STATE OF WISCONSIN
DIVISION OF HEARINGS AND APPEALS

In the Matter of the Review of the Water Level Decision for Lake Koshkonong and the Indianford Dam on the Rock River in Rock County, Wisconsin

Case No. 3-SC-2003-28-3100LR

PREFILED DIRECT TESTIMONY OF
ROBERT J. MONTGOMERY

Q. Please state your name and business address.

A. Robert J. Montgomery, 2820 Walton Commons West, Suite 135, Madison, WI 53718.

Q. What is your occupation?

A. I am principal at Montgomery Associates: Resource Solutions, LLC, a consulting engineering firm that I founded in 1998, based in Madison Wisconsin.

Q. Please summarize your educational and employment background.

A. I received a B.S. in civil engineering from the University of Illinois, Urbana, in 1976, and in 1980 I received an M.S. in civil engineering with an emphasis in water resources from Colorado State University. I was employed as an engineer by Warzyn Engineering of Madison, Wisconsin from 1980-1992, during which time I participated in a wide variety of water resource engineering, civil engineering and environmental engineering projects. In 1992, I opened the Wisconsin office of Johnson, Johnson & Roy, emphasizing the water resources, environmental engineering and site design aspects of their practice. In 1995, I joined the Madison office of Woodward Clyde consultants, where I worked on water resource engineering and environmental engineering projects. In 1998, I started my own practice, Montgomery Associates: Resource Solutions, LLC. The practice at Montgomery Associates has emphasized water resource engineering applied to river hydrology and hydraulics, groundwater and surface water hydrology, stormwater management, and erosion control. I am a registered professional engineer of the State of Wisconsin. My resume is attached as **Exhibit RKLD-101**.

Q. What is the purpose of your testimony?

A. I am testifying on behalf of Rock-Koshkonong Lake District ("RKLD") in support of the District's April 21, 2003 petition to modify the 1991 DNR operating order governing Indianford Dam and Lake Koshkonong. My testimony will describe the hydraulic and hydrological aspects of Lake Koshkonong and the Indianford Dam, and describe the relationship between historic flows and water levels and the operation of the Dam. I will discuss the criteria that were used in developing RKLD's petition for modification of the DNR operating order. My testimony explains and interprets the modeling utilized to predict the water levels under both the RKLD proposal and the DNR's 2005 proposed order, which is identical to the existing operating order for the summer season (May-October), as discussed below. Finally, I will provide foundational testimony for the public access and navigation exhibits developed for this proceeding.

Q. How did you come to be involved with this matter?

A. Beginning in 2001, I have provided consulting services to the District as follows:

- Participated in the September 2001 ordinary high water mark ("OHWM") study on Lake Koshkonong, and prepared the report summarizing that investigation.
- Analyzed the hydrology and hydraulics of Indianford Dam and Lake Koshkonong, including analysis of various options for control of water levels on Lake

Koshkonong. The first phase of this work is described in our 2003 report entitled *Hydraulic Analysis of Indianford Dam and Lake Koshkonong* (Exhibit DNR-39).

- Reviewed the water level orders for Lake Koshkonong, consulted with the District concerning water level management issues and assisted in the development of its proposed 2003 proposed modifications to the operating order for Indianford Dam.
- Attended and made presentations at the Annual Meetings of the District, monthly meetings of the District board and meetings with DNR staff and others.
- Participated in developing the Environmental Impact Report provided by the District to DNR as part of the review of the RKLD petition.
- Reviewed the DNR Environmental Assessment regarding water level management issues.
- Directed fieldwork on hydraulic data collection, water level surveys and OHWM evaluations.
- Updated hydrologic and hydraulic analysis of Indianford Dam and Lake Koshkonong, as described in this testimony.

Q. Please describe the location and physical characteristics of Lake Koshkonong and the upstream and downstream reaches of the Rock River.

A. Lake Koshkonong is a large shallow lake located on the Rock River in Jefferson, Rock and Dane Counties. Lake Koshkonong has a surface area of approximately 10,500 acres, with a maximum depth of approximately 7 feet and an average depth of approximately 5 feet during normal water levels. Much of the shoreline surrounding Lake Koshkonong has a very flat slope into deeper water, meaning that water depths of only a foot or two can extend hundreds of feet into the Lake. In some areas, water depths of only a few inches extend far from the shore. Land use on the shoreline of Lake Koshkonong consists of residential and resort areas, as well as large sections of relatively undeveloped shoreline, much of which is wetlands. The major features of Lake Koshkonong are shown on Exhibits DNR-1 and DNR-2.

Water levels on Lake Koshkonong are partially controlled by the Indianford Dam, located approximately 6 miles downstream of the Lake on the Rock River. The Rock River downstream of Lake Koshkonong to the Indianford Dam is typically 300 to 600 hundred feet wide and from 4 to 6 feet deep in the center of the channel. Land use along the Rock River downstream of the Lake and upstream of Indianford Dam is primarily residential, with some commercial development, including marinas, bait shops and restaurants. The Rock River upstream of Lake Koshkonong has a generally similar character to the River downstream of the Lake, but is relatively less developed.

Q. Please describe the general physical characteristics of the Indianford Dam.

A. Indianford Dam, which was originally installed in the 1800s and was reconstructed in 1917, is located in Rock County, approximately 200 feet downstream of the County Highway F bridge over the Rock River. The Dam consists of three sections (from west to east): a powerhouse which contains two wicket gates (which were formerly used to regulate water inflow to turbines for electric generation), a concrete spillway section approximately 277 feet wide, and six slide gates. Photographs of the Dam from various perspectives are attached in **Exhibit RKLD-102**. **Exhibit RKLD-103** includes a series of schematic views of the Dam and the wicket gate assembly.

Q. What are the sources of hydrologic data for Lake Koshkonong and the Rock River?

A. The primary sources of hydrologic data for Lake Koshkonong are USGS gages in the lake and river. A water level gage on Lake Koshkonong, referred to as "Lake Koshkonong near Newville Wisconsin," has been operational since 1987, and provides daily data on Lake Koshkonong water level, as well as seasonal data on rainfall depth. The gage is located on an excavated inlet connecting to the main body of Lake Koshkonong. Because of its location, this gage location is not subject to direct wave action. There are several flow gages on the Rock River near Lake Koshkonong, including but not limited to the gages at Afton, Indianford, Fort Atkinson and Watertown. The location of relevant gages in the Rock River watershed are shown on **Exhibit RKLD-104**, and are described in further detail in the memorandum entitled "Summary Description of USGS ages near Lake Koshkonong" attached as **Exhibit RKLD-105**. Data from these gages, where applicable, were some of the main inputs to our analyses.

Q. Please describe in general terms the hydrologic and hydraulic characteristics of Lake Koshkonong and the Rock River.

A. The Rock River is one of the larger rivers in the state of Wisconsin, having its origin north of Horicon Marsh and exiting the state at Beloit. The watershed of the Rock River has an area of approximately 2630 square miles at Indianford Dam. The extent of the watershed of the Rock River is illustrated on Exhibit RKLD-104, which also shows the locations of USGS gauging stations described above.

The discharge of the Rock River varies widely, both from year to year and during the course of each year. Floods on the river often occur each spring or early summer, and periods of low flow often occur in late summer and fall. The maximum flood on record at the gaging station at Indianford had a discharge of 11,900 cubic feet per second (cfs) in

April 1979. For reference, the 100-year flood described in the flood insurance study for this reach of the Rock River near Indianford is 11,000 cfs.) A graph showing the daily discharge of the Rock River at Indianford for 1977 – 2005 is included as **Exhibit RKLD-106**. While we have noted certain data quality issues for the Indianford gage (see Exhibit RKLD-105), this graph provides a useful description of flow variations in the Rock River. The principal observations from review of the discharge graph are:

- Typical low flow in the Rock River is below 1000 cfs, and is sometimes below 500 cfs.
- Typical yearly floods range from 4000 to 8000 cfs.
- Occasional prolonged low-flow periods occur, such as in 1988, 2003 and 2005.

The Fort Atkinson flow gage on the Rock River, located upstream of lake Koshkonong, shows a generally similar pattern of flow variation. Specific comparisons of the Fort Atkinson and Indianford flow data are presented later in this discussion.

Lake Koshkonong functions from a hydrologic and hydraulic perspective as a "wide spot" in the Rock River during times of moderate to high flow. This is because, although Lake Koshkonong has over 10,000 acres of surface area, the drainage basin of the Rock River at 1.68 million acres is so large in comparison that flood volumes are typically much larger than the volume of water in the Lake. Therefore, floods pass through the Lake without substantial alteration, and the water level of Lake Koshkonong is very closely related to the discharge on the Rock River during flood times. However, at lower discharges on the Rock River, especially for discharges below approximately 1000 cfs, the Indianford Dam does exert noticeable control on the water levels of Lake

Koshkonong. For this reason, we describe the Dam as exerting "partial control" over water levels in Lake Koshkonong.

Graphs illustrating the correlation between discharge of the Rock River and the water surface elevation of Lake Koshkonong are shown on **Exhibits RKLD-107** and **RKLD-108**, which are plots of flow in the Rock River at Fort Atkinson and at Indianford superimposed on the water level of Lake Koshkonong. Exhibit RKLD-107 displays Rock River discharge and Lake Koshkonong water level for year 2004, when a relatively large flood occurred, and shows that the timing and extent of water level fluctuations on Lake Koshkonong is very closely related to the flow in the Rock River at both Indianford and Fort Atkinson. Exhibit RKLD-108 shows that a similar lake level response occurs even during modest floods, such as those that occurred in 2003. Later in the summer of 2003, when Rock River flows were relatively low, the water level of Lake Koshkonong was much lower and fluctuated only slightly. The pattern of discharge in the Rock River upstream of Lake Koshkonong (at Fort Atkinson) and downstream of Lake Koshkonong (at Indianford) shows little alteration in passage through the Lake. In other words, the Lake impoundment does not store water or alter Rock River flows to any material degree.

Q. What is the current operating order applicable to Indianford Dam and Lake Koshkonong?

A. The current operating order was issued by DNR in 1991and modified in 2004 when the Rock-Koshkonong Lake District assumed ownership of the Indianford Dam. (See Exhibits DNR-3 and DNR-4.) The order regulates operations for summer (May 1-October 31) and winter (November 1-April 30) seasons. The summer operating orders establish a minimum lake level of 775.73 ft. mean sea level (MSL), a maximum elevation of 776.33 ft. MSL, and the target elevation of 776.20 ft. MSL. The winter operating orders establish a minimum of 775.00 ft. MSL, and a maximum of 775.77 ft. MSL. The operating order also specifies gate operations at Indianford Dam based on particular flow rates at upstream gaging stations, establishes a minimum discharge of 64 cfs, and establishes recordkeeping requirements.

Q. Have Lake Koshkonong water levels typically been in compliance with the 1991 DNR order?

A. No, they have not. Compliance with the existing order on Lake Koshkonong has been achieved only approximately half of the time. The record of Lake levels from 1987-2005 (from the Lake Koshkonong near Newville gage) plotted against the DNR's seasonal maximum and minimum water levels are illustrated in **Exhibit RKLD-109**. The exhibit illustrates that Lake Koshkonong water levels have very often been substantially higher than the DNR order minimum and maximum stages, usually by 2 feet or more, and occasionally by 3 to 5 feet. These times of high water levels correspond to flow conditions in the Rock River over 1000 cfs (see Exhibits RKLD-107 and RKLD-108), which typically occur several times during the course of each year.

A partial reason why Lake Koshkonong has experienced water levels above the Operating Order maximums is that the wicket gates were inoperable from the 1960s until August 2002, as described in more detail later in this testimony. Review of the water level plot (Exhibit RKLD-109) indicates that the summer and winter operating order ranges were more closely adhered to after August 2002. However, larger flows in the Rock River still have produced water levels far in excess of the ordered maximums. Exhibits RKLD-107 through RKLD-109 illustrate that Indianford Dam can exert only "partial control" on the water levels in Lake Koshkonong, even when all the gates are fully operational.

The record of daily water levels for the summer operating period (May-October) is also summarized in a stage-duration plot included as **Exhibit RKLD-110**. The stage-duration plot is a summary, statistical/graphical technique to describe the fluctuation of water levels on the Lake that would be expected over a long period of time. It describes the percent of time (on the x-axis) that water levels are at or above the water level indicated on the y-axis. Each interval on the x-axis represents 10% of summer season flows; it does not correspond to a particular month or day during the season. The 1991 DNR ordered summer maximum is also shown on Exhibit RKLD-110. This exhibit illustrates that Lake Koshkonong levels from 1987 through 2005 were below (in compliance) with 1991 DNR maximum water level orders for approximately 45 percent of the summer season.

Q. Is there an observable trend in historic water levels on Lake Koshkonong?

A. Lake Koshkonong has not exhibited a significant trend in water levels from 1987 through 2005. This conclusion is based on (1) analysis of data collected at the USGS gaging station at Lake Koshkonong; and (2) review of published reports on long term streamflow conditions.

We first considered this issue by review of the plot of daily Lake Koshkonong stage data (Exhibit RKLD-109). This data clearly shows a very wide fluctuation in Lake water levels with occasional higher flood peaks and low water periods. But it does not suggest any particular trend in either the low Lake levels (despite better compliance with the 1991 orders after year 2002) or the peak Lake levels. We next evaluated this data for indication of trends in average summer stage, low stage, and several other descriptors of water levels using two statistical analysis approaches. Both analyses evaluated water levels during the summer season (May through October) as defined in the 1991 DNR operating order. The details of the analysis are described in the memorandum entitled "Lake Koshkonong Stage Trend Analysis," attached as **Exhibit RKLD-111.** Our analysis USGS Lake Koshkonong stage data does not show any statistically significant trend, either rising or falling.

We also reviewed analyses performed by others of streamflow records that are available over a longer period of time than the Lake Koshkonong stage data. These reports did not find any significant trends in flows in the Rock River from the 1970s through the present. These analyses do indicate that flow appears to have shifted upward around 1970, in a relatively step-wise manner. Although flow now is generally higher than it was before 1970, this change occurred rather suddenly, as opposed to a gradual change that could be expected to continue into the future. This analysis is presented in a 2004 Illinois State Water Survey publication describing long-term trends in discharge within the Rock River watershed (Rock River Basin Streamflow Assessment Model, excerpts included as an attachment to Exhibit RKLD-111). This study analyzed a large number of data sets having long periods of record from the Rock River basin in Wisconsin and Illinois. The study analyzed the trend coefficients and found little change in average, low or high flows of the Rock River after 1970. The conclusions of the Illinois State Water Survey analysis are described as being consistent with the findings of other researchers with the US Geological Survey (referenced on page 39 of the ISWS report, full text of USGS study attached to Exhibit RKLD-111), which indicated that average and low flows in the 20th century for many rivers in the United States seem to have increased in a step-wise manner about 1970. This increase is described as being possibly related to an increase in precipitation. The ISWS study concludes that significant differences are observed in streamflow conditions before and after 1970, but there is no significant increase in flow conditions after 1970. These studies by the USGS and ISWS are consistent with our observation that Lake Koshkonong does not exhibit any overall trend in water levels since 1987.

Q. Does your knowledge of the Indianford Dam, the Rock River and Lake Koshkonong provide you with any understanding of what water level conditions were like on Lake Koshkonong prior to establishment of the USGS gage in 1987?

A. We don’t have direct data on Lake Koshkonong stage prior to 1987, but it is likely that the water level regime on the lake was similar for at least a decade prior to 1987. I say this because: 1) the general condition and operating procedure for Indianford Dam was very likely the same for at least 10 years prior to 1987; 2) flows in the Rock River appear to have remained similar after about 1970; and 3) the Ft. Atkinson treatment plant stage data presented in DNR’s Environmental Assessment appears to show a similar range in water levels for at least 10 years prior to 1987.

Q. Have you reviewed DNR Fisheries Ecologist Paul Cunningham’s analysis of Lake Koshkonong water level trends?

A. Yes I have. I am not convinced that this analysis describes a trend of continually increasing water levels. Mr. Cunningham analyzed Fort Atkinson water treatment plant river stage records, and developed a statistical correlation between the Ft. Atkinson data and Lake Koshkonong. I was surprised that DNR did not analyze the stage data of Lake

Koshkonong for the full duration of the available record, which provides the best direct data on lake levels during the past 18 years. In addition, DNR's analysis did not refer to other gages on the Rock River that have a longer period of record, or to the Illinois State Water Survey or US Geological Survey research publications discussed above. These sources all corroborate our conclusion that there is no evidence of a rising water level trend over the past 35 years.

Q. Please describe the operational state of the Indianford Dam

A. Rock County hired contractors to complete a number of repairs to the Dam in recent years, as required by a contract between the County and the Rock-Koshkonong Lake District and DNR orders. This repair work has restored Indianford Dam to a fully operable condition. The hydraulic capacity of the Dam includes the two wicket gates located in the power house, the six slide gates located at the east end in the Dam, and the overflow spillway crest that comprises the largest part of the Dam structure. (See Exhibit RKLD-103a.) The wicket and slide gates can be opened and closed using motorized actuators. The overflow spillway has a fixed crest that cannot be adjusted. Thus, the dam has operable capacity consisting of the two wicket and six slide gates, and inoperable capacity, consisting of the spillway. North American Hydro currently operates Indianford Dam under contract to the Rock Koshkonong Lake District to maintain compliance with the DNR operating order.

The slide gates and wicket gates provide a significant portion of the total hydraulic capacity of the Dam when the water levels are relatively low. The relative capacity of the operable and inoperable elements of the Dam at various water levels is illustrated by the bar charts in **Exhibit RKLD-112**. This exhibit shows the capacity of

Indianford Dam at three elevations of Lake Koshkonong: elevation 776.3 ft. MSL, which is the DNR summer maximum; elevation 777, which is the maximum elevation in the District's proposed order; elevation 779, which is a flood elevation that is reached nearly every year; and elevation 781.5, which is the elevation of an extreme flood. Exhibit RKLD-112 is based on the calibrated HEC-RAS hydraulic model, incorporating actual field discharge measurements of the wicket gates, as discussed in the memo entitled "Hydrologic and Hydraulic Modeling Updates Since January 2003 Hydraulic Report," attached as **Exhibit RKLD-113.**

Exhibit RKLD-112 illustrates that the gate capacity of the dam, as a percentage of overall capacity, decreases as water levels rise. At higher levels, the spillway represents a greater percentage of the dam's capacity to flow water. These bar graphs demonstrate the hydraulic limitations of wicket and slide gate operation orders in controlling water levels on Lake Koshkonong. For example, at lake elevation 777 ft. MSL, the total hydraulic capacity of Indianford Dam (2700 cfs) is dominated by the capacity of the operable gates. The wicket gates provide more than half of the total capacity, and the slide gates provide another 700 cfs. At elevation 777, the spillway has a relatively small depth of water overflowing its crest, and therefore the spillway discharge is relatively low. At this elevation, the majority of the hydraulic capacity of Indianford Dam is operable by opening and closing the wicket and slide gates.

In contrast, at Lake elevation 781.5 ft. MSL, most of the total hydraulic capacity (8900 cfs) is provided by the overflow spillway section. The capacity of the slide and wicket gates is actually less at this elevation than at Lake elevation 779. This is because at high discharge rates, the river water level downstream of the Dam rises so substantially that it reduces the capacity of both the wicket gates and the slide gates. During extreme flood events (such as those producing Lake Koshkonong water levels of approximately elevation 781.5), the operable capacity of the Dam is a small fraction of its total capacity. The relative discharges at lake Koshkonong elevation 779 show a similar, but less prononunced, shift in the operable vs. inoperable spillway capacity. The exhibit illustrates that at higher flood elevations, the water level of Lake Koshkonong is not as substantially affected by whether the gates were opened or closed as it is at lower flow conditions.

Q. Please describe the repair work done on the Dam, and summarize the effect of those repairs on the hydraulic capacity of the Dam.

A. Available records indicate that in the 1960s the wicket gates became inoperable, and the slide gates could only be operated using manual cranks. The progression of repairs to Indianford Dam, based on available records, is summarized as follows:

1983: Repair and reconstruction of the slide gates section at the east end of the Dam. These repairs restored operability to the slide gates, but some problems remained.

December 1999: Repair of the powerhouse building and the east wicket gate (previously stuck shut).

August 2002: Repair of the west wicket gate (previously stuck partially open).

December 2003: Repair of the slide gates, provision of slide gate deicing equipment, provision of portable electric gate actuators.

December 2005: Repair of powerhouse trash racks upstream of the wicket gates, which will improve the reliability of gate operation by control the entry of debris.

The most significant aspect of the repairs described above is that previous to 1999 the wicket gates were inoperable, whereas after August 2002 both wicket gates were fully operable via motor-driven actuators. Now that the wicket and slide gates are fully operable, the capacity of Indianford Dam at elevation 777 ft. MSL on Lake Koshkonong can be varied over a wide range, from approximately 400 cfs with all gates closed, to approximately 2700 cfs with all gates open. Data for Lake elevation 777 indicates the substantial effect that repair of the wicket gates have had on the total and operable capacity of Indianford Dam, and the ability of the Dam to regulate water levels on Lake Koshkonong under variable flow conditions. Prior to repair of the wicket gates, both the total capacity and the operable (or gated) capacity of the Dam was substantially lower.

Q. Please identify the information used to predict the effect of the District's requested modification to the Koshkonong water level order.

A. Information used to analyze the hydraulics of Indianford Dam and Lake Koshkonong to predict the effects of the District's requested water level changes included the following:

- USGS gaging station data
- Data from field observations of the Dam and Lake Koshkonong
- Indianford Dam operation records
- Field data collected on wicket gate hydraulic capacity conducted with the USGS in June 2005
- Data from earlier fieldwork, flood insurance study hydraulic models, USGS publications, repair plans for the Dam, and other data referenced in development of our 2003 hydraulic report.

Q. In your analysis of various options for modifying water levels on Lake Koshkonong, were you given specific directives by the District Board? Please explain.

A. Yes. The RKLD Board directed me to consider the effect any proposed water level operating regime would have on flooding and the ordinary high water mark ("OHWM") and to eliminate alternatives that would increase flooding, encroach the OHWM or result in any change to the OHWM.

Q. Did you conduct an analysis of the OHWM on Lake Koshkonong?

A. Yes. We conducted a joint OHWM study with DNR personnel in September 2001. Mike Halsted and Sue Josheff of DNR participated with Steve Hjort and me in the conduct of the OHWM study in the field. Survey of the marks determined to USGS elevations was accomplished by DNR and surveying staff from RSV Engineering, Inc. OHWM determinations were made, and corresponding OHWM elevations were obtained at 14 locations around Lake Koshkonong and in adjacent portions of the Rock River. The elevations of the OHWM observations ranged from 778.11 ft. MSL to 778.83 ft. MSL. Montgomery Associates assembled portions of the data and observation descriptions, and the report was issued by RSV Engineering. The results of that analysis are described in an OHWM study report dated November 18, 2002, issued by RSV Engineering, which is included in our January 2003 hydraulic analysis report (Exhibit DNR-39).

Q. Was the OHWM study taken into account in developing the District's proposed operating order? Please explain.

A. Yes. As we began work on evaluating potential water level modifications, the District requested that we identify a vertical allowance (it could be called a "buffer") sufficiently below the surveyed OHWM to protect private property. Our approach to estimating an appropriate buffer was to evaluate Lake Koshkonong wind/wave and wave run up conditions. We conducted the buffer distance analysis considering wave run up conditions on several different types of shoreline (including wetland, beach and riprap) using a wind speed exceedence frequency of 5%, which resulted in a wind speed of 20 mph. Several conservative assumptions were made in this analysis regarding shoreline slope, wind fetch, and other variables. Utilizing these assumptions, we estimated that limiting lake level changes to be below elevation of 770.0 ft. MSL was sufficient to maintain an ample buffer distance below the lowest surveyed OHWM (elevation 778.11) to protect against possible OHWM changes. This elevation, 777.0, MSL could be described as the “OHWM criteria elevation,” above which the Lake stage frequency statistics were to remain unaltered, with the objective of avoiding OHWM impacts.

Q. Did you attempt to predict changes to the OHWM as a consequence of the District’s proposed modification to the water level order?

A. No. We did not feel that it was possible to make such predictions. Rather, we used the OHWM study together with the buffer distance evaluation to establish the limits to which we felt comfortable in modifying the stage duration relationship of Lake Koshkonong. Our buffer elevation analysis has several levels of conservatism, including use of the lowest surveyed OHWM elevation and use of long wind fetch lengths. In my opinion, assumptions based on extreme conditions (such as those used in waterfront structure design) are not appropriate when one is trying to evaluate the "ordinary" conditions that are likely to produce an OHWM. Similarly, the inclusion of water level set-up based on unusually high and prolonged wind speeds may not be appropriate because this degree of set-up occurs only during a very low percentage of the time on Lake Koshkonong.

It is not appropriate to attempt to calculate OHWM elevations using a hydraulic analysis, because a wide variety of factors are involved in creating the OHWM on a particular shoreline. These factors prompt consideration of the observed height variation between surveyed OHWMs on the Lake Koshkonong shoreline. **Exhibit RKLD-114** shows the 14 surveyed points on an approximately northeast-southwest axis. Several of the points are on the open shoreline of Lake Koshkonong and are subject to wind, wave and set-up effects. However, several of the OHWM points are not subject to wind and wave effects, including the points in the Rock River outlet and inlets, and the two OHWM points taken at the location of the USGS Lake Koshkonong gage near Newville. As discussed previously, this gage is located on an excavated channel off the main body of Lake Koshkonong and is not subject to wind - wave action.

The two OHWMs recorded on the channel near the USGS gage are in the middle of the range of OHWM elevations recorded on Lake Koshkonong. They are not substantially below the range of OHWM elevations identified in the study, as might be expected if wind and wave action on "high energy" open shorelines was an important factor in the creating the OHWM. The maximum range of the observed high water mark elevations, regardless of location, is approximately 0.8 feet. If the appropriate buffer were arbitrarily assigned as the maximum difference in observed OHWMs regardless of location (a very conservative approach, considering the observations on the lake), this would suggest an operating regime with a maximum lake elevation that is higher than the District's proposed 777.0 feet maximum elevation.

Exhibit RKLD-114 also illustrates the surveyed OHWM points in relation to the District's and the DNR's proposed summer target elevations, as well as in relation to the typical and high Lake flood elevations. It is important to note that typical yearly flooding substantially exceeds the OHWM elevations, and typical low-flow lake levels, the subject of this operating order dispute, are substantially below the OHWM elevations.

Q. Have you evaluated the OHWM issue as it may affect reaches of the Rock River and its tributaries upstream from Lake Koshkonong?

A. Yes. We evaluated water level and OHWM elevations on the Rock River upstream of Lake Koshkonong. This survey is described in our memorandum "Survey of Tributary Water Levels and Estimated OHWM Elevations," included as **Exhibit RKLD-115**. We also evaluated observed OHWM elevations on Lake Koshkonong as an indicator of the sensitivity of the OHWM to shoreline characteristics, as described previously.

We evaluated the extent of low water upstream from Lake Koshkonong on July 13 and 14, 2005, when the discharge on the Rock River was very low. This survey indicated that "flat" water conditions extend up the Rock River to the Jefferson Dam, and also include portions of the Bark and Crawfish Rivers, among other tributaries. However, several tributaries appeared to have water surface elevations above those that could be impacted by increased Lake levels, including Ditch 39 at Lower Hebron Road. We also made initial OHWM determinations at selected sites on the Rock River tributaries. The conclusions of this survey are that the Rock River and several tributaries upstream of Lake Koshkonong have very flat gradients. However, OHWMs upstream of Lake Koshkonong are generally well above the OHWM elevations around Lake Koshkonong (Exhibit RKLD-114).

We conclude from this study that the Rock River above Lake Koshkonong does not require downward adjustment of the OHWM criteria elevation that we had established in the 2003 Report.

Q. Please summarize the District's requested water level changes.

A. RKLD has requested a water level order that specifies a maximum elevation for Lake Koshkonong of 777.0 ft. MSL, a minimum elevation of 776.4, and a target water surface elevation of 776.8. These water levels are proposed to be maintained throughout the year, with no distinction between summer and winter operating order conditions. The details of the District's proposed order are described in Exhibit DNR-5.

Q. Please describe the modeling used to analyze the proposed operating orders.

A. The approach taken in this testimony for evaluating the District's and the DNR's proposed water level orders is similar to the analysis described in our 2003 hydraulic analysis report (Exhibit DNR-39), and consists of two basic steps: 1) revision and recalibration of our hydraulic model, followed by 2) simulation of the water level response of Lake Koshkonong to the 1991 DNR order and the District's proposed order. Our work for this revised analysis includes several modifications made in response to comments from DNR staff and the addition of data not available in 2003 to improve the model's prediction accuracy. The process of revising and calibrating our hydraulic model is described in Exhibit RKLD-113.

Q. In updating the 2003 model, have you considered the critique presented in the Direct Testimony of DNR Engineer Sue Josheff?

A. Yes. In addition to other improvements to the HEC-RAS model described in Exhibit RKLD-113, we addressed Ms. Josheff's concerns regarding the calibration of the wicket gates and the flow record. We incorporated the direct calibration of wicket gate discharge capacity based upon a field data collection program conducted with USGS personnel in June 2005. This field data collection allowed us to model the wicket gates using a much higher degree of confidence than we had in our earlier modeling effort.

We also developed a revised long-term daily flow record in the model analysis, to reduce potential errors in the data from the USGS Indianford gage used in the 2003 model, the quality of which had been downgraded to "poor" by USGS. We evaluated several alternative means of constructing a long-term Lake Koshkonong Rock River inflow record and selected a flow record based on the USGS Rock River gaging station at Afton (near Janesville), accounting for additional discharge from increased watershed area by subtraction of flows from the Yahara River using the USGS Gage for the Yahara River at Fulton. These adjustments were incorporated into the HEC-RAS model, which was then recalibrated to provide best reproduction of the Lake Koshkonong stage for August 2002 through September 2005. These years were selected because the hydraulic characteristics of Indianford Dam were known with much more precision than was possible for the calibration work that we conducted as reported in our 2003 hydraulic report. (See Exhibit RKLD-113.) The calibration statistics for the revised model indicate that 95% of the modeled Lake Koshkonong stage data is within 0.2 feet of the actual stage measured by the USGS Lake Koshkonong gage.

Q. How did you analyze the 1991/2004 DNR order and the District's proposed order?

A. We analyzed the two orders using the calibrated hydraulic model, which we ran to simulate daily Lake Koshkonong Lake level under the respective orders for summer (May through October) operating conditions for July 1987 through September 2005. The details of the hydraulic analysis are described in the memorandum titled "HEC-RAS Analysis of 1991 DNR and RKLD Proposed Orders," attached as **Exhibit RKLD-116**.

The respective operating orders were simulated using a schedule of gate operations, which specifies the Lake Koshkonong water surface elevation that is used to trigger "gate open" and "gate closed" operation of the slide and wicket gates. For the 1991 DNR order, the gate opening and closing target elevations were centered around the target Lake stage of 776.20 feet MSL. The details of the gate opening and closing sequences are described in Exhibit RKLD-116, and are consistent with the recommendations described by Ms. Josheff in her direct testimony on this issue. For the District's proposed order, we used a similar approach, in that gate opening and closing control elevations were grouped slightly above and slightly below the District's proposed summer target elevation, which is 776.80 ft. MSL. We modeled the District's order having the first set of gates open at lake elevation 776.40 ft. MSL, and the last set of gates open at 776.90 ft. MSL, which is slightly below the District's proposed maximum Lake elevation. This procedure for specification of gate operation provides a consistent approach to modeling the effects of the two operating orders.

Modeled results are presented in two formats. Exhibit RKLD-116 includes graphical output for May-October of each year of the simulation, from 1987 through 2005. The plots show the water level recorded on the Lake Koshkonong gage for that year, together with the simulated water levels that would have occurred for that year for Dam operation under the 1991 DNR order and the District's proposed order. It is important to note that the water levels shown for Lake Koshkonong gage data for 1987 through 1999 represent lake level conditions that resulted from both wicket gates being inoperable. For the period from December 1999 through August 2002, one wicket gate was operable, and the other was still inoperable. After August 2002, both wicket gates and all of the slide gates at Indianford Dam have been operable.

Exhibit RKLD-116 also includes a stage-duration plot, which shows the Lake Koshkonong gage data and the projected stage duration for the two operating orders. As explained above, a stage-duration plot is a statistical/graphical technique that describes the percent of time (on the x-axis) that water levels are at or above the water level indicated on the y-axis. The lake level and duration do not correspond to particular months or days during the season, but rather to an average percent of time during the season

Q. Does your hydrologic and hydraulic modeling allow you to draw conclusions about the effects of the RKLD's proposal, in comparison to DNR's proposed order?

A. Yes. DNR's proposed summer minimum, maximum and target levels are the same as those in the operating order. These conclusions are illustrated by the stage-duration plot and year-by-year water level plots included in Exhibit RKLD-116. Also attached as **Exhibit RKLD-117** is a copy of the stage-duration plot, labeled to highlight the differences between the District's Petition and DNR proposed orders and historic water level conditions taken from gage readings between 1987-2005. **Exhibit RKLD-118** is a copy of the same plot, showing RKLD's and the DNR's respective target water levels. The major conclusions of our analysis are as follows:

a. *If the water level order remains unchanged, as DNR proposes, there will be a significant decrease in Lake Koshkonong summer water levels.* The DNR's proposed order, although it identical to the current summer order, will result in lower Lake Koshkonong water levels than those observed over the past 18 years for approximately 50% of the summer season, when water levels have been above approximately elevation 776.3 ft. MSL. The reduction in water levels produced by the 2005 proposed order is expected to be as much as approximately 0.5 feet, compared to historic levels.

The difference between the recorded 1987 through 2005 water levels on Lake Koshkonong (the blue line on the stage-duration plots) and the model results for the 1991 DNR order (red line) is primarily due to the fact that until recently, Indianford Dam has not been fully operable. If the 2005 proposed order is enforced, Lake Koshkonong stage will be significantly lower than had been observed prior to August 2002 (the date the Dam became fully functional). The 1991 DNR order will produce slightly higher water levels than those that have been observed under lowest flow conditions, which occur approximately 10% of the season. For the remaining 40% of the summer season, the DNR 1991 orders will produce water levels very similar to those that have occurred over the past 18 or more years.

b. *RKLD's proposed order will result in higher water levels than the DNR order for the bulk of the summer season.* The District's proposed order will produce water levels higher than those observed historically for approximately 70% of the season, when water levels have been below elevation 776.8 ft. MSL. During the time that the District's proposed orders result in higher water levels on Lake Koshkonong, the increased water level is typically 0.2 to 0.3 feet higher than historical conditions. RKLD's proposed order will produce slightly lower water levels than have been observed for the past 18 years for approximately 30% of the summer season, during times when existing water levels have been above approximately elevation 776.8 ft. MSL.

c. *Describing the difference in water surface elevations produced by the two operating orders as simply the difference between their target elevations is inaccurate.* The typical difference between the water surface elevations produced by the two orders is **not** the same as the difference in summer target elevations (0.6 feet). The two orders produce water surface elevations that are typically from 2.4 to 3.6 inches (0.2-0.3') apart for about 65% of the summer season. The maximum difference in water surface elevation between the two orders is approximately 0.5 feet. For the remainder of the season (during times of extremely low water conditions or moderate to high flood conditions), the two orders produce very similar water surface elevations on Lake Koshkonong.

d. *DNR's proposed order results in a more static pool elevation than the RKLD proposed order.* Lake water surface elevations will be more variable under RKLD's proposed order, whereas the water surface elevations will be a near-static pool for approximately 60% of the summer season under the DNR's proposed order.

e. *There is no meaningful difference in the effect of the District's and the DNR's proposed summer orders when Lake elevations are above 777.3 ft MSL.* Both orders produce similar results for Lake water surface elevations above approximately 777.3 ft. MSL.

Q. Please describe the differences between RKLD's and the DNR's proposed orders under your model for flood, drought and average flow years on Lake Koshkonong.

A. Review of the year-by-year output from the modeling analysis (included in Exhibit RKLD-116) indicates that for dry years (for example 1988, 2003 and 2005), the lake stage for both orders tends to converge. In these conditions when the discharge in the Rock River is low, the spillway elevation of Indianford Dam will gradually draw the Lake level down, even if the gates are closed. To the extent that any year on Lake Koshkonong could be characterized as "normal," looking at 1995, 1997, and 1998, lake stages produced by the two orders are approximately the same for elevations above approximately 777.3 ft. MSL. However, the District's proposed order produces higher water levels during times of lower discharge. For years of higher flow in the Rock River (for example 1983, 1996, 2000 and 2004), the modeled lake stage is the same for both orders during flood times. During times of lower flow, the District's proposed order produces higher stages than the 1991 DNR order.

Q. Does RKLD's requested water level order have an effect on flooding?

A. No. However, both orders will produce slightly lower flood elevation on Lake Koshkonong, due to the restored operable condition of the Indianford Dam gates.

Q. Does RKLD's requested water level order comply with the OHWM criteria elevation described previously?

A. Yes. RKLD's proposed order does not affect stage duration from that observed on Lake Koshkonong over the period 1987 to 2005 above 776.8 feet MSL, which meets the criteria discussed previously.

Q. Are there any limitations on the ability of the model to forecast future water levels?

A. Yes, to the extent that we are not able to forecast future water levels directly with this analysis approach, we have not simulated Rock River flows representative of possible future conditions. Our modeling is based on observed data for years 1987 through 2005. Our ability to describe our analysis results as representative of future conditions is dependent upon two key factors:

a. Flows in the Rock River having the same general hydrologic variability as has been observed in the previous 18 years. Our analysis indicating a lack of any significant trends in the water level of Lake Koshkonong or of flow in the Rock River suggests that flows remaining similar to those observed in the recent past are a reasonable expectation.

b. The hydraulic characteristics of the Indianford Dam remaining the same in the future. The recently completed repairs to Indianford Dam should provide long-term maintenance of the full operable capacity of the Dam. The District has the means and the regulatory responsibility to maintain the Dam and operate it in accordance with DNR orders. Therefore, it is reasonable to assume that Indianford Dam will retain its full operable capacity for the foreseeable future.

Q. Have you conducted a bathymetric analysis of Lake Koshkonong?

A. We have not conducted a full-scale bathymetric survey of Lake Koshkonong. That would require a very substantial survey effort. For purposes of this proceeding, we have collected all the survey data available to us to create a bathymetric projection map. The data utilized for this projection consists of: (1) The Lake survey map available from DNR, (2) survey data points obtained from several surveys, and field data to correct 3-foot depth contour locations shown on the DNR mapping. This data was integrated in a CADD system and a digital terrain model was developed to display contours at depths of 1-foot, 2-feet and 3-feet below the current order target elevation of 776.2. The results of our analysis are set forth in **Exhibit RKLD-120**, which shows the contours generated over a July 2005 aerial photograph of Lake. Exhibit RKLD-120a shows the 1, 2 and 3-foot contours on Lake Koshkonong. Exhibits RKLD-120b through 120d show enhanced detail of the Rock River inlet near Blackhawk Island and Stinker's Bay; Carcajou Point, and Thiebeau Point /Lautz Bay, respectively.

Q. Are the opinions in your testimony expressed to a reasonable degree of professional engineering certainty?

A. Yes.

Q. Does this conclude your direct testimony?

A. Yes.