



CITY OF ST. LOUIS
**PLANNING & URBAN
DESIGN AGENCY**

FRANCIS G. SLAY, Mayor

PDA-155-04-CMP

To: City of St. Louis Planning Commission

From: Don Roe

Subject: Amendment of the Strategic Land Use Plan (2005) of the St. Louis Comprehensive Plan
(Amendment #15 -- Lighthouse Saint Louis)

Date: January 29, 2016

Executive Summary

The Presentation and Public Hearing for proposed Amendment #15 of the Strategic Land Use Plan (SLUP) of the St. Louis Comprehensive Plan was held at the January 6, 2016 Planning Commission meeting. The public review period opened on December 15, 2015 and ended on January 20, 2016. Review comments and questions from two persons were received after the Public Hearing and are addressed in this resolution.

The proposed amendment is based on a proposed development of a large, unique riverfront site located at the northern tip of the City. The approximately 84-acre site consists of three parcels and is generally bounded by the City Limits, the Mississippi River, Interstate 270 and Riverview Dr. The site currently consists of vacant land. It was most recently used as a golf course. The site was heavily damaged by major floods during the 1990's. The current owner raised the site out of the 100-year flood plain by the addition of more than 10 feet of clean fill, pursuant to a Section 404 permit from the U.S. Army Corps of Engineers. Approval of the SLUP amendment, and a subsequent zoning change for the site, would facilitate the development of Lighthouse Saint Louis, a multi-phase, mixed-use development project with a development cost of up to \$300 million.

The proposed development project would be in conflict with the existing SLUP. SLUP Amendment #15 proposes changing the existing Recreational/Open Space Preservation and Development Area (ROSPDA) Strategic Land Use Category for two of the three site's parcels in the City -- 11050 Riverview Dr. and 11110-80 Riverview Dr. -- to the Specialty Mixed Use Area (SMUA) Strategic



Land Use Category. (The site's third parcel -- 11190 Riverview Dr. -- would retain its existing ROSPDA designation, as the parcel would not be developed and would remain vacant land.)

Recommended Action

That the Planning Commission **adopts and approves Amendment #15 of the Strategic Land Use Plan of the St. Louis Comprehensive Plan.**

Background

The Strategic Land Use Plan (SLUP) was initially adopted on January 5, 2005 and has been amended subsequently as part of the St. Louis Comprehensive Plan. Section 3.48.100.A of the St. Louis City Revised Code provides that “the adoption of a Comprehensive Plan or of any part, amendment, revision, extension or addition shall be by resolution of the Planning Commission carried by the affirmative votes of a majority of all the members of the Planning Commission at a regular or special meeting thereof.” Prior to adoption or amendment, the Planning Commission shall conduct a public hearing as part of the review and approval process. Adoption and all amendments to the SLUP have been implemented according to procedures required by City Code and Section 89.360 RSMo. (2000).

The attached Exhibit “A” document provides background information and recommendations for the proposed SLUP amendment. This document has been available for public review on PDA’s website (<http://www.stlouis-mo.gov/planning>) from December 15, 2015 through January 20, 2016.

- Proposed Strategic Land Use Plan Amendment #15 is a proposal to amend the City’s Strategic Land Use Plan (SLUP) of the St. Louis Comprehensive Plan for a large unique site located at the northern tip of the City in the Riverview neighborhood.
- Proposed SLUP Amendment #15 is based on a proposed development of a large riverfront site generally bounded by the City Limits, the Mississippi River, Interstate 270 and Riverview Dr. The site currently consists of vacant land. It was most recently used as a golf course. The site was heavily damaged by major floods during the 1990’s. As documented by the Federal Emergency Management Agency (FEMA), the current owner of the site raised the site out of the 100-year flood plain by the addition of more than 10 feet of clean fill, pursuant to a U.S. Army Corps of Engineers Section 404 permit. As a condition of approval of the permit, the owner is obligated to create 2.5 acres of off-site wetlands in Godfrey Township, Illinois to mitigate the loss of wetlands on the site.
- The proposed Lighthouse Saint Louis development is approximately 84 acres in size and includes three parcels located in Out Lot 121: 11050 Riverview Dr., 11110-80 Riverview Dr. and 11190 Riverview Dr. The first two parcels (comprising approximately 70 acres) are owned by BBN, LLC and would be developed as part of the Lighthouse Saint Louis development. The third parcel (approximately 14 acres) is located in two jurisdictions -- the City of St. Louis (3.5 acres) and unincorporated St. Louis County (10.5 acres) -- and is owned by Massman Construction Co. This parcel -- although technically part of the Lighthouse Saint Louis development -- would be leased from the owner to the developer, but it would not be developed. It would remain vacant land and serve as a buffer to the nearby environmentally-sensitive Watkins Creek. (See the attached aerial photo of the site and vicinity.)

- Approval of the SLUP amendment would facilitate the development of Lighthouse Saint Louis, a multi-phase, mixed-use development project with a development cost of up to \$300 million. The developer is Lighthouse Development, LLC. The proposed development project would include retail, residential, hotel and recreational uses and amenities. The retail uses range from a gas station/convenience store to a large-scale retail store. The residential and hotel uses would be sited to take advantage of riverfront views. The proposed recreational uses and amenities include a visitor center, a lighthouse, a boardwalk, a riverwalk, a marina (that would include kayaking and canoeing) and a bicycle path and trailhead -- all of which would take advantage of the riverfront site's natural features. The bicycle trailhead would link to Great Rivers Greenway's Old Chain of Rocks Bridge and the Mississippi River Greenway through a dedicated passage under Interstate 270. Major infrastructure improvements would include the construction of the interior road system, access road improvements and the installation of all necessary utilities. A concept site plan of the proposed development project (provided by the development team) is included in Exhibit "A". As stated, the site plan is conceptual in nature and subject to change.

Presentation and Public Hearing, and Subsequent Review Comments

The Presentation and Public Hearing for proposed Amendment #15 of the Strategic Land Use Plan (SLUP) of the St. Louis Comprehensive Plan was held at the January 6, 2016 Planning Commission meeting. The public review period opened on December 15, 2015 and ended on January 20, 2016. Presentations were made by PDA staff and William Kuehling, of Thompson Coburn LLP, who was representing the Lighthouse Saint Louis development project. Also present were the developer -- Adam Hartig, of Lighthouse Development, LLC -- and one of the property owners -- Mark Repking, of BBN, LLC. Several questions were asked by Planning Commission members. No one appeared during the Public Hearing to make comments or answer questions.

However, review comments and questions from two persons were received via e-mail after the Public Hearing. Libby Reuter, a City resident, referenced a stone dike in the river, and asked several questions, some of which are technical issues related to the river, and some of which relate to public access to the river. Professor Robert E. Criss, of Washington University, strongly opposes the proposed development and the amendment. Copies of these review comments and questions are attached as Exhibit "B".

Representatives of the Lighthouse Saint Louis development project were offered the opportunity to respond to these comments. A memorandum from William Kuehling addresses these comments and questions. A copy of this memorandum is attached as Exhibit "C".

Recommendations

The proposed Lighthouse Saint Louis development project would be in conflict with the existing SLUP map. The SLUP designates all three parcels within the City limits as Recreational/Open Space Preservation and Development Area (ROSPDA). The ROSPDA Strategic Land Use Category is defined as: *"Areas including the existing network of parks, open space and recreational facilities within the City that should be preserved and enhanced, as well as locations for new permanent green space, including planned new greenways and permanent locations for some community gardens. ..."* Thus, the SLUP would need to be amended in order for the development project to proceed.

The proposed amendment of the City's SLUP from the ROSPDA Strategic Land Use Category to a designation allowing commercial development would still allow the construction of a number of recreational uses and amenities that are proposed to be built as part of the Lighthouse Saint Louis development project. If constructed, the visitor center, lighthouse, boardwalk, riverwalk, marina and bicycle path and trailhead would provide relatively rare recreational amenities and access for residents of the City of St. Louis, St. Louis County and the St. Louis metropolitan area to enjoy the Mississippi River and the riverfront, including the proposed extension of the Mississippi River Greenway.

SLUP Amendment #15 proposes changing the existing ROSPDA Strategic Land Use Category for two of the three parcels in the City -- 11050 Riverview Dr. and 11110-80 Riverview Dr. -- to Specialty Mixed Use Area (SMUA). The SMUA Strategic Land Use Category is defined as: *"Areas like Downtown where it is intended that a unique mix of uses be preserved and developed."* This designation would accommodate the various uses proposed by the Lighthouse Saint Louis development project, including the recreational uses and amenities. (The third parcel, 11190 Riverview Dr., would retain its ROSPDA designation, as the parcel would not be developed and remain vacant land.) Maps of the existing SLUP and proposed SLUP Amendment #15 are shown on the following page.

In addition, this change would further the City's adopted Sustainability Plan by implementing the following stated strategies in the Sustainability Plan:

- Increase riverfront development and provide safe public access and associated recreational activities
- Celebrate and increase activity along the Mississippi Riverfront
- Remove/change infrastructure to improve riverfront access
- Leverage the Mississippi River as an inexpensive transportation, drinking water, and recreation resource.

While any riverfront development project is certainly deserving of scrutiny in light of previous and recent flooding in the St. Louis area, the proposed development project would provide recreational uses and amenities that may not be realized otherwise at this unique site. Thus, PDA staff is recommending approval of SLUP Amendment #15.

If the SLUP amendment is approved, a zoning change for the site would be presented to the Planning Commission for its review in the coming months, as the existing zoning -- "A" Single-Family Dwelling District -- does not allow most, if not all, of the uses proposed by the development project. The zoning change may be the establishment of a form-based district, a zoning overlay district that could help to ensure a high-quality development for a unique site.

Table of Strategic Land Use Map Changes -- Amendment #15

Description of Area or Project	Neighborhood Name	Nbr #	City Block #	Current SLUP	Proposed SLUP
Lighthouse Saint Louis	Riverview	75	Out Lot 121	ROSPDA	SMUA

Existing Strategic Land Use Plan



Proposed Strategic Land Use Plan Amendment #15



Please note that larger-scale versions of the above maps are shown in Exhibit "A".

Comments

If SLUP Amendment #15 is approved, all approved items will be placed in the Planning Commission files, and the City's computer-based Geographic Information System (GIS) will be updated with the changes. Notification of Amendment #15 of the SLUP map will be certified by the Chairman and conveyed, as required by City Code and Missouri statute, in keeping with changes to the Comprehensive Plan for the City of St. Louis, to the following City entities: the Board of Aldermen, the City Register, and the Recorder of Deeds, along with a complete set of prior amendments, the original document, and an updated map of the entire City which reflects all the amendments.

PDA promotes the use of the Strategic Land Use Plan of the St. Louis Comprehensive Plan as a citywide document and the published printed maps have stimulated much discussion as a tool that depicts the urban character of areas of the City and also shows areas with opportunities for various types of investment.

SLUP information is available on PDA's website. The printed version directs one to the website for updates. The website allows people to zoom in to view specific areas of the City, as viewing the entire City is difficult on the computer. This update will make close-in views accurate and up to date. Printed map copies are available for a fee.

Requested Action

That the Planning Commission **adopts and approves Amendment #15 of the Strategic Land Use Plan of the St. Louis Comprehensive Plan** -- as shown on the table and map -- inclusive of all prior amendments.

NOW, HAVING COMPLIED WITH ALL PROCEDURAL REQUIREMENTS, THEREFORE, BE IT RESOLVED BY THE CITY OF ST. LOUIS PLANNING COMMISSION AS FOLLOWS:

1. All prior amended versions of the Strategic Land Use Plan are ratified.
2. Having conducted a Public Hearing, Amendment #15 of the Strategic Land Use Plan of the St. Louis Comprehensive Plan -- as shown on the table and map -- is hereby adopted and approved.
3. The Director of Planning of the Planning and Urban Design Agency is hereby directed to seek and affix the signature of the Chairman of the Planning Commission to the relevant materials as certification of action and of the copies and distribute copies of the materials to the Board of Alderman, the City Register, the Recorder of Deeds and make any other required notifications or filings of this amendment as a part of the Strategic Land Use Plan.

Exhibit A

Proposed Amendment #15 of the Strategic Land Use Plan (SLUP) of the St. Louis Comprehensive Plan

The City of St. Louis Planning Commission is holding a Presentation and Public Hearing regarding Amendment #15 of the Strategic Land Use Plan (SLUP) of the St. Louis Comprehensive Plan at its regular meeting on Wednesday, January 6, 2016 at 5:30 p.m. at 1520 Market St., Suite 2000.

Proposed Strategic Land Use Plan Amendment #15 is a proposal to amend the City's Strategic Land Use Plan of the St. Louis Comprehensive Plan for a large unique site located at the northern tip of the City in the Riverview neighborhood.

The SLUP is the City's general land use plan that covers the entire City. It categorizes each city block into one (sometimes more) broad land use/development category, known as a Strategic Land Use Category.

A table summarizing the proposed changes for the designated area is shown below. Background information and recommendations for the proposed land use changes are also provided.

Written and oral comments on proposed SLUP Amendment #15 can be made at the Public Hearing. Comments also can be made prior to or after the hearing (through Wednesday, January 20, 2016) in care of Roman Kordal by e-mail at kordalr@stlouis-mo.gov, by mail at Roman Kordal, City of St. Louis Planning and Urban Design Agency, 1520 Market St., Suite 2000, St. Louis, MO 63103, or by fax at 314-613-7014. These comments will be forwarded to the Planning Commission for its review before a vote to adopt the proposed amendment is held at its regular meeting on Wednesday, February 3, 2016 at 5:30 p.m. at 1520 Market St., Suite 2000. For further information, please contact Roman Kordal at 314-657-3872.

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Description of Area or Project	Neighborhood Name	Nbr #	City Block #	Current SLUP	Proposed SLUP
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Proposed SLUP Amendment #15
Lighthouse Saint Louis
Background Information and Recommendations

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Proposed SLUP Amendment #15 is based on a proposed development of a large riverfront site generally bounded by the City limits, the Mississippi River, Interstate 270 and Riverview Dr. The site currently consists of vacant land. It was most recently used as a golf course. The site was heavily damaged by major floods during the 1990's. As documented by the Federal Emergency Management Agency (FEMA), the current owner of the site raised the site out of the 100-year floodplain by the addition of more than 10 feet of clean fill, pursuant to a U.S. Army Corps of Engineers Section 404 permit. As a condition of approval of the permit, the owner is obligated to create 2.5 acres of off-site wetlands in Godfrey Township, Illinois to mitigate the loss of wetlands on the site.

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Greenway's Old Chain of Rocks Bridge and the Mississippi River Greenway through a dedicated passage under Interstate 270. Major infrastructure improvements would include the construction of the interior road system, access road improvements and the installation of all necessary utilities. A concept site plan of the proposed development project (provided by the development team) is attached. As stated, the site plan is conceptual in nature and subject to change.

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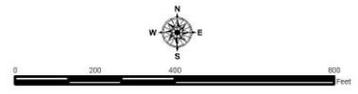
- Leverage the Mississippi River as an inexpensive transportation, drinking water, and recreation resource

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Aerial Photo (2014)



-  Lighthouse Saint Louis
-  Parcel Lines
-  St. Louis City Limits
-  Interstate Highway





SMS Sheppard, Morgan & Schwab, Inc.
CONSULTING ENGINEERS AND LAND SURVEYORS
ENGINEERS

CONCEPT SITE PLAN #02
Highway I-270 & Riverview Drive
St. Louis, Missouri 63138
Date: DECEMBER 14th, 2015

Lighthouse Development, LLC
12533 Bonyoyal Drive
St. Louis, MO 63138
573-585-9277 / 793-9316

T.H. HOOPER, L.L.C.
ARCHITECTS
12533 Bonyoyal Drive
St. Louis, MO 63138
573-585-9277 / 793-9316

CS-2

Lighthouse Saint Louis

A Riverfront Development

Existing Strategic Land Use Plan



 Lighthouse Saint Louis

Strategic Land Use Categories

- | | |
|--|---|
|  Neighborhood Preservation Area |  Business/ Industrial Preservation Area |
|  Neighborhood Development Area |  Business/ Industrial Development Area |
|  Neighborhood Commercial Area |  Institutional Preservation and Development Area |
|  Regional Commercial Area |  Specialty Mixed Use Area |
|  Recreational/ Open Space Preservation and Development Area |  Opportunity Area |



CITY OF ST. LOUIS
PLANNING
 & URBAN DESIGN
 AGENCY

Proposed Strategic Land Use Plan Amendment #15



- Lighthouse Saint Louis
 - Change from ROSPDA to SMUA
- Strategic Land Use Categories**
- | | |
|--|--|
| <ul style="list-style-type: none"> Neighborhood Preservation Area Neighborhood Development Area Neighborhood Commercial Area Regional Commercial Area Recreational/ Open Space Preservation and Development Area | <ul style="list-style-type: none"> Business/ Industrial Preservation Area Business/ Industrial Development Area Institutional Preservation and Development Area Specialty Mixed Use Area Opportunity Area |
|--|--|









EXHIBIT B

Kordal, Roman <kordalr@stlouis-mo.gov>

Proposed Amendment #15 Lighthouse at # 270

1 message

Libby Reuter <libbyreuterwc@gmail.com>

Thu, Jan 7, 2016 at 7:04 PM

Reply-To: "libby. reuter" <libby.reuter@charter.net>

To: kordalr@stlouis-mo.gov

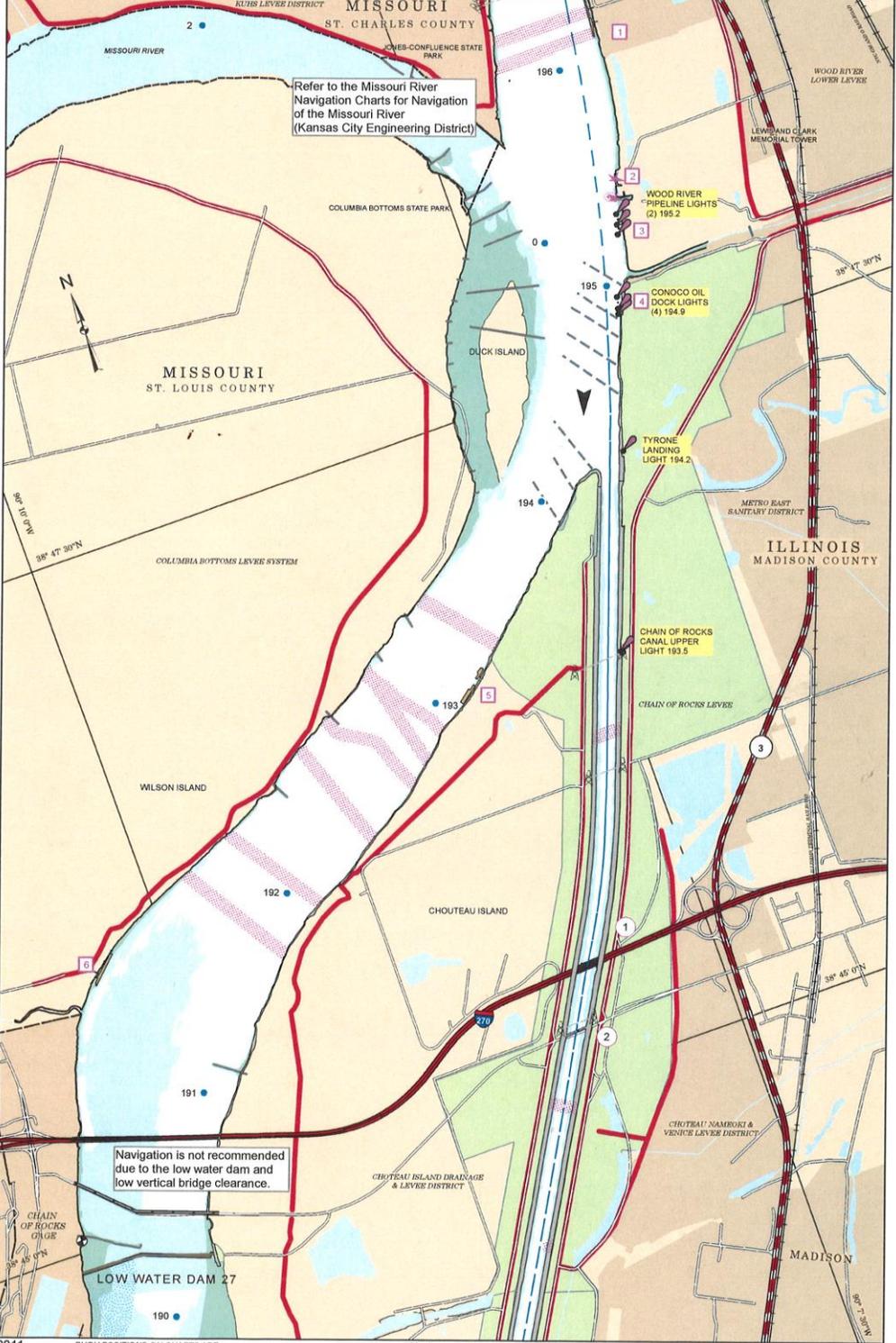
Cc: Brad Walker <bwalker@moenviron.org>, "libby. reuter" <libby.reuter@charter.net>

As a St. Louis resident interested in St. Louis' place at the heart of the Mississippi River watershed, I support creating new ways that people can connect with the river as a recreational and clean water resource. The Lighthouse development and the proposed amendment to the St. Louis Strategic Land Use Plan prompts a few questions about how this development will help the city meet its goals for sustainable development.

The Lighthouse plan includes a stone dike in the river. The Army Corps of Engineer's Upper Mississippi River Chart #26 (attached) doesn't show an existing dike. Has this been studied by a fluvial geomorphologist to determine what effect this river-training structure will have on river current? What is the potential for damage to the St. Louis city facilities down-river? After the recent floods, I wonder if this with this change in the direction of the river's flow, the nearby City of St. Louis's water treatment plant could be negatively impacted during high water or floods? Also, would the location of the dike contribute to the ongoing erosion at the former St. Louis construction landfill farther down river? If so, this could release lead, asbestos, and other toxic materials into the river. Either of these effects could be in direct conflict with the Sustainability Plan goal of providing clean drinking water.

Additionally, I would ask how will the proposed change provide public safe public access to the river? Would the marina allow the public to launch their boats, or would it be only for members? Will the public be allowed to fish from the docks or shore?

 **CHART_126.pdf**
1083K



Refer to the Missouri River Navigation Charts for Navigation of the Missouri River (Kansas City Engineering District)

Navigation is not recommended due to the low water dam and low vertical bridge clearance.



Kordal, Roman <kordalr@stlouis-mo.gov>

Comment: Amendment#15

1 message

Bob Criss <criss@wustl.edu>
To: kordalr@stlouis-mo.gov

Wed, Jan 20, 2016 at 11:26 AM

The site north of 270 is a very poor choice for additional development, and rezoning this parcel for such use would be very poor policy. Even if enough fill were added to prevent flooding of the proposed development, water levels would increase elsewhere in our community because the floodwaters that would have been stored there would be displaced. How can such matters even be discussed only days after another tragic example of this effect? This proposal doesn't pass the laugh test, unless you want our suffering community to be the laughing stock.

All such projects are viewed as permissible because computer models are used to "certify" that they will cause no harm. Real experience is far better than models. Witness what has happened since Charles Belt's prophetic paper in *Science* (1975; attached), titled "The 1973 Flood and Man's Constriction of the Mississippi River". Our region should be ashamed of its longstanding and continuing aggravation of this obvious problem.

Robert E. Criss
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Email: criss@wustl.edu
http://eps.wustl.edu/people/Bob_Criss

Belt1975.pdf
663K



The 1973 Flood and Man's Constriction of the Mississippi River

Author(s): C. B. Belt, Jr.

Source: *Science*, New Series, Vol. 189, No. 4204 (Aug. 29, 1975), pp. 681-684

Published by: [American Association for the Advancement of Science](#)

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The 1973 Flood and Man's Constriction of the Mississippi River

C. B. Belt, Jr.

Naturam expelles furca, tamen usque recurret.—Horace, 20–30 B.C. (1).

The news media reported the 1973 Mississippi deluge as a 200-year flood, yet the flow was only a 30-year event (2). I analyzed the hydrographic history to find out the reasons for record-breaking stages.

The 1973 flood broke the stage (river level) records between Burlington, Iowa, and Cape Girardeau, Missouri, a distance of 562 km (349 miles). At Saint Louis, Missouri, the flood, which began 10 March, continued for 77 consecutive days, exceeding the record set in 1844 when the river was in flood for 58 days during the entire year. The river crested at Saint Louis on 28 April 1973 at a gage height of 13.18 m (4.03 m above flood stage) and a peak discharge of 24,100 m³/sec. The stage topped the 189-year record by 0.3 m. The flood peak was 0.61 m higher in 1973 than in 1844 but the discharge was about 35 percent less than the estimated flow for 1844. The 1908 flood had the same flow as the 1973 flood but the peak was 2.51 m lower.

Maher (3), Leopold (2), and Kazmann (4) attribute rise in stage to man-made levees, which confine the water to the channel and prevent it from spreading over the floodplain. Belt (5) and Simons *et al.* (6) attribute higher stages to a combination of levee confinement and navigation works such as wing dikes, side channel dikes, and revetments, which reduce channel cross section by causing net bank deposition. Increased flooding on the Mississippi River has been attributed to navigation works (7).

Maximum and minimum annual stages were studied for two rated and six unrated gages on the Mississippi using polynomial

time trend analyses. At rated gages both discharge and river stage records are taken, at unrated gages only stage records are. These gages extend over a distance of 129.5 km from Chain of Rocks, Missouri, to Chester, Illinois (Fig. 1). Polynomial time trend analysis of maximum annual discharge was done for Saint Louis and Chester gages. Estimates of the rise in stage from the early 20th century were obtained using plots of stage versus discharge (rating curves), routing the 1927 flood, and differential stage analysis. Changes in average riverbed elevation in relation to flood peaks were studied. Average bottom elevations of a series of sections taken at low water when the discharge was about the same were studied to determine a base-



Fig. 1. The Mississippi River and tributaries, showing gage stations from Chain of Rocks to Chester.

line before and after the peak. Average bottom elevations for higher flows were calculated from records of the U.S. Geological Survey using the same location as the standard low-water section. Finally, the history of man-made modifications of the river was studied to see if they correlated with changes in the river's hydrology.

Historical Changes in Hydrology

The minimum yearly stages at Saint Louis have been falling since 1865 (Fig. 2A). According to Simons *et al.* (6) and Maher (3, 8) this results from the downward erosion of the river bottom due to man-induced channel confinement. Man's tampering with the river started in 1837 when Lieutenant Robert E. Lee built the first confinement dikes to remove sandbars threatening the Saint Louis harbor. The river was narrowed by man from 1300 m in 1849 to 610 m in 1907, and finally to 580 m in 1969 (6, 8). Channel confinement has taken place over the middle Mississippi from Saint Louis to Cairo, Illinois (6). Although the width of the river at one place at Saint Louis was stabilized at about 610 m in 1907 and about 85 percent of the navigation works were constructed before 1909 (3), bottom erosion and other hydrologic effects continued until 1930. There were no dams upstream of Saint Louis in 1930, only wing dikes and other navigation works. There appears to have been at least a 20-year lag between the construction of wing dikes and the effects of bank-full widths and bottom erosion.

A plot of average bottom elevations of sections measured when the discharge was about 4930 m³/sec (the mean flow of the river) was made over time for five stations in the Saint Louis reach. All stations were within a distance of 3.7 km. It is remarkably similar to the time trend of minimum annual stages, showing that at Saint Louis this trend reflects bottom elevation. The time trend of maximum annual stages is flat except for the four large floods in the middle 19th century (and is not statistically significant) (Fig. 2B). After about 1900, there is increased dispersion in the maxi-

The author is associate professor of geology in the Department of Earth and Atmospheric Sciences, Saint Louis University, Saint Louis, Missouri 63156.

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29 AUGUST 1975

imum yearly stages, with the highest being higher and the lowest stages lower. The time trend for yearly maximum discharge (Fig. 2C) has a similar shape (and is also not statistically significant), but the scatter from the polynomial trend is uniform, showing that changes in stage do not result from changes in discharge.

If the stages below discharges of 11,300 m³/sec in Fig. 2B are eliminated, there is a significant rise in trend. This discharge is below bankfull for the entire time interval. The higher the cutoff the more the stage rise (Fig. 2D). A flow of 14,200 m³/sec is close to bank-full discharge for 1973, and 17,000 m³/sec was close to bank-full discharge for 1881. Thus, the increased dispersion of the time series diagram for maximum annual stage is due to rising high stages accompanied by falling low stages during the period 1870–1973.

The maximum annual stage and associated discharge values for 1861–1927 were plotted in chronological order on log-log

paper. The whole sequence was found to lie remarkably close to a gentle curve (Fig. 3), which defines a good baseline. There is a possibility that this may be due in part to the variety of different methods of measuring discharge that were used during this period. Studies of rating curves from this period by Maher (3) and Belt indicate that fluctuations between adjacent curves were at most 0.6 m above 9910 m³/sec. The trend seems to be significant. The estimates are based on the best available information (9). Maher's paper (3) includes two diagrams that show progressive changes in rating curves from 1861–1927 below 8490 m³/sec, but very slight changes in rating curves above a discharge of 8490 m³/sec. This discharge is approximately the point at which the family of rating curves cross. The 1973 preliminary rating curve was plotted for the Saint Louis gage to indicate the net change between the two periods. At bank-full discharge—the flow at flood stage—for 1973 (13,500 m³/sec) the base-

line is 0.9 m below the 1973 curve. This is due to the loss in cross-sectional area of the channel and its discharge-carrying capacity. The bottom erosion caused by the confinement and increased velocity due to a more efficient channel shape did not compensate for the channel narrowing. Instead, the channel's cross-sectional area was reduced by one-third (6) and its discharge-carrying capacity by about one-fourth. At a discharge of 24,100 m³/sec the baseline is 2.4 m lower than the 1973 rating curve (Fig. 3). This was caused by levee confinement, channel narrowing for navigation, and perhaps slight sedimentation. The 1881 rating curve is 3.0 m lower than the 1973 curve at 24,300 m³/sec. Missouri River dams cut the peak 0.1 m on 28 April 1973. Under 19th-century conditions, the 1973 flood would have been about 2.9 m lower.

A plot of difference in stage of all yearly maxima from the baseline was constructed (Fig. 4). After 1930 there are significant in-

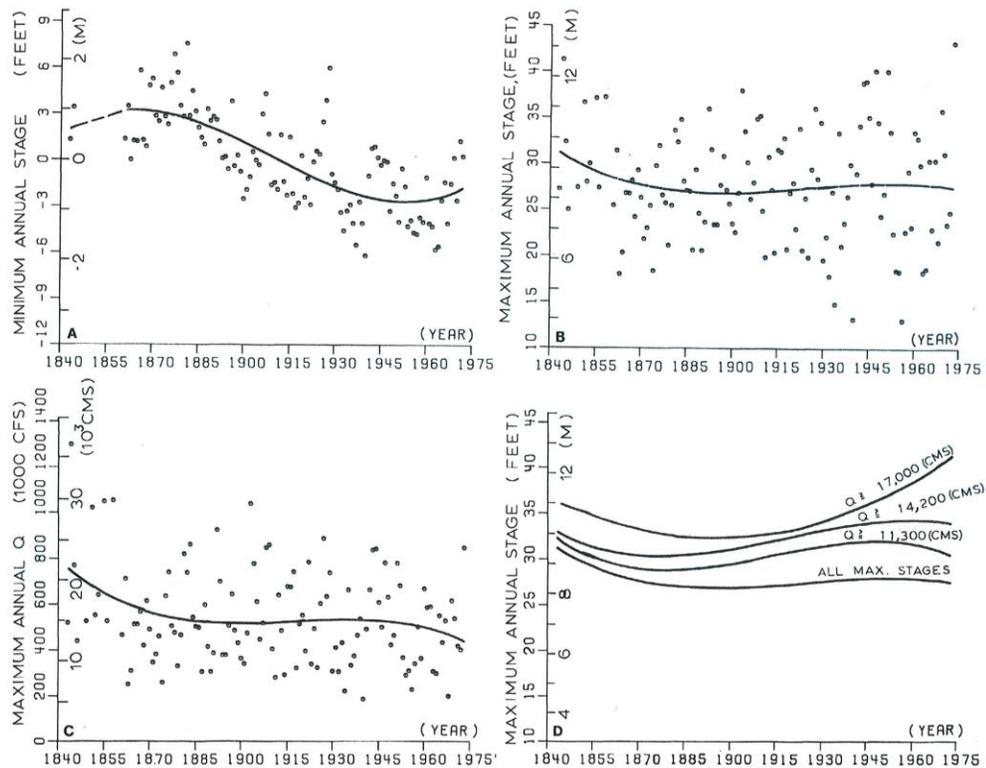


Fig. 2. Time trends at Saint Louis: (A) minimum yearly stages, (B) maximum yearly stages, (C) maximum yearly discharges (Q), and (D) maximum yearly stages with different cutoff values of discharge. Abbreviations: CFS, cubic feet per second; CMS, cubic meters per second.

creases in fluctuations of stage-discharge relations, which can be explained by the large bottom fluctuations and other changes in hydrologic regimen to which the channel is not adjusted. The year 1930 may have been the end of a 90-year erosional phase at Saint Louis and the beginning of a phase marked by large fluctuations in bottom elevation.

A natural alluvial river generally widens its channel in response to large floods (10), depending on the relative erodibility of its bed and banks. The width of an alluvial river channel over a long period of time is a function of average discharge, when different rivers are compared, all other hydrological and geomorphologic factors being equal (10-12). The Mississippi widened itself between 1803 and 1860 in response mostly to four large floods (6). After 1881, it became more difficult for the river to widen itself because of the number of navigation dikes and the bank protection in-

stalled for navigation. Total channel widening in response to floods is now insignificant because of navigation works. This man-modified channel is not in equilibrium according to the natural relationships found by Schumm (10) between channel shape and sediment load. Man has forced the Mississippi out of the natural dynamic regimen it established since the ending of the Ice Age.

At Saint Louis three different trends in erosion and deposition can be seen. First, there was bottom erosion between 1865 and 1930 (with superimposed bottom fluctuations). Second came a period of bottom fluctuations with about 10-year cycles. Third were the shortest cycles, related to flooding. During the rise in stages in a 4-month period before the 1951 flood at MacArthur Bridge (288.1 km from the Ohio River) 1.8 m of bed was eroded. A 0.3-m rise in bottom occurred just after the peak because of transport of coarse mate-

rial at or on the river bottom (bedload). A comparable situation was observed by Jordan (13).

Erosion occurred on the falling stages 1 week or more after the discharge. Deposition during the next 6 months raised the channel bottom to nearly the same elevation as before the flood. A similar situation was observed at Poplar Street Bridge in 1973 (0.3 km downstream). Maher (3) reported on hydrographic surveys of three stretches of river totaling 8.8 km in length between bridges from 3 months before the peak of 21 July 1951 to 9 months later. He concluded that "the river bed fills during and scours after a flood." The bridges confine the river. Bank-full widths are about 560 m under bridges and about 610 m elsewhere. During floods the river scours under the bridges but may deposit in areas of broader channel between. During the winter of 1951-1952 the Missouri River dumped a 6.1-m-high mound of bedload

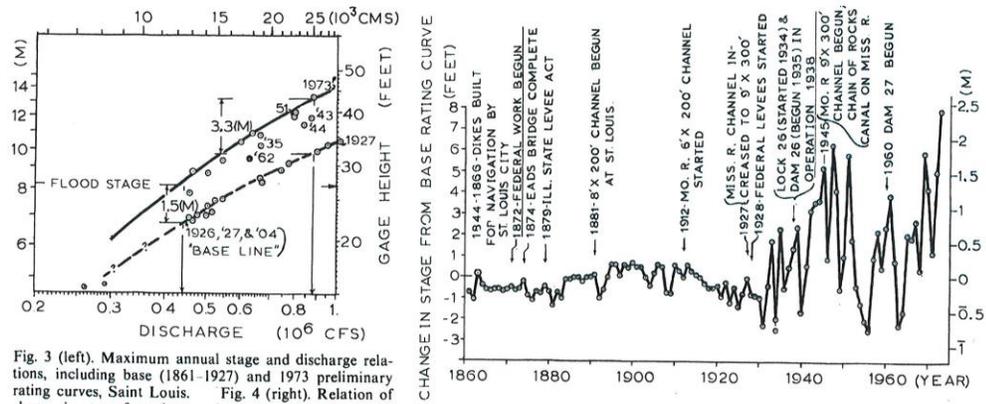


Fig. 3 (left). Maximum annual stage and discharge relations, including base (1861-1927) and 1973 preliminary rating curves, Saint Louis. Fig. 4 (right). Relation of change in stage from base rating curve to time at Saint Louis.

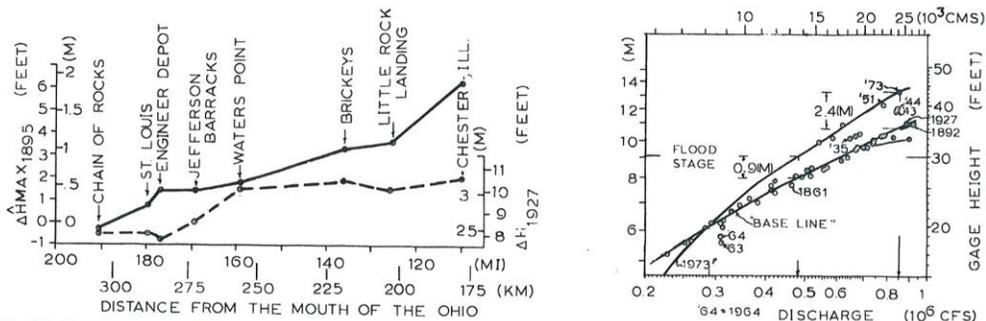


Fig. 5 (left). Relation of difference in stage of 1927 and 1973 flood (ΔH_{1927}) (dashed line) and difference in regression annual maximum stage from 1895 to 1973 ($\Delta H_{max, 1895}$) to river distance of each gage from the Ohio River. Fig. 6 (right). Maximum annual stage and discharge relations, including base and preliminary 1973 rating curves at Chester.

into the Mississippi; the slug moved downstream (3). The Missouri often dumps more material into the Mississippi after floods.

The net rise in stage since 1927 at 24,100 m³/sec was estimated for six unrated gages in the reach from the Chain of Rocks gage to Chester by routing the 1927 flood. The crest was followed downstream. Two small tributaries, the Meramec River and the Kaskaskia River, did not contribute a significant discharge to the river for the 1927 flood. Subtraction of 1927 from 1973 peak stages gives an estimate of the rise in stages, but the flow of the 1927 flood was 25,200 m³/sec. Small correction factors were calculated from the slope of the baseline at the nearest rated gage and added to the difference in stage. The 1908 flood was also studied. The average difference between the 1927 and 1908 figures is only 8 percent. The rise in stages increases downstream from Saint Louis (Fig. 5). The difference in maximum annual regression stage between 1895 and 1973 was calculated using a polynomial fit for each station and plotted against river distance from the mouth of the Ohio River (Fig. 5). The difference increases from -0.049 m for Chain of Rocks to +1.9 m for Chester in the same direction as the rise in stages between 1927 and 1973.

A base rating curve (baseline) was constructed for Chester using hydrologic data from 1903, 1906, and 1926-1927 (Fig. 6). All yearly maximums after 1928 lie 0.3 m or more above the baseline. At bank-full discharge for 1973, 12,500 m³/sec, the baseline is 1.5 m below the preliminary 1973 rating curve. Navigation works have caused a decrease in channel capacity of 5100 m³/sec. At the peak discharge of the 1973 flood, 24,100 m³/sec, the two curves are 3.3 m apart, indicating a net rise in stage since 1927. This is due to levee confinement and navigation works. The time trends of minimum yearly stage and bottom elevation are flat and undulating (not statistically significant). The river was apparently not confined enough to significantly lower bed elevations as at Saint Louis. Unlike the trend at Saint Louis, this time trend has a significant and marked upward slope and a calculated increase in maximum annual stage of almost 2 m since 1892. This trend is mainly affected by channel changes, as is the case for Saint Louis.

The errors in rise in stage calculations probably range from 10 to 25 percent and are largely due to errors and uncertainties in the published discharge figures.

Hypothesis of Historical River Response

There are several possible causes for the dramatic changes in hydrology of the Mississippi. Channel confinement caused downward erosion until about 1930 at Saint Louis. After that date there were severe bottom fluctuations. According to Leopold and Maddock (12) and Schumm (10), natural alluvial streams transporting a high percentage of bedload have wide, shallow channels. Channel confinement makes the channel unnaturally narrow and deep in relation to sediment load. Upstream dams (6) and navigation works (14) apparently reduce suspended sediment load. Dams tend to stop bedload almost entirely, but the streams erode downstream and pick up bedload again. There has been a reduction in suspended load at Saint Louis since 1948; most of the suspended load comes from the Missouri River (6, 13, 14).

Increased velocity due to change in channel shape and to both levee and channel confinement may make the Missouri, and the Mississippi from Saint Louis to Cairo, Illinois, even more efficient transporters of bedload than they were under early 19th-century conditions. Navigation locks and dams on the upper Mississippi probably cause channel deposition of bedload during periods of low flow. When the gates are open during floods there may be a slight flushing action. The slight deposition of bedload in the middle Mississippi from this area and the much more important contribution of bedload from the Missouri River may explain the deposition during flood peaks found by Maher (3).

Under natural conditions, the Mississippi eroded its bottom and banks during flood peaks, making room for some of the floodwaters. The rest spilled out over the natural reservoir, the floodplain. Since 1837, the channel has lost about a third of its volume (6) so now, during a flood on the man-modified Mississippi, the stages are higher for a given discharge. In some reaches of the river deposition occurs, causing a further rise in stages. Excess floodwater tries to spill over the floodplain but, hemmed in by levees, flood crests are forced even higher. As flood stages rise, the effect of channel confinement is diluted in the increased flows. Even at the peak flows of the 1973 flood it is probably still significant, although less important in rising stages than levees. The transport of bedload during and shortly after flood peaks causes rises in stage. The system, in dis-

equilibrium, fluctuates wildly. Navigation works and levees make big floods out of moderate ones.

Conclusions

The progressive constriction of the Mississippi for navigation since 1837 has caused bottom erosion in some stretches. In others the bottom oscillates up and down with time. The high stages rise much more rapidly. Constriction of the river channel causes flooding and makes floods higher; thus navigation works degrade the protection afforded by levees. The combination of navigation works and levees causes significant rises in the stages of floods. Additional channel constriction and levee building will cause further problems. The 1973 flood's record was man-made.

References and Notes

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9. The hydrologic data used in this article were taken from U.S. Army Corps of Engineers publications and the records of the Saint Louis District of the Corps and the U.S. Geological Survey. The methods used by the Corps to measure and estimate discharge from 1884 to 1934 were different from modern methods, but how the differences affect the data is poorly understood. Maher (3) wrote a brief history of the measurements. I propose a historical search for all discharge measurement methods. Field measurements of the river should be made using many methods simultaneously. All this would enable a computer model to be made to correct published discharge figures. I suggest that this be done by the government agencies involved, with the cooperation of outside scientists.
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15. I thank D. Spencer of the U.S. Geological Survey and the U.S. Army Corps of Engineers, Saint Louis District, for their help; W. Stauder, S.J., for computer time; and my friends and readers for their assistance. I particularly thank L. B. Leopold for his inspiration and encouragement.



EXHIBIT C

Memorandum

To: Roman Kordal, Urban Planner

From: William Kuehling 

Date: January 27, 2016

Re: SLUP Amendment #15 Response to Comments

1. Response to Libby Reuter:

“Ms. Reuter is correct that the stone dike that would be part of the proposed marina does not currently exist.

The Marina and attendant dike are planned to be part of phase 2 of the project.

Developers of the site have had preliminary discussions with the U. S. Army Corps of Engineers regarding the proposed marina, and it is anticipated that a structure of this type will be required. However in these preliminary discussions the Corps of Engineers have been very encouraging of the idea

Prior to the construction of any structure in the river, Corps of Engineers approval is of course necessary. As part of that approval process the Corps will require detailed plans and studies that will look at the implications of such a structure on the river itself and on other river users, including the City of St. Louis Water Division. These detailed studies will be done as part of phase 2 of the project.

It should be noted that the developers have also presented the concept of the marina to various City officials, including the head of the Water Division and no one has expressed any concerns regarding the effect of the marina on the water intake at the Chain of Rocks water treatment plant, or any other concerns regarding impacts on other users. It is important to remember that that the Chain of Rocks treatment plant is not only protected by the Chain of Rocks themselves, but by a cofferdam at the location.

Regarding providing the public safe access to the river, the developers believe that the project will accomplish this sustainability goal. The marina is planned to be a public marina open to anyone. There will also be a boat ramp at the site which will not only serve the marina, but also general public users. There will also be an area with steps leading into the river from the public “Riverwalk”, which will run along the river for a long portion of the site. Any member of the public will be able to go into the river at these steps, if they so wish. (However, due to water quality concerns developers do not plan on encouraging swimming.)

Draft Response to Bob Criss:

Mr. Criss expresses concerns regarding the displacement of water and other impacts on the river due to this project.

Mr. Criss's concerns might warrant discussion if in fact execution of the project required importing fill and raising the level of the land. **However, it does not. There is no new fill is required to be added to this site for this project.**

Flooding is always a concern when located next to a river. However, we believe this site to be more secure from flooding than the portion of the City of St. Louis protected by the flood wall. The flood wall protects up to a 50 foot river level. This site is above a 50 foot river level. The flood wall would be breached first.

During the recent high water on the area rivers, the site was well below flood stage.