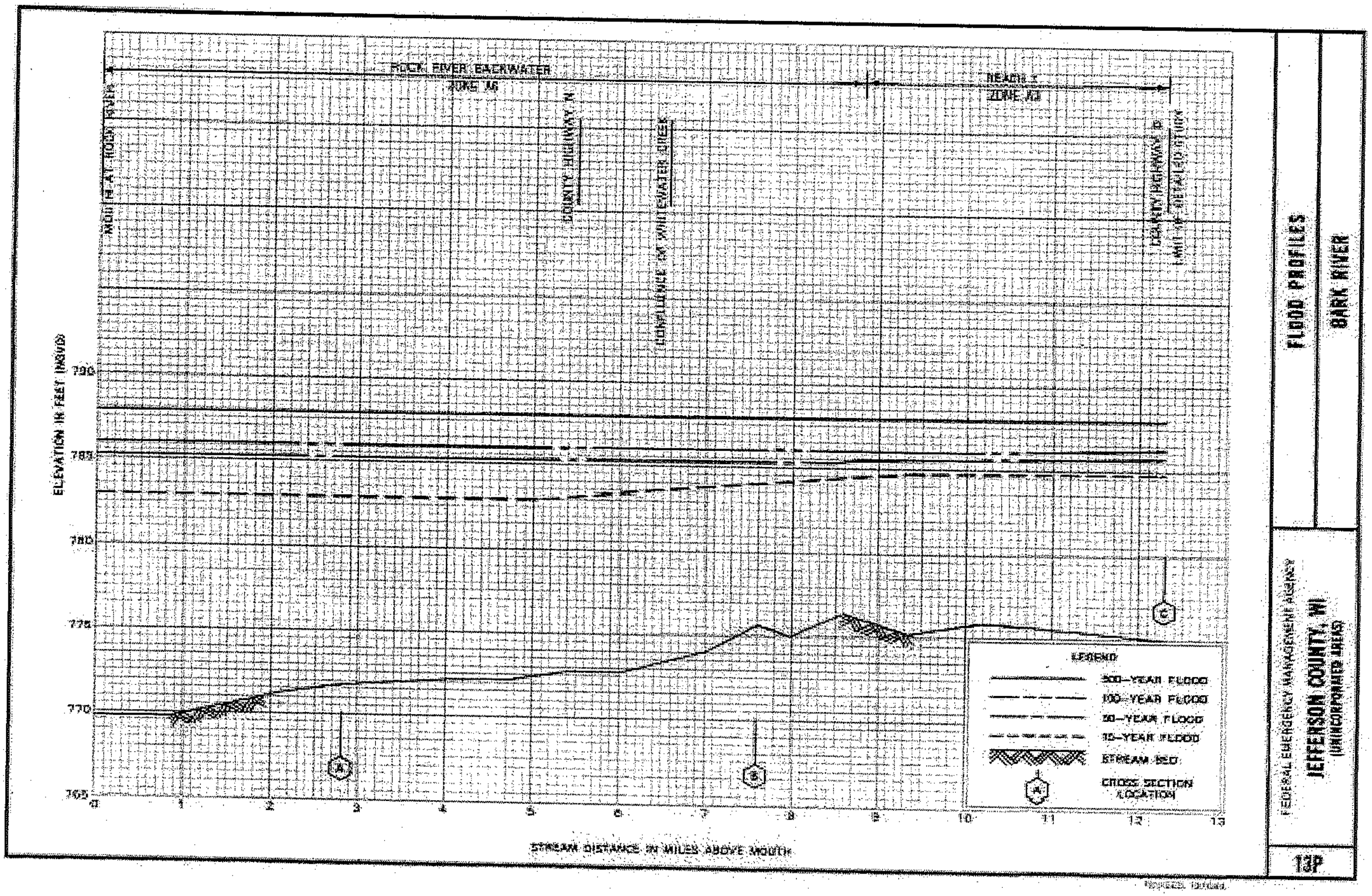
Lake Christina (Butler and Hanson)

Coops and Vander Velde 1996;

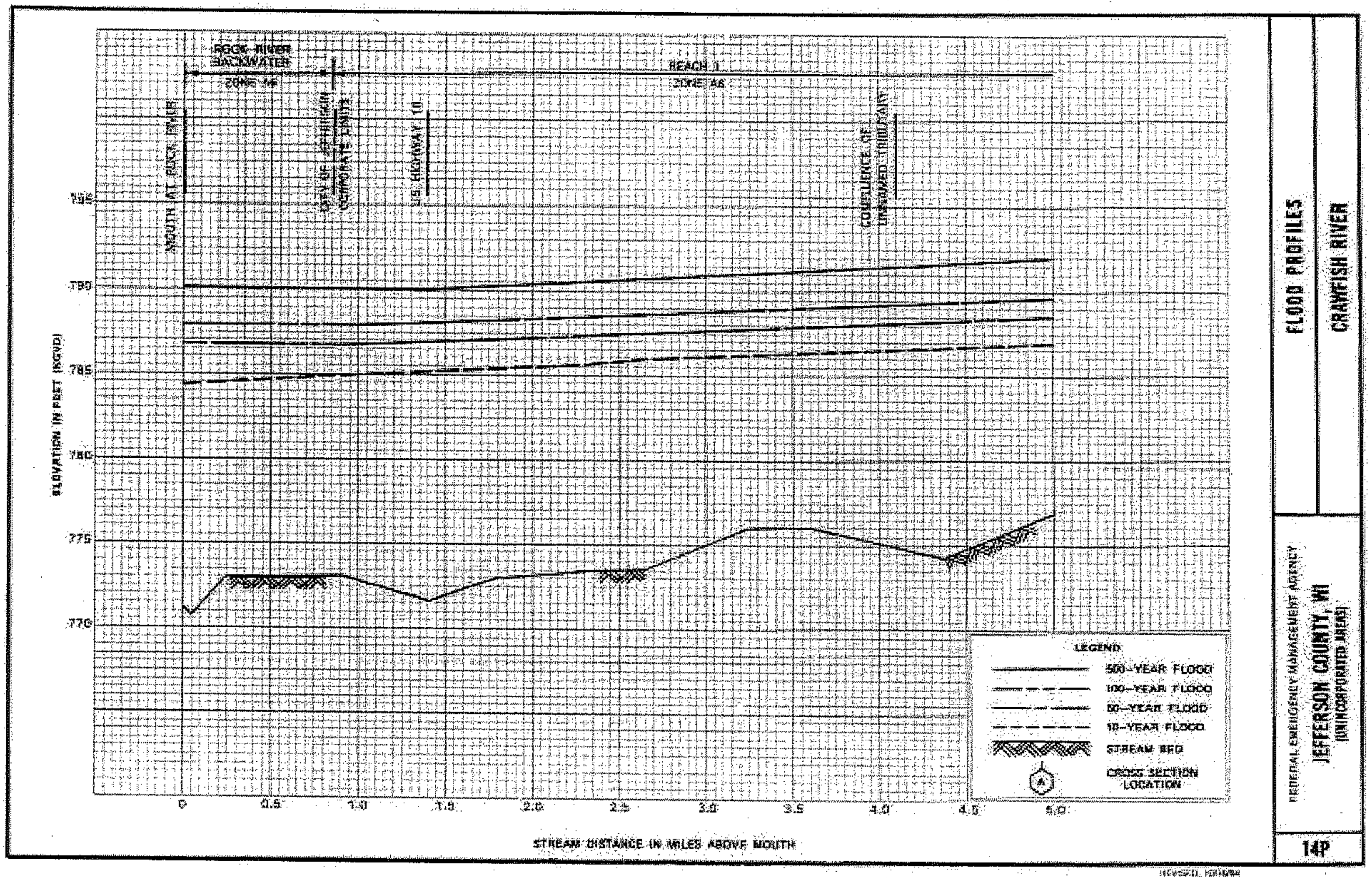
Rea 1996;

Clevering and Lissner 1999.

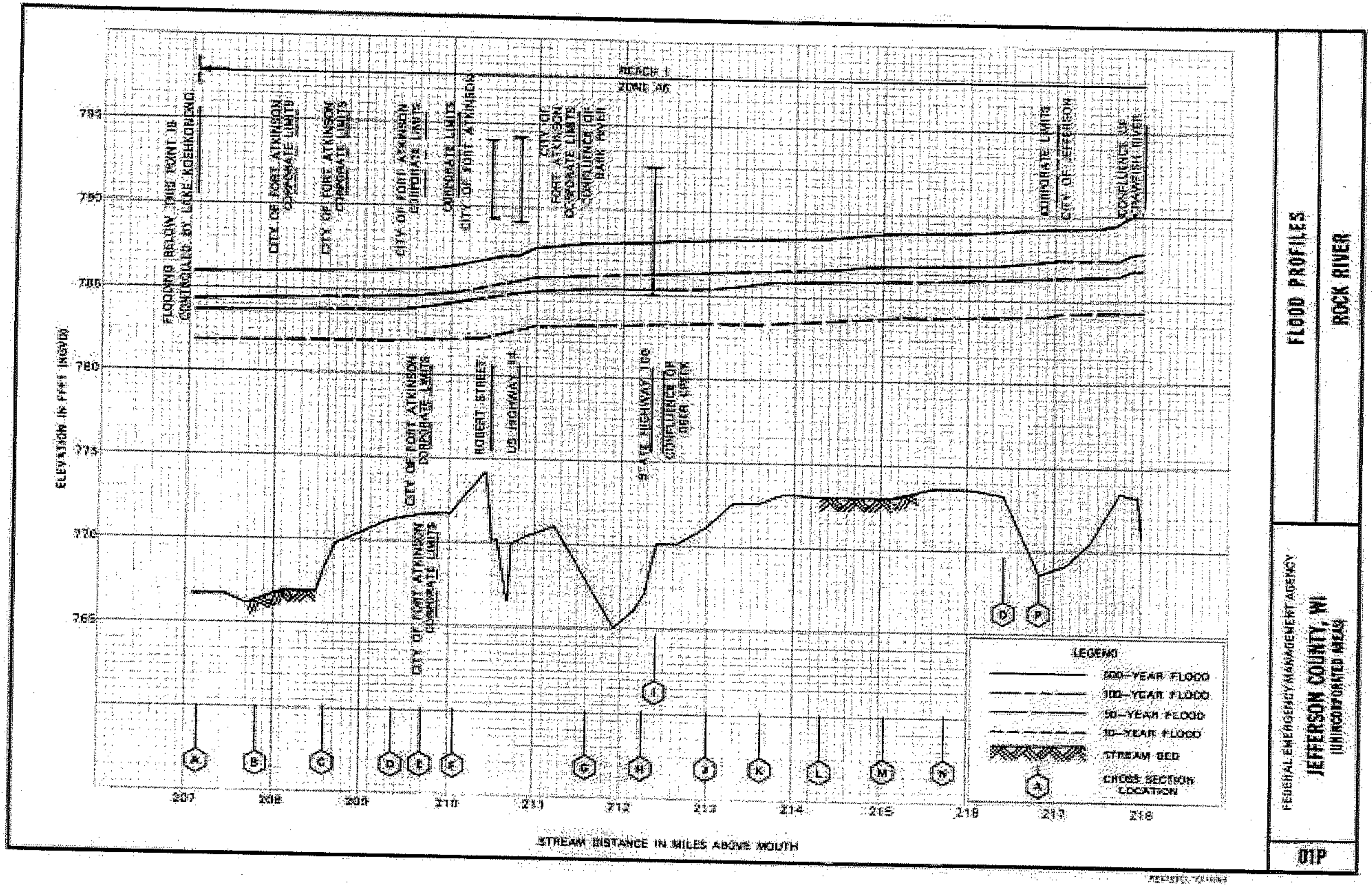
Attachment 7. Channel profiles



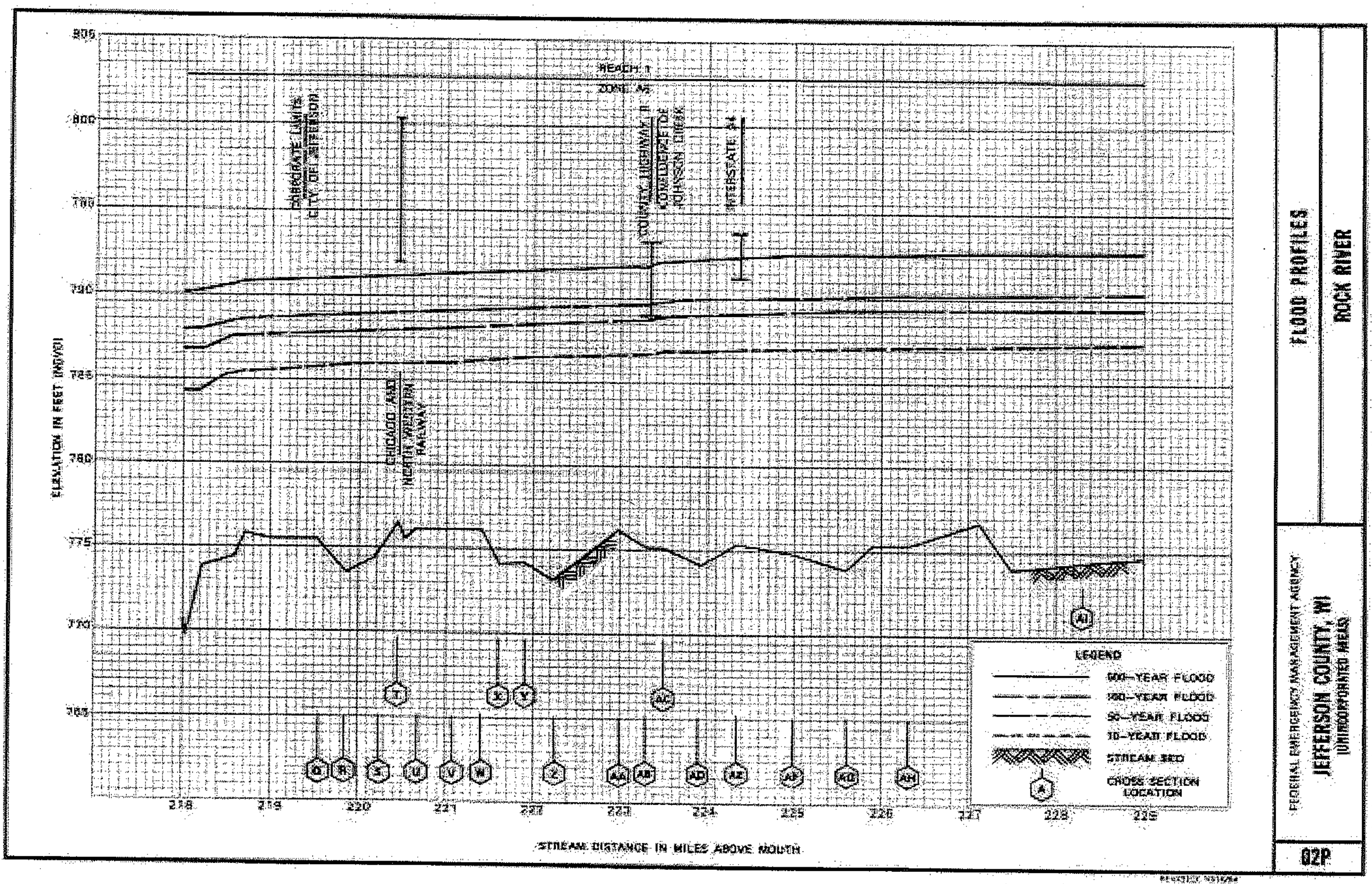
Attachment 7. Channel profiles



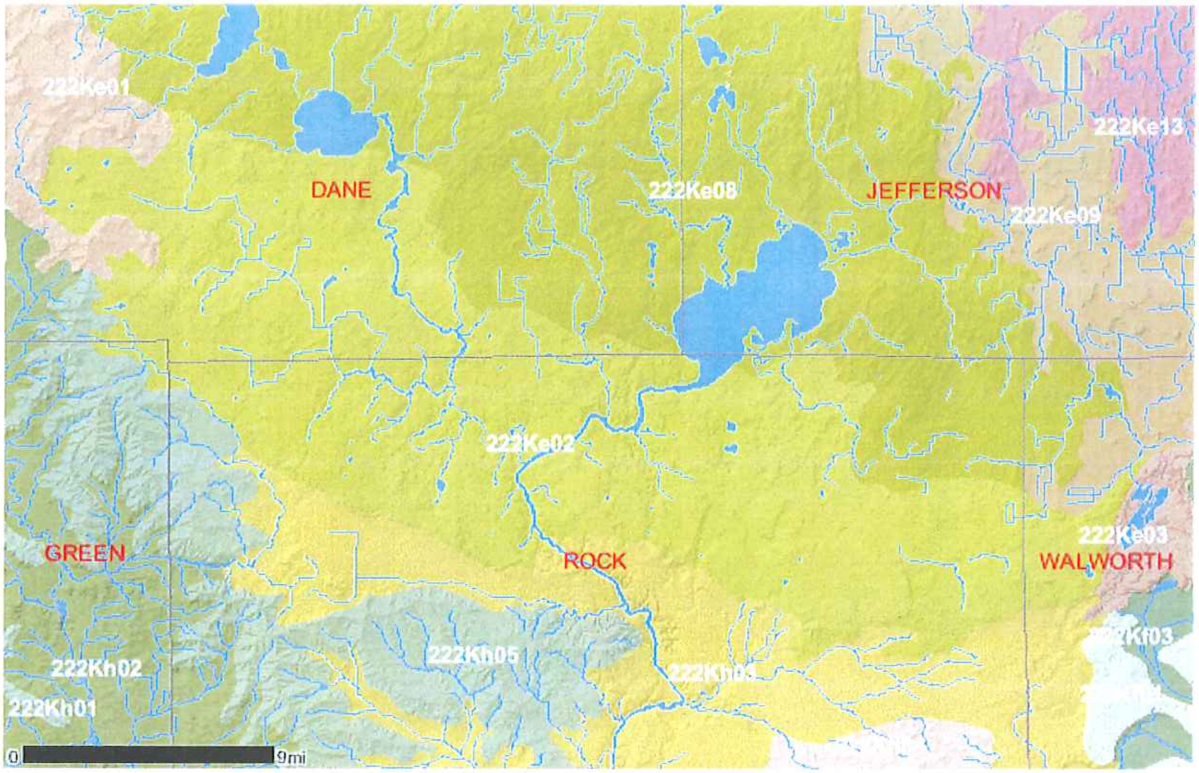
Attachment 7. Channel profiles



Attachment 7. Channel profiles



Attachment 9.



Lake Koshkonong Water Quality Modeling
For the
Lake Level Change Environmental Assessment

Conducted by

John Panuska, WT/2

Completed

June 1, 2004

Attachment 8. Water Quality Modeling for Lake Koshkong

Introduction

The following water quality modeling analysis is being conducted to assess the environmental impact of a proposal submitted by the Rock Koshkonong Lake District to: a) eliminate the winter draw down and b) raise the winter and summer pools 7.2 inches above the current summer pool elevation for Lake Koshkonong. The following nutrient loading modeling analysis focuses on the water column total phosphorus (TP) concentration before and after the proposed level change. Modeling was conducted using the Wisconsin Lake Modeling Suite (WiLMS) model. WiLMS is a Windows based planning level modeling system that couples 13 empirical lake response models with an export coefficient based watershed and point source loading module (Panuska and Kreider, 2002).

Method of Analysis

The time period used for the model study was October 1998 through September 1999. The 1998-99 period was chosen because the USGS monitored flow and total phosphorus loading in the Rock River and the water column TP in Lake Koshkonong concurrently during that time. This period was used to represent a base line condition against which the water column TP concentration associated with the proposed change in water level was compared. Additional information not included in Tables 1 and 2 is contained Appendix A. The empirical model selected from WiLMS for use in the analysis was the Vollenweider 1982, Combined OECD which was found to fit the parameters for the Lake Koshkonong system.

Information provided by the applicant for the proposed surface area and elevation change was used to calculate the lake volume for the proposed condition. The net internal loading for the proposed condition was estimates by extrapolating the existing areal internal loading using the proposed increase in lake surface area. The analysis assumed that the land uses within the direct tributary area did not change as a result of the proposed conditions. The surface area and volume used in the analysis were calculated at a point assumed to be located half way between the proposed target level of 776.8 MSL and the maximum level of 777.0 MSL. This condition was selected because it is assumed that the lake level will be within this range the majority of the time. In addition, due to lack of specific data this analysis was not able to consider the impact of changes in boating activity.

Model Inputs

Table 1 below summarizes the WiLMS model inputs and data sources used in the analysis.

Table 1

A Summary of WiLMS Model Inputs

Parameter	Value	Data Source
Net Precipitation	3.0 In.	Regional Maps
Rock R. TP Load	4.72×10^5 Kg	USGS Water Data 1998-99
Rock R.. Flow	1.53×10^9 m^3	USGS Water Data 1998-99
Direct Area Loading	45,540 Kg	Land use export values
Direct Area Flow	92,240 AF	WiLMS default runoff 7.2 In.

Results and Discussion

Table 2 below summarizes the output from WiLMS for both the base line and proposed conditions.

Table 2

A summary of WiLMS Output

Parameter	Baseline Value	Proposed Value	Change
Lake Surface Area	10,460 Ac	10,513 Ac.	53 Ac
Lake Volume	55,793 AF	63,133 AF	7,340 AF
Internal Loading	740,000 LB	743,780 LB	3,780 LB
Water Residence Time	15.6 Days	17.5 Days	1.9 Days
Ave. Annual Water Column TP	312 ug/l	310 ug/l	1 ug/l

WiLMS predicts a 70% confidence range (170-520 ug/l) around the predicted mean TP of 310 ug/l. Given this range of prediction uncertainty, a change of -2 ug/l is essentially insignificant.

Conclusion

Review of the results summarized in Table 2 indicates a realistically insignificant change in water residence time and water column TP. It therefore appears reasonable to conclude that the proposed change in water level would not result in a measurable change in the average annual water column TP concentration and the associated trophic state indicators. It is important to note however that due to lack of data this analysis did not consider the impact of changes in boating activity.

References

Panuska, J.C., and Kreider, J.C., 2002, Wisconsin lake modeling suite program documentation and user's manual, Version 3.3 for Windows: Wisconsin Department of Natural Resources PUBL-WR-363-94, 32 p. [Available online through the Wisconsin Lakes Partnership: accessed March 16, 2004, at URL http://www.dnr.state.wi.us/org/water/fhp/lakes/laketool.htm]

Appendix A

WiLMS Model Printouts

Attachment 9.

Ecological Land Classification as related to Lake Koshkonong

Wisconsin DNR's Division of Forestry uses an ecological land classification system based on the National Hierarchical Framework of Ecological Units (NHFEU). The structure of the NHFEU was developed by staff of the USDA-Forest Service, in cooperation with federal and state partners. The National Hierarchical Framework of Ecological Units (NHFEU) is a hierarchical ecological land classification system. Ecological units are identified and differentiated based on unique combinations of physical and biological characteristics, which may include climate, geology, geomorphology, soils, hydrology, or potential natural vegetation. Ecological units at each spatial scale are nested within the broader scales. Appropriate uses of ecological units vary by scale. The scales used by WDNR are **Province**, **Section**, **Subsection**, and **Landtype Association.**

Province: 222, Eastern Broadleaf Forest
The broadest spatial scale of the NHFEU used by WDNR is the Province level. Provinces are distinguished by climatic factors that control the distribution of biomes, such as solar radiation and continental precipitation patterns. Potential natural vegetation zones like those mapped by Kuchler often correspond with Province boundaries. Province 222, the Eastern Broadleaf Forest Province, includes southern Wisconsin as well as much of the central portion of the Eastern United States.

Section: 222K, Southwestern Great Lakes Moraino Section
Section-level ecological units are nested within Provinces. Sections are based primarily on climate and broad-scaled glacial or bedrock geology. Section boundaries in Wisconsin follow former glacial lobes of the Wisconsin glaciation, and also separate the Driftless Area.

Subsection: 222KE, Southern Green Bay Lobe Subsection
Subsection-level ecological units are nested within Sections. Subsections in Wisconsin are often based on associated groups of glacial features such as morainal systems. In the parts of the state not glaciated during the Wisconsin Ice Age, patterns of topography formed by erosion on different bedrock surfaces are the basis for differentiating Subsections.

Landtype Associations (LTA): 222Ke02 (East Johnstown-Milton Moraines) and **222Ke08 (Dane-Jefferson Drumlins and Lakes)** abut Lake Koshkonong. Landtype Associations (LTA's) are nested within Subsections. They are identified by surficial geology, patterns of vegetation, soil parent materials, and water tables. LTA's are mapped at a landscape scale (1:60,000 to 1:250,000). At the landscape scale, these ecological units are defined by general topography, geomorphic process, surficial geology, associations of soil families, and potential natural communities, patterns, and local climates (Forman and Godron 1986). These factors affect biotic distributions, hydrologic function, natural disturbance regimes, and general land use. Local landform patterns become apparent at this level in the hierarchy, and differences among units are usually obvious to on-the-ground observers. At this level, terrestrial features and processes may also have a strong influence on ecological characteristics of aquatic habitats.Most LTA's in the Lake States are between 10,000 and 300,000 acres in size. In Wisconsin, they are usually based on glacial features like individual moraines or outwash plains. LTA's that are formed in outwash sand are often infertile and droughty, and support vegetation adapted to these harsh conditions. LTA's on moraines have nutrient-rich, moist conditions, and vegetation adapted to a rich environment. These are groupings of landtypes or subdivisions of subsections based on similarities in geomorphic process, geologic rock types, soil complexes, stream types, lakes, wetlands, subseries or plant association vegetation communities. Repeatable patterns of soil complexes and plant communities are useful in delineating map units at this level. Names of Landtype Associations are often derived from geomorphic history and vegetation community.

The purpose of the classification is to distinguish land areas that differ from one another in ecological characteristics. A combination of physical and biological factors, such as climate, geology, topography, soils, water, and vegetation, are used to differentiate areas. These factors are known to control or influence biotic composition and ecological processes. Together, they provide a useful approximation of ecosystem potentials. Land areas identified and mapped in this manner are known as ecological units. Maps of ecological units can be developed at many spatial scales, depending on the needs of the user. The maps, along with information about the ecological units, convey information about land characteristics and capability.

Attachment 9.

An important application of this information is in planning for future land uses. Understanding an area's ecological characteristics informs resource management decisions about vegetation composition and structure, wildlife species to feature, and desirable recreational uses

Note-SE Glacial Plains Ecological Landscape is used for WDNR planning purposes and is comprised of 222Ke (Southern Green Bay Lobe Subsection), and the following additional subsections:

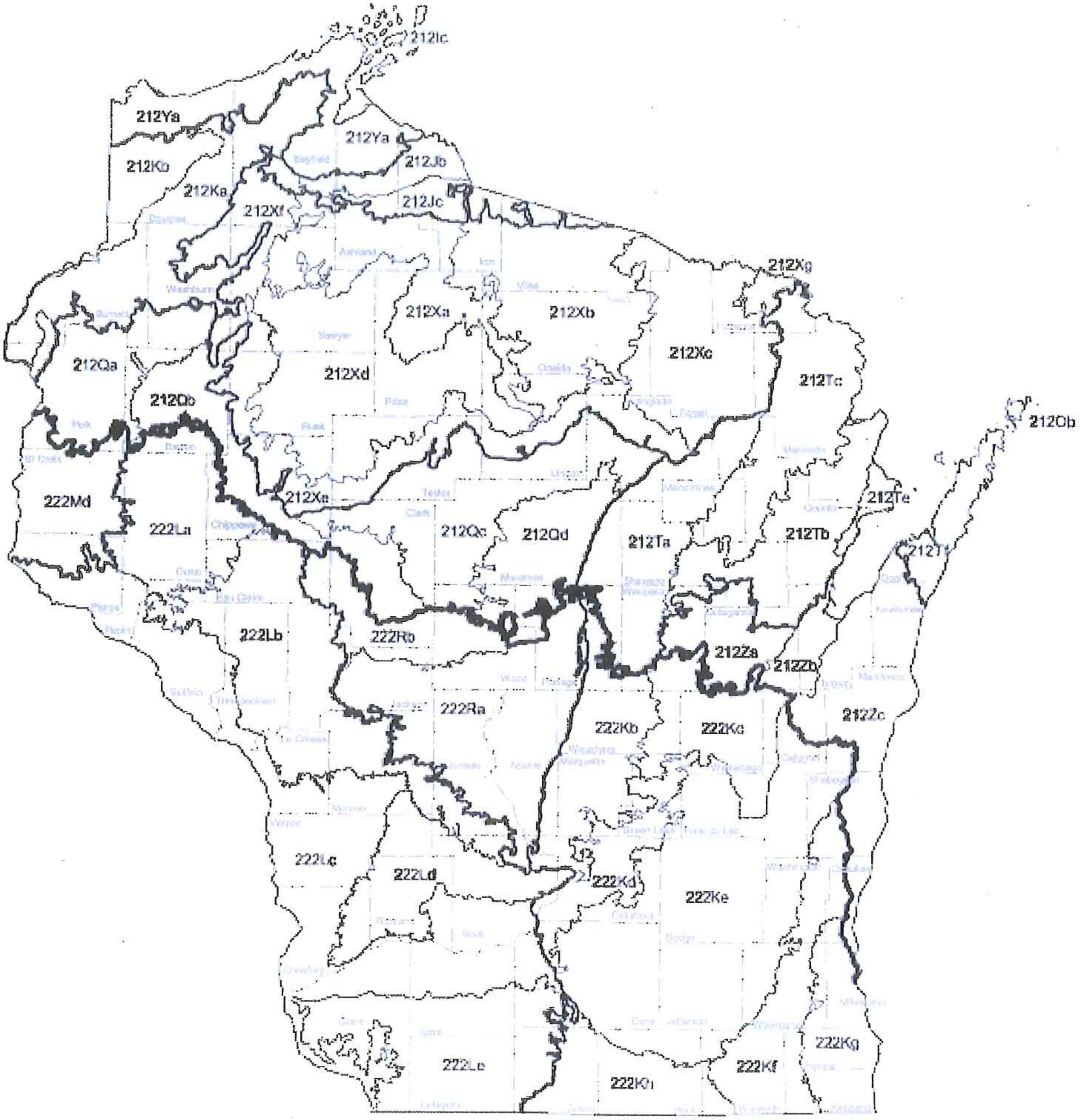
222Kc: Lake Winnebago Clay Plain (49,276 acres, 6%)
Flat lake plains and ground moraines reworked by glacial lakes characterize this subsection, which extends into the northeastern part of the FRHE. Red clay soils dominate, and are high in carbonates because of the dolomitic rock that underlies the area. Sugar-maple basswood forests dominated this subsection prior to settlement, but oak openings and forests were common on the portion within the FRHE because of high fire frequency (Albert, 1995). Extensive wetlands and agriculture dominate the area today.

222Kh:

222Kf :

Attachment 9.

Figure__The heaviest line shows the division between Provinces, approximating the location of the Tension Zone. The line of medium thickness indicates Section boundaries. The thinner lines are Subsection boundaries.



Attachment 9.

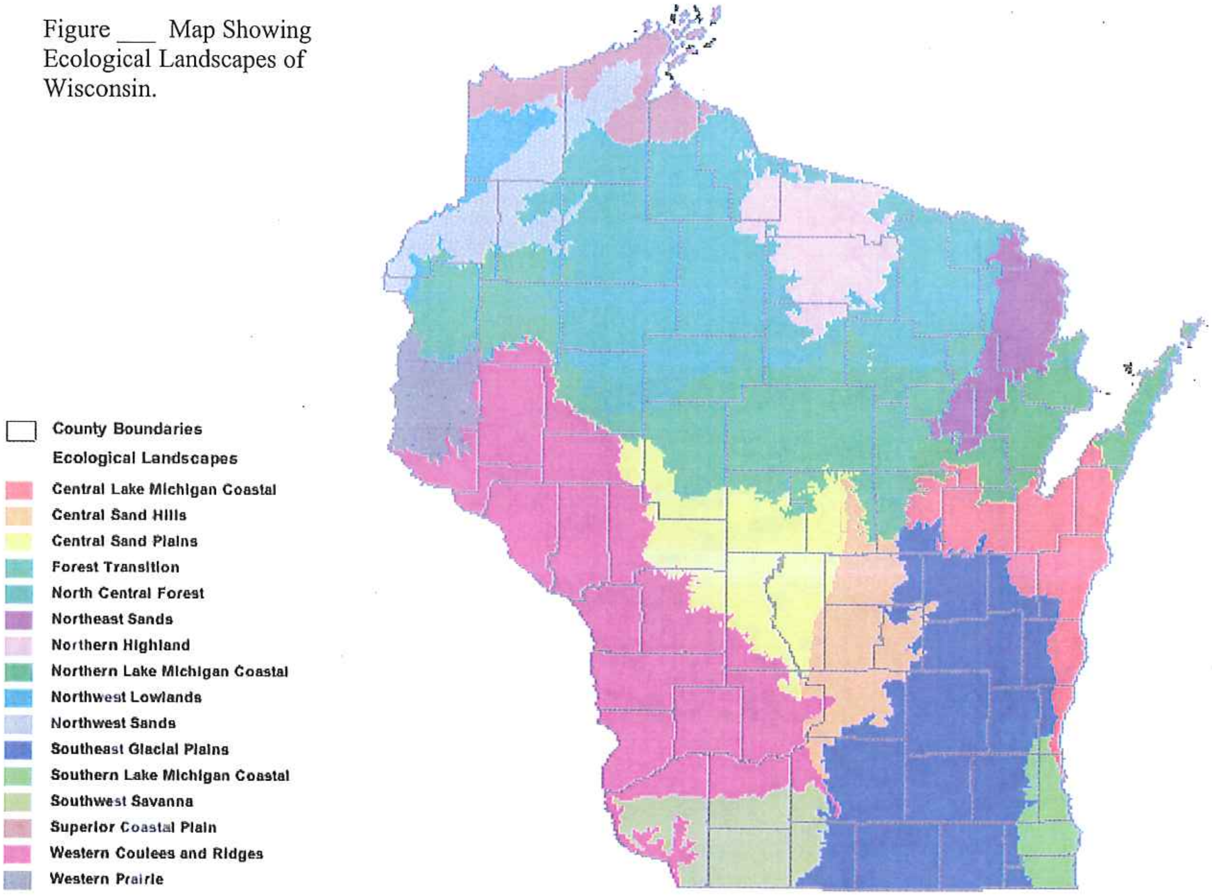


Figure ___ Map Showing Ecological Landscapes of Wisconsin.

Attachment 10. Effects of Water Level Management on Floodplain Forests

Malecki, R. A. et al. *1983. Effects of Long-Term Artificial Flooding on a Northern Bottomland Hardwood Forest Community. Forest Science 29(3): 535-544.*

Introduction
Creation of artificial wetland habitats, including both permanently and seasonally flooded areas, is a management practice used to remedy this situation (the serious reduction of suitable waterfowl habitat) (Rudolph and Hunter 1964).

Incentive for the development of impoundments is reinforced by findings that forest growth can be enhanced in some cases by seasonal inundation with shallow water during the winter period (Broadfoot 1967).

Here (specifically the Montezuma National Wildlife Refuge in central New York),management generally favors permanent inundation of lowland areas. While this achieves its intended wildlife function, the desired effect is of limited duration because of the eventual decline of the forest community (Cowardin 1965).

Results (of the 12-year monitoring effort)
Flooding was seasonal: mid-March to late June and the authors indicate that the mean water depth during this flooding was 27-30 cm.
Frequency of occurrence estimates indicates that the composition of tree species in the treatment pools ... has remained relatively constant.

Mean densities of the five major tree species in the east, west, and control pools in 1979 revealed no significant differences (*t*-test; p>0.05).

Tree seedling survival, as indicated by density estimates in 1979 of individuals less than (1 inch) dbh, favored red maple. Red ash, elm, and blue beech declined significantly. Among shrub species, spicebush (*Lindera benzoin*) and winterberry (*Ilex verticillata*) had significantly lower mean densities...

Of the herbaceous vegetation, mean densities of all fern species decreased significantly in the east and west pools during the period 1965 to 1979...

Discussion
(R)educed tree growth and alteration of the understory plant communities (in a northern bottomland hardwood forest), including tree reproduction, in the treated pools is evident (following continuous spring flooding over a 12-year period).

Greater injury and lower survival of most tree species are associated with increasing periods of flooding during the growing season (Gill 1970, Broadfoot and Williston 1973, Teskey and Hinckley 1978). Hall and Smith (1955) found that survival of even the most flood tolerant species required an unflooded condition for at least 50 percent of the growing season.

The major effect of flooding is to create anaerobic conditions in the rhizosphere (Teskey and Hinckley 1977) which promotes immediate dormancy or death of roots developed under aerobic conditions (Hosner and Boyce 1962, Broadfoot and Williston 1973).

Over the long term, reduced stem growth reflects the interrelated effects of decreased total photosynthesis due to crown dieback and reduced water and nutrient uptake due to root death (Teskey and Hinckley 1977).

The impact of continuous seasonal impoundment is most striking with regard to tree regeneration. However, this appears to be due to the impact of flooding on seedling survival rather than on seed germination (Teskey and Hinckley 1977).

The controlled spring flooding of the bottomland forest at Montezuma has greatly enhanced the attractiveness and utility of this habitat to breeding waterfowl, in particular the wood duck (*Aix sponsa*) (Haramis 1975).

Recognition of the need to limit the duration of flooding to no more than 50 percent of the growing season, to provide for periodic or aperiodic nonflooded years, to allow seedling establishment and to maintain the vigor of the existing plant community, appear essential to the successful continuance of such a management scheme.

Mitsch, W.J. and Rust W.G. 1984. Tree Growth Responses to Flooding in a Bottomland Forest in Northeastern Illinois. Forest Science 30(2): 499-510.

Introduction

Bell and Johnson (1974) reported that continued flooding during the growing season decreased tree growth and caused increased tree mortality. Tree ring data of three bottomland hardwood species were compared with reconstructed hydrologic conditions of flooding for the period 1917 through 1978 for a riparian forest along the Kankakee River in northeastern Illinois.

Results and Discussion

The fact that no substantial linear relationships between tree growth and flooding were found in the above correlations suggests a more complicated interplay of several factors determining the growth of trees in this riparian ecosystem.

Conclusions

This study found a general lack of correlation between growth of moderately water-tolerant trees and measures of floodplain flooding duration, whether the flooding was in growing season or during the entire year.

Causes and effects of tree growth vs. flooding are difficult to determine because flooding can have both positive (nutrient and water replenishment) and negative (anaerobic root zone) influences. The overall relationship between growth and flooding has been shown here to be difficult to represent through the use of simple linear regression models.

Harris, M.D. 1975. Effects of Initial Flooding on Forest Vegetation at Two Oklahoma Lakes. Journal of Soil and Water Conservation 30(6): 294-295.

Discussion

Trees with a small portion of the crown above water or that were submerged for a few days displayed varying degrees of stress during July.

Following initial flooding in 1973, Keystone Lake crested 28.5 feet above normal pool, while Oologah Lake crested 21.28 feet above. Keystone is normally 26,300 acres (at 723 feet elevation) and increases to 55,4000 acres at flood pool level, whereas Oologah is typically 29,500 acres (at 638 feet elevation) and increases to 57,000 acres. Both lakes were constructed in the mid-1960s by the US Army Corps of Engineers and are meant to store high levels of runoff.

Approximately 80 percent of the trees that were less than 10 inches diameter breast high and 25 feet tall and exhibiting such stress perished. Living trees larger than 10 inches dbh and taller than 25 feet in height showed no visible stress other than a reduced growth rate in late summer.

Mortality was greatest among oak-hickory types and increased as tree size decreased.

On the basis of these surveys, trees and shrubs planted for recreation purposes in such flood zones should be confined to the following species: green ash, sycamore, cottonwood (cottonless), buttonbush, willow, mulberry (fruitless), silver maple, bald-cypress, river birch.

Attachment 10. Effects of Water Level Management on Floodplain Forests

Ernst, K.A. and Brooks, J.R. 2003. Prolonged Flooding Decreased Stem Density, Tree Size and Shifted Composition Towards Clonal Species in a Central Florida Hardwood Swamp. Forest Ecology and Management 173(2003): 261-279.

Introduction

Studies have shown that prolonged or chronic flooding causes a compositional shift toward more flood-tolerant tree species through the elimination of less flood-tolerant species (Malecki et al., 1983; King, 1995; Young et al., 1995)

(T)ree size has been reported to influence flood-tolerance, but many results are conflicting. In some studies, large trees have greater survival rates than small trees (Harms et al., 1980; Kozlowski, 1982; Lugo and Brown, 1984). Other studies have contradicted this apparent size advantage, suggesting that larger trees may be more sensitive to flooding (King, 1995; Young et al., 1995). Clearly, more studies are needed that can document the role of tree size on flood-tolerance.

Prolonged flooding may also bring about changes in stand composition and structure by favoring clonal (vegetative) reproduction over seed germination.

Because clonal reproduction is not a characteristic shared by all wetland tree species, conditions that prevent seed germination and seedling establishment can lead to dramatic changes in community composition over time.

Discussion

Studies in similar hardwood swamps have shown that depth of flooding impacts growth rates and the length of time it takes for trees to die, even under permanently flooded conditions (Eggler and Moore, 1961; harms et al., 1980). For example, Megonigal et al. (1997) found that aboveground production decreased by approximately (4.89 lb/ft^2) per year with every centimeter increase in mean growing season water depth. Harms et al. (1980) found that stands exposed to more than 4.27 feet of flood depth were entirely dead after 3 years of flooding, whereas those subject to less than 1 m had mortality levels that varied between 2 and 41%.

Conclusions

The alteration of water flow into Flatford Swamp has caused tree communities to shift towards shrubby, more flood-tolerant and less diverse assemblages.

Although previous studies have examined the relationship between tree diameter and vigor under varied levels of flood stress, results are highly variable and deserve further research (Lugo and Brown, 1984; King, 1995; Harms et al., 1980).

Virginia Carter et al. *1978. Water Resources and Wetlands. Wetland Function and Values: The State of our Understanding. American Water Resources Foundation.*

Species, like red maple, found growing under a wide range of flooding conditions may have ecotypes well adapted to flooding and other ecotypes that are poorly adapted.

Plants of a particular species, established and matured under conditions of infrequent flooding, will prove to be more sensitive to growing season inundation than plants of the same species established and matured under a regular regime of flooding. Therefore, it's sometimes not sufficient to consider species alone; some insight into natural flooding conditions during the period of establishment is also required.

Trees normally growing in unflooded parts of the natural streamside forests were affected as the flood period increased beyond 30 days.

Chambers, J.L. et al. *1992. Flood Timing, Growth and Morphological Responses of Bottomland Oak Species. In: Brissette, John C., ed. Proceedings of the 7th biennial southern silvicultural research conference; 1992 November 17-19; Mobile, AL. Gen. Tech. Sep. S)-93. New Orleans, LA: US Department of Agriculture, Forest Service, Southern Forest Experiment Station: 407.*

Abstract

Controlled, somewhat regular flooding, over a period of years as is common in greentree reservoirs, appears to reduce successful regeneration of bottomland oak species.

For flood sensitive Cherrybark oak even the November to February flood treatment heights were 17.8 % less than in the control treatment.

Martha R. McKevlin. 1992. Guide to Regeneration of Bottomland Hardwoods. Southeastern Forest Experiment Station. Ashville, NC.

The following tabular guide (adapted from Kennedy 1990) provides information on species flood tolerance. Those who use this guide must take into account that tolerance to flooding depends not only on duration and season of flooding but also on depth of flooding and number of flooding events each year.

	Periodic Flooding	
January - May	January - April	January - March
Sweetgum	Sawtooth Oak	Shumard Oak
Water Oak	Sycamore	Cherrybark Oak
Willow Oak	Cottonwood	Swamp Chestnut Oak
Nuttal Oak	Sweet Pecan	Nuttal Oak
Green Ash	Nuttal Oak	Green Ash
Swamp Tupelo	Green Ash	Swamp Tupelo
Red Maple	Swamp Tupelo	Red Maple
	Red Maple	

NEWS RELEASE

Wisconsin Department of Natural Resources
South Central Region Headquarters
3911 Fish Hatchery Road
Fitchburg, WI 53711
Phone: 608-275-3292
E-mail: Kenneth.johnson@dnr.state.wi.us

FOR RELEASE: **December 20, 2004**
CONTACT: **Ken Johnson, 608-275-3243, Kenneth.johnson@dnr.state.wi.us**
SUBJECT: **Lake Koshkonong EA Regarding the Indianford Dam and Lake Koshkonong Water Levels**

Fitchburg, Wis. – The Wisconsin Department of Natural Resources (WDNR) has prepared an environmental assessment (EA) for Lake Koshkonong regarding the Indianford Dam and Lake Koshkonong water levels. This EA was prepared to evaluate Rock-Koshkonong Lake District's (RKLD) proposed water levels. On April 21, 2003, RKLD filed a petition with the WDNR pursuant to Section 31.02, Wisconsin Statutes, to amend Order 3-SD-82-809 Regarding the Lake Koshkonong – Indianford Dam Water Level.

The EA describes RKLD's proposed changes and provides a summary of Lake Koshkonong's current conditions. The EA also gives a description of the probable adverse and beneficial impacts of RKLD's proposed water levels. The EA also discusses which of these impacts are on geographically scarce resources and threatened and endangered resources. It also elaborates on whether these environmental consequences are reversible. Finally it discusses the significance of cumulative impacts of the proposal and explains the significance of precedence to other similar situations.

The public is invited to comment on the EA. A public meeting will be held from 4:30 to 9:00 on January 19, 2005, at the Fort Atkinson High School Auditorium. If you have questions and would like to talk to a DNR representative, please come at 4:30 until 6:00. A formal presentation will be held at 6:00, which will explain the EA and its contents. After the presentation the public will be invited to make public comments. If there is still time after taking public comments you will be able to talk with DNR officials who will be on-hand to answer questions or hear further individual comments until 9:00 pm. There will also be a table for written comments.

The proposed Department action is not anticipated to result in significant adverse environmental effects. The Department has made a preliminary determination that an environmental impact statement will not be required for this action.

Copies of the Environmental Assessment (EA) that led to the DNR's preliminary determination can be downloaded from the DNR's website (http://dnr.wi.gov/org/water/fhp/). Copies can also be seen at the following public facilities: Edgerton Public Library, 414 Albion St., Edgerton; Dwight Foster Public Library, 102 E. Milwaukee Avenue, Fort Atkinson; Milton Public Library, 430 E. High Street, Milton; or the DNR Service Center, 2514 Morse St., Janesville.

Public comments, either written or oral, on the environmental assessment are welcome and must be submitted to Ken Johnson no later than 4:30 p.m., February 2, 2005.

Email: Kenneth.johnson @dnr.state.wi.us,
Phone: 608-275-3243,
Address: Ken Johnson
Wisconsin Department of Natural Resources
3911 Fish Hatchery Road,
Fitchburg, WI 53711.

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DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary
Ruthe E. Badger, Regional Director

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TTY Access via relay - 711

March 18, 2005

Dear Sir or Madam

Subject: Lake Koshkonong EA decision

I am writing you because of your expressed interest in the Department of Natural Resource's Environmental Assessment (EA) of the Rock Koshkonong Lake District's proposal to raise water levels on Lake Koshkonong. If you are getting this letter it means you either specifically commented on the assessment or attended the public meeting held on January 19th. Attached you will find the Department's summation of the comments we have received since releasing the EA and our clarifying comments or answers to those questions.

The Department has determined that the EA satisfies the requirements of the Wisconsin Environmental Policy Act, which is codified for the DNR in Wisconsin Administrative Code NR 150. Therefore, the formal review process by means of the EA is complete. The next step will be a formal decision by the Department. We expect the decision to be issued shortly. After the decision is issued, there will be a 30 day appeal period in which any interested party may request a formal contested case hearing. If the Department's decision is not appealed, it will become final 30 days after it is issued.

Thank you for you interest in this matter. If you have any further questions on the water level matter and/or technical issues, feel free to call me at 275-3243. If you have specific questions to the EA process, please call Russ Anderson, Environmental Analysis and Review Program Supervisor, at 275-3467.

Sincerely,

Kenneth G Johnson

Kenneth G. Johnson P.E.
Lower Rock River Water Leader

Cc: Ruthe Badger, SCR
Russ Anderson, SCR

Comments on the Environmental Analysis of the Rock Koshkonong Lake Districts Petition to Raise the Water Levels of Lake Koshkonong.

The Department of Natural Resources released its draft Environmental Analysis (EA) of the District's proposal to raise the water levels on Lake Koshkonong on December 21st 2004. The Department requested that comments on the EA be submitted prior to February 2, 2005. The Department also held a public meeting on the draft environmental analysis on February 19th where a Power Point Summary of the EA was presented. At the Public Meeting there were 10 public comments. Including the public hearing comments, the Department received a total of 53 timely comments from email, mail and verbal comments over the phone. While the Department's EA does not directly take a position on the merits of the District's petition, all of those commenting expressed an opinion either for or against the proposal. Of those commenting, 33 were opposed to the District's proposal, 17 were in support, and 3 people wanted the winter drawdown removed.

Almost all of the comments fall under one of the following categories:

1. Concern about damage to wetland, wetland habitat, or shore land property resulting form raising the water levels; 23 comments
2. Concern that the proposal will negatively affect forested wetlands; 5 comments
3. Concern about the impacts on septic fields and agricultural fields resulting from higher ground water as a result of raising water levels; 5 comments
4. Concern about falling property values resulting form higher water levels: 4 comments
5. Believe that higher water levels will improve property values; 1 comment
6. Believe that the current Ordinary High Water Mark (OHWM) is the result of improper operation of the dam and is therefore wrong; 2 comments
7. Believe that the current winter drawdown will negatively affect fish; 4 comments
8. Believe that the current winter drawdown will negatively affect amphibians ; 2 comments
9. Believe that the current winter drawdown protects shorelines and helps to generate aquatic plant growth; 4 comments
10. Believe that the current order negatively impacts navigation; 2 comments
11. Concern that the proposal will negatively affect threatened and endangered species; 3 comments
12. Another comment stated there is a substantial dispute of facts between the EA and the Environmental Impact Report, and they intend to seek contested case review under Chapter 227, Stats; 2 comments (1 form the RKLD and the other from the Rock River Koshkonong Association)
13. A 7-inch rise in water levels will affect more than 50 acres of water as stated in the EA (and the EIR); 2 comments
14. Concern about the impacts on wildlife from rising water levels; 2 comments

15. The Department should require an EIS before it implements this proposal; 1 comment
16. Concern about shoreline erosion from raising water levels; 2 comments
17. Armoring the remaining unarmored areas of the lake will mitigate the effects of erosion from raising water levels; 4 comments
18. Higher water levels will make some of the existing riprap ineffective; 2 comments
19. Higher water levels will result in more plants and better fishing; 2 comments
20. Higher water levels will improve boating access from piers; 5 comments
21. Higher water levels will mitigate thermal impacts on fish during the summer months; 1 comment

The above comments were general in nature and will not result in a revision of the EA.

There were two additional specific comments on the quality and quantity of information in the EA. **The first was a concern raised during the comment period that there was not much information on the bird species in the area** - Please note that More bird information can be found in the Endangered Resource section of the EA. Also, the EA was not all-inclusive but indicative of the significance of the area for birds. It is also important to point out that the Lake Koshkonong area has been nominated as an Important Bird Area (IBA), which is significant on a national level, with more surveys to occur this year (2005).

The second comment questioned the Boat survey quoted within the EA because it was 16 years old and should be updated with more recent information - The Department is not aware of any study on the Rock River or Lake Koshkonong that would give better statistical information on the navigable use of Lake Koshkonong other than the studies referred to in the EA. Warden Mike Cross did shed some personnel observations of boat traffic on Lake Koshkonong as a result of his 18 years of work in the area of Lake Koshkonong. His observations are:

1. Boat use of Lake Koshkonong has easily quadrupled in the last 18 years. This increase is very similar to what he has observed on other lakes and water bodies within South Central Region.
2. There has been an increase in the size of boats and the horsepower of boats but the actual increase has not been documented
3. There has been a huge increase in personal watercraft.
4. There has been a large increase in large boats like "cigar boats".
5. The dominate watercraft used on the lake is still the pontoon boat.
6. Most boats are launched from the deeper river boat accesses.

This concludes the questions we received with the answers we gave.

Project Name: County:

DECISION (This decision is not final until certified by the appropriate authority)

In accordance with s. 1.11, Stats., and Ch. NR 150, Adm. Code, the Department is authorized and required to determine whether it has complied with s.1.11, Stats., and Ch. NR 150, Wis. Adm. Code.

Complete either A or B below:

A.EIS Process Not Required ☒

The attached analysis of the expected impacts of this proposal is of sufficient scope and detail to conclude that this is not a major action which would significantly affect the quality of the human environment. In my opinion, therefore, an environmental impact statement is not required prior to final action by the Department.

B.Major Action Requiring the Full EIS Process ☐

The proposal is of such magnitude and complexity with such considerable and important impacts on the quality of the human environment that it constitutes a major action significantly affecting the quality of the human environment.

Signature of Evaluator Kenneth D Johnson	Date Signed 12/14/04

Number of responses to news release or other notice:

Certified to be in compliance with WEPA Environmental Analysis and Liaison Program Staff R A Anderson	Date Signed 3/18/05

NOTICE OF APPEAL RIGHTS

If you believe that you have a right to challenge this decision, you should know that Wisconsin statutes and administrative rules establish time periods within which requests to review Department decisions must be filed.

For judicial review of a decision pursuant to sections 227.52 and 227.53, Stats., you have 30 days after the decision is mailed, or otherwise served by the Department, to file your petition with the appropriate circuit court and serve the petition on the Department. Such a petition for judicial review shall name the Department of Natural Resources as the respondent.

To request a contested case hearing pursuant to section 227.42, Stats., you have 30 days after the decision is mailed, or otherwise served by the Department, to serve a petition for hearing on the Secretary of the Department of Natural Resources. The filing of a request for a contested case hearing is not a prerequisite for judicial review and does not extend the 30-day period for filing a petition for judicial review.

Note: Not all Department decisions respecting environmental impact, such as those involving solid waste or hazardous waste facilities under sections 144.43 to 144.47 and 144.60 to 144.74, Stats., are subject to the contested case hearing provisions of section 227.42, Stats.

This notice is provided pursuant to section 227.48(2), Stats.