Lake of the Ozarks Flood Levels

Ameren MISSOURI

Two significant floods in 2015 have caused many people to question whether anything has changed in how the Lake of the Ozarks (LOZ or Lake) levels are managed and whether that is resulting in more flooding on the Lake. The fact is that Lake level controls have changed and they can contribute to higher lake levels during flood events. This article will try to explain how levels are controlled and how floods are managed at the Lake of the Ozarks.

There are several main points that we will try to address:

- The Osage Plant guide curve is based on input from many stakeholders and has changed considerably over the years, resulting in higher average Lake levels. Higher average Lake levels will increase the peak Lake levels during floods.
- Bagnell Dam is not designed for any significant flood control, either upstream or downstream of the dam.
- Both Harry S. Truman (HST) Dam and Bagnell Dam must follow the operational rules established by the Federal Government when flood triggering thresholds are met.
- Major operational decisions during floods are not based on weather forecasting and inflow forecasting.

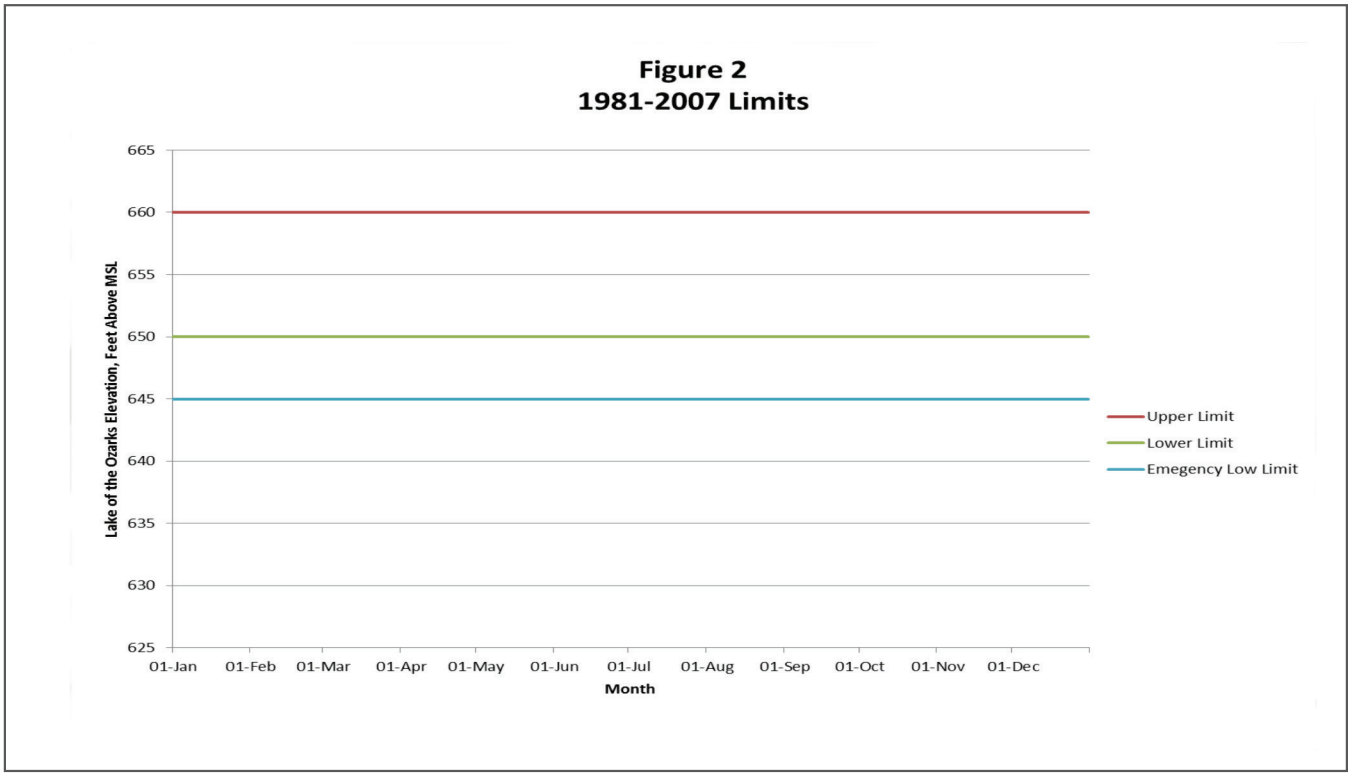
The Osage Plant guide curve and limits are based on input from many stakeholders and have increased Lake levels.

Upper and lower limits for the level of Lake of the Ozarks have always been included in the Federal Energy Regulatory Commission (FERC) license for the operation of the Osage Power Plant at Bagnell Dam. The Plant has also always utilized a Guide Curve for general use in establishing the Lake levels, although the Guide Curve was not included in the FERC License until the most recent License issued in 2007. Changes to the limits and guide curves have resulted in Lake levels averaging nearly 2.5 feet higher under the current license than they did during the 50 years of the first license.

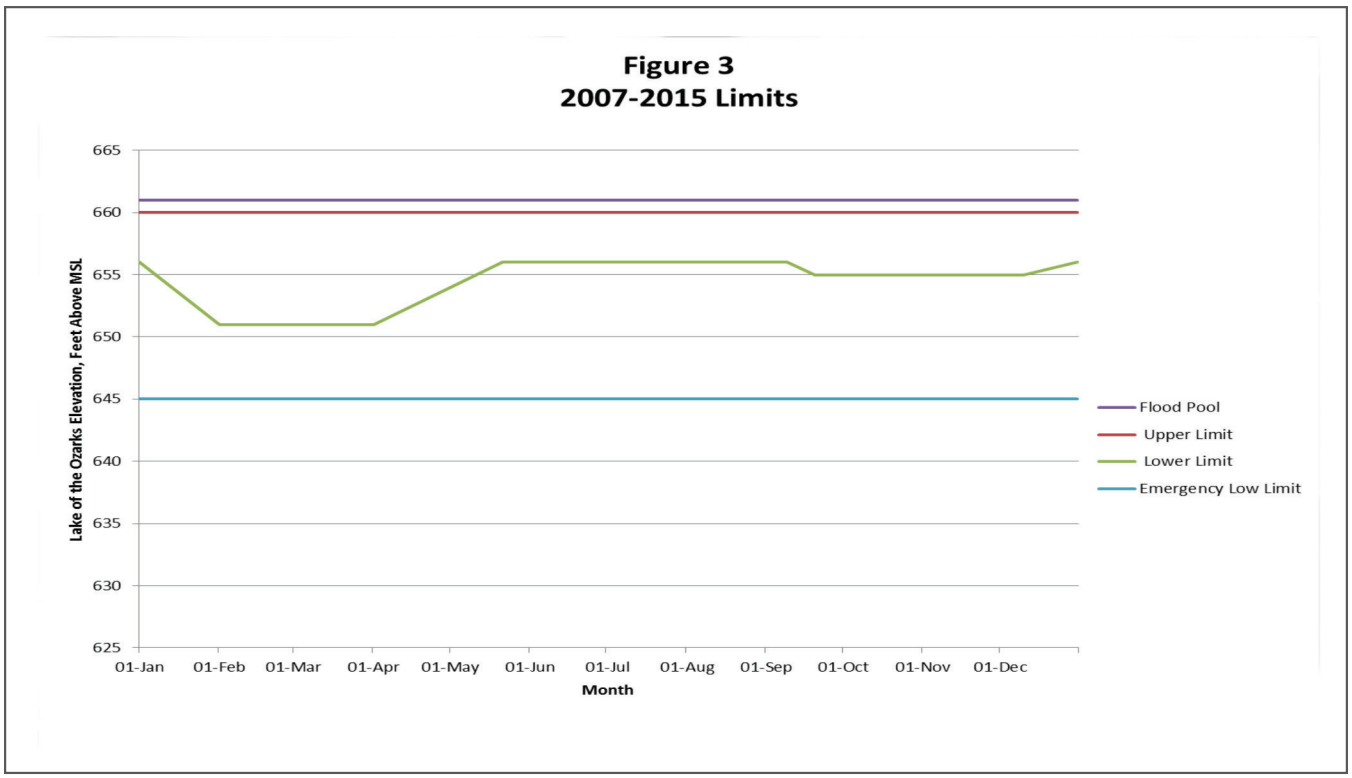
The first Federal Power Commission (predecessor to FERC) license issued in 1925 included a low level limit of 630', which was the value used in the design calculations for the electric power generating range to make the project feasible. The high level limit of 660' (the high level limit is the level at which the spill gates must begin to be opened) was not specified in the license but was used for operation of the Plant and Lake. During the first 10 years of operation, there were a considerable number of floods downstream. After the 1943 largest flood on record for LOZ, the Federal Power Commission (FPC) held several hearings regarding how the Lake level was being managed. Based on those hearings and considerable input from the Osage River Flood Control Association (ORFCA), the FPC then issued a new Order in 1947. An FPC Order is an official change to the license. This 1947 FPC Order made two significant changes. The first was to include an upper limit. The upper limit was lowered to 657' during the spring months of March, April, and May, with the limit not rising to 660'

until the first of July. (All Lake elevations specified in the FERC license and all of the operating rules are levels at Bagnell Dam. It is understood and recognized that elevations at other points on LOZ may be 5-10 feet higher than they are at the dam during flood events.) The second was to include a requirement to calculate a "natural flow" and to release water at the natural flow rate when above 50,000 CFS (Cubic Feet per Second) with the Lake rising. The natural flow is defined as the flow that would exist in the river downstream if Bagnell Dam was not in existence. The only time the plant can discharge higher than this natural flow calculation during a flood is if the Lake gets above 665', then we can release as much as necessary to stop the level increase to protect the integrity of the dam. These limits remained in effect throughout the remainder of the first license in 1981. These limits are depicted in **Figure 1** below.

Osage Plant received its second FERC license in 1981. This was right at the time that Truman Dam (and 5 other smaller dams upstream) had just been completed to provide the first major flood control for the Osage River basin. Truman Dam also included power generation capability and the ability to pump water back upstream from Lake of the Ozarks to Truman Reservoir. Based on these factors, the U. S. Army Corps of Engineers (USACE) became a major stakeholder in the second license. Based primarily on the USACE input, the LOZ limits underwent a significant change. The upper limit was increased to 660' year around since the added flood protection of 657' was no longer necessary. The lower limit was raised from 630' to 650' in order to support the suction head needed for Truman's pump back capability. A new emergency low limit was added at the request of Union Electric to cover any significant drought periods. While the Lake tourism and property owners were not yet a major stakeholder in the FERC licensing process, they obviously supported the effort to keep the Lake level higher throughout the year and to have less fluctuation in Lake levels. The "natural flow" requirement above 50,000 CFS discharge from the 1947 FPC Order was carried forward and a license requirement was added for coordination between the USACE and Union Electric in managing the flood flows on the Osage River. The limits from the second FERC license are depicted in **Figure 2**.



The third and current FERC license for the Osage Plant was issued in 2007. The Lake tourism and property owners had now become a significant stakeholder in the licensing process. Over 100 meetings were held with stakeholders over about a 5 year period. The current license carried forward the rules regarding natural flow discharges above 50,000 CFS (essentially between 660' and 665'), the 645' emergency low limit, and the 660' upper limit. The lower limit was once again raised, this time from 650' to 3' below the guide curve, effectively restricting even further the amount of fluctuation allowed in the Lake level. The guide curve was added to the license for the first time, but it was made very clear that it is not a rule curve. LOZ can be anywhere between the upper and lower limits, but the guide curve gives the public and plant operators a guideline for normal operations. The guide curve lowers to 654' in the spring months of March and April, but raises to 659' by Memorial Day, essentially filling the Lake one month earlier than allowed by the upper limit from the 1947 FPC Order. One other change was to add a "flood pool" from 660' to 661'. This flood pool was added as a minor protection for downstream property owners to minimize having to open spill gates if it is clear that the Lake will not go over 661' using the turbine generators to discharge the excess water. The current limits from the FERC license are depicted in **Figure 3**.



The continuing restriction on the amount of fluctuation allowed in Lake level, specifically on the low end, has resulted in increasing the average Lake level throughout the year. While the guide curve has always been used, it has changed with each new license based on the tightening limits from the license. **Figure 4** shows a representative guide curve for each of the license periods. The average Lake level increased about 2' from the first to the second license and it has increased about another 0.5' with the current license. **Figure 5** shows the average Lake level for each of the three license periods.

Figure 4
Guide Curves

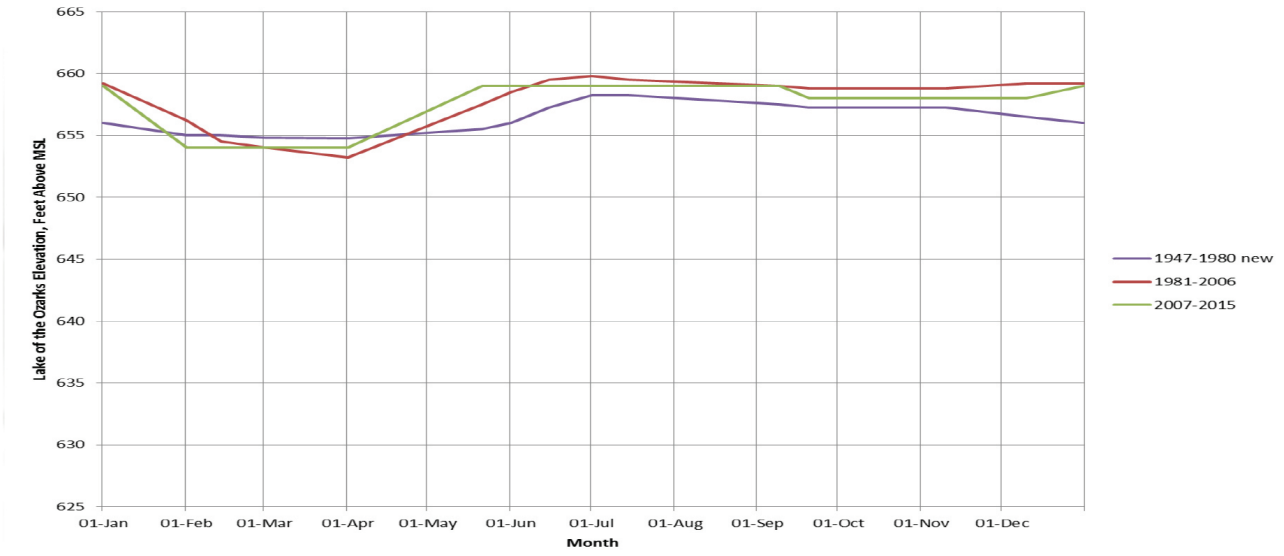
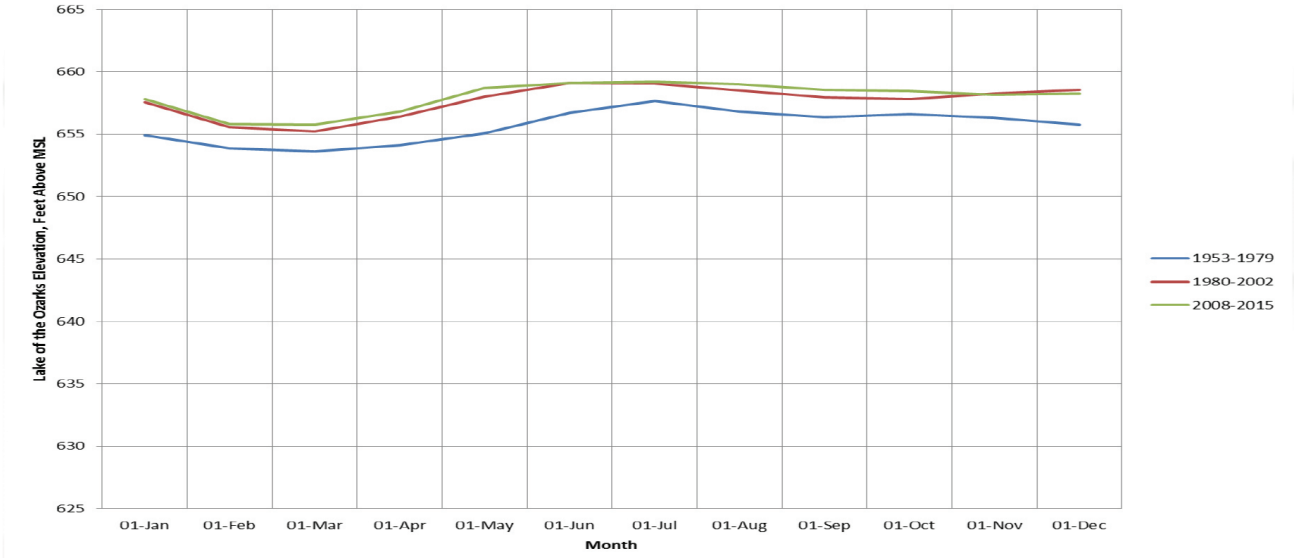


Figure 5
Average Lake Level by Month



With the average Lake level about 2.5" higher throughout the year now as compared to the first 50 years of operation, it should not come as a surprise to anyone that Lake levels during significant flood events are higher than they were historically. This can be seen when you compare the highest Lake level events with the highest Osage River flow events. As seen in the list of **Figure 6**, the two events in 2015 were ranked 5th and 8th in highest Lake levels, but only ranked 10th and 22nd in highest flow events.

Figure 6: Lake of the Ozarks Highest Levels and Discharge Flows

Rank by Highest Lake Level	Lake Level at Dam	Date	Highest Discharge	Rank by Flow
1	665.45	May-43	212,000	1
2	664.41	Jul-51	125,000	4
3	664.31	Oct-86	105,000	9
4	663.9	Aug-46	93,100	14
5	663.83	Dec-15	102,000	10
6	663.32	May-61	169,000	2
7	663.08	Jun-48	99,000	11
8	662.55	Jul-15	77,000	22
9	662.48	Jun-42	89,700	18
10	662.42	Oct-41	139,000	3
	660.08	Jul-35	114,000	6
	661.91	Apr-41	116,200	5
	661.53	Apr-94	108,000	7
	661.78	Apr-45	105,000	8
	661.85	Apr-73	98,400	12
	661.78	Apr-47	97,000	13
	661.46	May-44	92,600	15
	661.8	May-70	91,900	16
	661.91	Mar-74	90,400	17
	661.75	Jul-58	84,500	19
	661.75	May-90	80,000	20
	660.95	May-95	80,000	20

Discharge is Daily Mean Discharge in Cubic Feet per Second (CFS)

An interesting note is that 6 of the above high flow events occurred during World War II from 1940-1945. During that period, Union Electric intentionally kept the Lake very full in order to always provide the maximum electric generation capability in order to support the War effort for manufacturing in the St. Louis area. This again indicates that the higher level the Lake is maintained at, the higher potential to reach high flood levels.

In conclusion, during the most recent FERC Licensing process, the Lake property owners and tourism industry stakeholders asked for tighter limits on the Lake level fluctuations and to maintain the Lake at higher elevations to support the recreation industry. Changes to the guide curve and operating limits included in the FERC license has resulted in higher average Lake levels during much of the year. These higher average Lake levels will continue to result in higher peak Lake levels during flood events resulting from major rains downstream of Truman Dam.

Bagnell Dam is not designed for any significant flood control.

When Bagnell Dam was designed and built in 1929, the primary project purpose was electrical power generation. Recreation and flood control were not major considerations. While the Lake could fluctuate from 630' to 660', this was done for electric generation purposes, not flood protection. After the 1935 flood, it was recognized that keeping the Lake steady by trying to match discharge flows to inflow caused downstream flooding to be worse than it would have been if the dam were not there. This was due to the loss of the valley storage from the natural river valley. This realization resulted in the 1947 FPC Order to pass "natural flows". The natural flows action better balanced the impact of flooding between the Lake and the Osage River downstream. To provide any significant flood protection, the Lake of the Ozarks would have to be able to fluctuate 20-30 feet. While this was possible during the early years, it obviously is no longer feasible to support the Lake property owners and the tourism industry.

Truman Dam was constructed immediately upstream of LOZ to provide flood control that Bagnell Dam could not provide. If Bagnell could have provided significant flood control, Truman may not have ever been built. Truman also has multiple purposes, but their primary purpose is flood control. HST is capable of storing two complete volumes of the LOZ above the normal full pool level of HST. In 1981, after HST was constructed to provide substantial flood storage, the guide curves and upper/lower limits for Lake of the Ozarks were revised to rebalance recreation, flood control, power production and environmental concerns. The combined effect of the construction of HST and the changes to the LOZ limits is to significantly enhance flood protection for both LOZ and the Osage River, but the changes did reduce the flood control capability of Bagnell Dam for rains downstream of Truman.

Ameren and the USACE have a coordinated operation agreement called the Memorandum of Agreement (MOA). This MOA obligates both parties to operate in a manner to mitigate flood impacts. The coordinated effort aims to balance the impacts of floods between Truman reservoir, LOZ, the Osage River, and the Missouri River.

Both HST and Bagnell must follow the operational rules established by the Federal Government when flood triggering thresholds are met.

The USACE has a Lake Regulation Manual for Harry S Truman Reservoir that mandates releases when level is in the flood storage ranges. Their release criteria are based on levels in Truman Reservoir and stages (flowrates) in the Osage and Missouri Rivers downstream. The general objectives for regulation of the flood control storage at HST are to evacuate the water accumulated in the exclusive flood control storage space as rapidly as downstream channel capacities and flow conditions permit. The flood control space is to be maintained empty, to the extent practicable, for the purpose of storing future flood inflows as they occur. To accomplish this objective, the required discharges from Truman at various lake levels are:

Truman Level	Osage River level at St. Thomas
<706'	No required level
706-717'	<34,000 CFS
717'-735.5'	<54,000 CFS
735.5'-739.6'	<80,000 CFS

The only deviation from the above flows is when the Missouri River at Hermann reaches 260,000 CFS and is still increasing, then Truman can shut off completely until the Missouri River crests.

Ameren operates the Lake of the Ozarks per their license from FERC. On rising Lake levels above 660' but below 665', Ameren must discharge the "natural flow" that would exist in the river if Bagnell Dam were not there. The natural flow calculation is based on Truman and Bagnell discharge rates and LOZ level changes over a period of time, not to exceed 6 hour intervals.

Both the USACE and the Ameren rules are intended to balance the impact of the floods between the upstream and downstream property owners and stakeholders. In both cases, the rules are established after multiple years of studies and inputs from all stakeholders. Once the rules are established, neither the USACE nor Ameren have the authority to deviate from the prescribed releases. Flows cannot be reduced to protect the lower river and flows cannot be increased to protect the reservoirs. The only exceptions are once the reservoirs reach a level that could challenge the integrity of their dams (739.6' for Truman and 665' for LOZ). At these levels, both entities can go to maximum discharge to keep the lakes from rising any further.

Major Operational decisions are not based on weather forecasting and inflow forecasting.

Ameren and the USACE coordinate with the National Weather Service (NWS) at least daily during routine operations and multiple times a day during heavy rain events. During routine operations, when neither LOZ nor Truman is above flood levels, we can use weather forecasts to make adjustments to our discharges as appropriate. However, once a lake goes above flood level (LOZ above 660' or Truman above 706'), we must manage the flood waters per our operating manuals. During flood conditions, both operating manuals are based on actual lake levels, not forecasts of rain. We use the forecasts to help prepare and plan for what is coming, but not to actually adjust discharge flows during floods.

Keep in mind, to make several feet of changes in LOZ level would mean that either upstream or downstream property owners are going to suffer actual impact. Either Truman will have to flood additional land by holding back extra water or Bagnell Dam will have to discharge larger flows onto the Osage River property owners to draw down LOZ. Imposing these actual impacts based purely on forecasts is not deemed appropriate. While the NWS forecasts continue to get more and more accurate, they still have limitations. To make any significant impact on flooding, major changes in flows would have to be taken at least 5 to 7 days in advance. While the 5 day forecasts have proven to be fairly accurate in the total amount of precipitation to occur in that window, they do not so accurately depict how fast the rain will come on any given day or exactly what the boundaries of the rain storm will be.

The forecast for the December rainfall showed the area below Truman Dam was to receive 4-7 inches of rain. The actual observed amounts were 7-9 inches. The 48 hour forecast for the July, 2015 flooding event showed the area below Truman would recieve 1.5-3 inches of rain but actually received over 9 inches of rain in this two day period.

If we reacted to 5 or 7 day forecasts, we would have to fluctuate the LOZ levels by three or four feet frequently. At times this could result in draining water from the Lake and then the storm move out of our drainage basin, leaving the LOZ low for several weeks or even months. This could have significant impact on the tourism industry at LOZ.

The final point is to recognize the significance of the amount of rain actually received in the July and December, 2015 flood events. Both events were preceded by several weeks of heavy rains, saturating the soils and putting Truman into its flood pool and required higher discharges from the flood pool. As discussed earlier, it is not possible to make major changes in LOZ level when Truman is having heavy discharges from their flood pool. Truman and Osage Plant had heavy discharges throughout June and December attempting to evacuate the already stored flood waters as rapidly as possible to prepare for additional rains to come. To have lowered LOZ level by any substantial amount would have meant holding back already stored water in Truman based only on a projection of rains to come.

Both events occurred due to record rainfalls. On July 2, Springfield received 1.58" of rain, breaking the old record of 1.5" on that day. On July 1, the Lake of the Ozarks received over 5 inches of rain on parts of the Lake. December 26 and 27 were both new record rainfall amounts for those days in Springfield. The 6.03" received on December 26 shattered the old record of 3.06". The monthly rainfall in December set new records for Springfield, Joplin, Vichy, and St. Louis. December 26 and 28 were new record rainfall amounts for those days in St. Louis, as well as the highest rainfall for any December day in St. Louis. In fact, December 26 was the third wettest day ever recorded in St. Louis, for any time of the year. The December rain was wide spread across all of southern Missouri, resulting in 20 deaths across Missouri and Illinois. This was unprecedented rainfall for December in Missouri.

Website:
AmerenMissouri.com/Lake

Important Phone Numbers:

Lake Protection Hot Line
1.573.365.9203

Lake Level
1.573.365.9205

Adopt-the-Shoreline
1.573.365.9252

Missouri State Highway Patrol
1.573.751.3313

Water Patrol Division
(Non-Emergency)
1.573.751.3313

Benton County
(Emergency Management)
1.660.438.8412

Camden County
(Planning & Zoning)
1.573.346.4440

Miller County
(County Commission)
1.573.369.1900

Morgan County
(County Commission)
1.573.378.4643

Shoreline Management Staff is here to assist you with your next Lakeside project and to help answer your questions about Ameren Missouri's role at the Lake:

Osage Arm –
Bagnell Dam to 16-mile marker and Gravois Arm
Josh Friedrich **1.573.365.9247**
Chris Korsmeyer **1.573.365.9209**

Osage Arm –
16-mile marker to 32-mile marker, and the Niangua's and Glaize Arms
Chuck Van Bebber **1.573.365.9215**

Osage Arm –
32-mile marker to Truman Dam
Joe Daly **1.573.365.9207**

Commercial docks and docks larger than 3,000 square feet
Heidi Shewmaker **1.573.365.9216**

Dredging, wetlands, shoreline vegetation or other environmental questions
Bryan Vance **1.573.365.9252**
Georganne Bowman **1.573.365.9217**

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