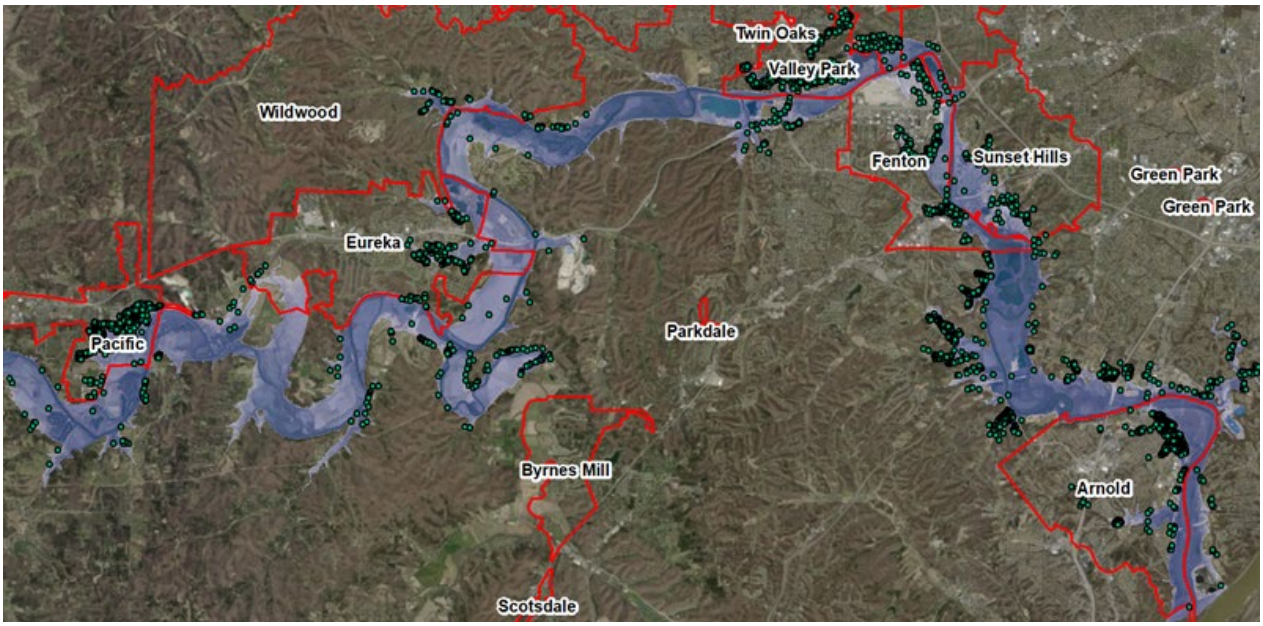
# Lower Meramec Multi-Jurisdictional Floodplain Management Plan

## For the Communities in the Lower Meramec Basin




Prepared by the Lower Meramec Multi-Jurisdictional Floodplain Management Planning Partners

April 2020

## Executive Summary

The Lower Meramec Multi-Jurisdictional Floodplain Management Plan (FMP) was developed as an interagency Flood Risk Management (FRM) study via the Silver Jackets program. This program allows the U.S. Army Corps of Engineers (USACE) to conduct small, conceptual studies for local communities with the objective of fostering public understanding of the options available to manage flood hazards and to promote prudent use and management of the nation's floodplains.

The purpose of the FMP is to foster comprehensive floodplain management and enhance a community's flood resilience. An effective FMP offers options to lessen the impacts of flooding to the community's economy and the lives of those living near the many waterways. A comprehensive approach includes planning, public information, regulations, financial support, open space protection, public works activities, emergency management, and other appropriate flood risk reduction measures. Once adopted, the FMP is a living document that is updated as new information arises or as additional goals and strategies are developed.

A FMP for this watershed is timely given the flood events that have occurred in the Meramec River Basin over the past five years. Three record flood events have occurred within the Lower Meramec Basin since August 2015, and new record stages have been recorded on all river gages in the two million acre basin. The December 2015 flood resulted in tens of millions in federal disaster assistance (DR-4250-MO). Sixteen months later (May 2017) new, or near, record levels were reached on all Meramec Basin gaging stations. A Presidential Disaster Declaration (DR-4317-MO) was made in June 2017 making federal assistance available to supplement state and local recovery efforts.

Repetitive flood damages in the Meramec River Basin are attributed to many factors including increased frequency of heavy rainfall and severe storms, geology, topography, land use changes, increase in storm water runoff, and loss of wetlands and open space. USEPA (2016) observed that rainfall during the four wettest days of the year in Missouri has increased approximately 35 percent, resulting in a 20 percent increase in stream flows. Wide spread development in the Lower Meramec floodplain and other flood-prone areas of the watershed has reduced storage and cumulatively results in unintended and potentially unanticipated consequences for neighboring properties and communities. These factors collectively contribute to repetitive damages in the Lower Meramec Basin to include water and wastewater treatment plants, electric substations, closure of Interstates 44 and 55 (10 days total within 16 months), as well as over a thousand homes and businesses directly flooded. The Lower Meramec Basin is identified as highly vulnerable based on socio-economic conditions, location of communities and school districts, repetitive loss claims, and hazard event history.[1]

While nearly every community in the Lower Meramec Basin was impacted during these flooding events, eight city governments and three county governments were partners in the development of this FMP. These communities are: City of Arnold, City of Eureka, City of Fenton, City of

[1] Missouri State Hazard Mitigation Plan, 2018. Accessed 20 November 2019.

Pacific, City of Sunset Hills, City of Union, City of Valley Park, City of Wildwood, Franklin County, Jefferson County, and St. Louis County.

The FMP focuses on the goals and objectives of these communities and uses those goals to form broad flood risk strategies and more specific tools that each could implement individually or as a whole watershed. In order to support the recommendation of these tools, the USACE – St. Louis District performed an analysis using USACE's National Nonstructural Committee's (NNC's) assessment of 17 representative structures within the Lower Meramec Basin and applying the Committee's findings to all of the structures in the 1-percent Annual Exceedance Probability (AEP) floodplain. **Table 1** below lists the various tools and evaluates each as either effective or ineffective and either recommends the tool, does not recommend the tool, or suggests that further evaluation is needed before considering the tool.

*Table 1. Summary of Tools*

| TOOLS | EVALUATION | |
|---|---|---|
| Land Use Policies and Regulations | EFFECTIVE | **RECOMMENDED** |
| Public Alert Flood Warning System | EFFECTIVE | **RECOMMENDED** |
| Warning Dissemination, Multi-Media | EFFECTIVE | **RECOMMENDED** |
| Flood Emergency Preparedness Plans (or EAPs) | EFFECTIVE | **RECOMMENDED** |
| Development Policies - Moratorium | EFFECTIVE | **NOT RECOMMENDED** |
| Structure Elevations | EFFECTIVE | **RECOMMENDED** |
| Buyouts (Structure and Land Acquisition) | EFFECTIVE | **RECOMMENDED** |
| Flood proofing (Wet & Dry) | EFFECTIVE | **RECOMMENDED** |
| Community Education and Advocacy | EFFECTIVE | **RECOMMENDED** |
| Temporary Flood Risk Adaptive Measures | EFFECTIVE | **RECOMMENDED** |
| Information and Education | EFFECTIVE | **RECOMMENDED** |
| Flood Insurance | EFFECTIVE | **RECOMMENDED** |
| Community Rating System (CRS) | EFFECTIVE | **RECOMMENDED** |
| Local Drainage and Utility Protection | EFFECTIVE | **FURTHER EVALUATION NEEDED** |
| Tax Adjustments | EFFECTIVE | **FURTHER EVALUATION NEEDED** |
| Post-Flood Recovery Processes | EFFECTIVE | **RECOMMENDED** |
| Wetlands, Stream, and Riparian Protection and Restoration | EFFECTIVE | **RECOMMENDED** |
| Enhancement of Recreation and Education Opportunities | EFFECTIVE | **RECOMMENDED** |

| TOOLS | EVALUATION | |
|---|---|---|
| Detention/Retention Basins | EFFECTIVE | **FURTHER EVALUATION NEEDED** |
| Levees and Floodwalls | EFFECTIVE | **FURTHER EVALUATION NEEDED** |

The FMP concludes with the recommended Action Plan, which provides a path forward for the local governments for both the short term and the long term. The Action Plan can be implemented as one package or in phases based upon the goals of the community and available funding. Potential funding sources have been included in Appendix F of the FMP.

The Lower Meramec Multi-Jurisdictional FMP Action Plan includes the following actions:

1. Adopt the Lower Meramec Multi-Jurisdictional FMP
2. Implement Nonstructural Recommendations in Appendix E
3. Develop/Update and Implement a Comprehensive Public Outreach Plan
4. Develop/Update a Flood Emergency Preparedness Plan (and Evacuation Plan)
5. Adopt/Update Higher Regulatory Floodplain Management Standards
6. Maintain and Expand the Existing Flood Warning Systems
7. Join the Community Rating System

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## List of Acronyms

**ACE:** Annual Chance of Exceedance
**AEP:** Annual Exceedance Probability
**BMP:** Best Management Practice
**COAD:** Community Organizations Active in Disaster
**CRS:** Community Rating System
**EPA:** U.S. Environmental Protection Agency
**EWG:** East West Gateway Council of Governments
**FEMA:** Federal Emergency Management Agency
**FIM:** Flood Inundation Mapper
**FIRM:** Flood Insurance Rate Map
**FMP:** Floodplain Management Plan
**FPMS:** Flood Plain Management Services
**FRM:** Flood Risk Management
**HD:** House Document
**HMGP:** Hazard Mitigation Grant Program
**ICC:** Increased Cost of Compliance
**IWR:** [USACE] Institute for Water Resources
**LiDAR:** Light Detection and Ranging
**MoDNR:** Missouri Department of Natural Resources
**NFIP:** National Flood Insurance Program
**NNC:** [USACE] National Nonstructural Committee
**NOAA:** National Oceanic and Atmospheric Administration
**NWS:** National Weather Service
**PL:** Public Law
**SEMA:** [Missouri] State Emergency Management Agency
**SFHA:** Special Flood Hazard Areas
**SLARCC:** St. Louis Area Regional Coalition of Community Organizations Active in Disaster
**SLRO:** St. Louis Regional Office
**STARRS:** St. Louis Area Regional Response System
**TNC:** The Nature Conservancy
**USACE:** U.S. Army Corps of Engineers
**USGS:** U.S. Geological Survey
**WRDA:** Water Resources Development Act
**WWTP:** Waste Water Treatment Plant

# 1 Introduction

## 1.1 Study Authority

This Floodplain Management Plan (FMP) was developed as an interagency Flood Risk Management (FRM) study via the Silver Jackets program. Silver Jackets is funded under the USACE Flood Plain Management Services (FPMS) program and is authorized by Section 206 of the 1960 Flood Control Act (P.L. 86-645), as amended. The program allows the U.S. Army Corps of Engineers (USACE) to conduct small, conceptual studies for local communities with the objective of fostering public understanding of the options available to manage flood hazards and to promote prudent use and management of the nation's floodplains. The Silver Jackets program brings together multiple state, federal, and local agencies, as well as non-governmental agencies, to leverage resources, learn from one another, and apply trans-disciplinary knowledge to reduce the risk of flooding as well as enhance response and recovery efforts when such events do occur.

## 1.2 Description of the Area

The Meramec River watershed, located in east-central Missouri, southwest of St. Louis, MO, has two major tributaries: the Big River and the Bourbeuse River. The area encompasses 3 counties and 8 cities. The Lower Meramec Basin is representative of the Ozarks Highlands Ecological Sub-region and is known for its biodiversity (125 fish species, 40 mussel species, 8 crayfish species, and 107 aquatic insects, including 11 federally listed species and 37 state-listed species). The once forested and agricultural floodplain is rapidly developing (MDC, 1998).

Three record flood events have occurred within the Lower Meramec Basin since August 2015, and new record stages have been recorded on all river gages in the two million acre basin. The December 2015 flood resulted in tens of millions in federal disaster assistance (DR-4250-MO). Sixteen months later (May 2017) new and near record levels were reached on all Meramec Basin gaging stations. A Presidential Disaster Declaration (DR-4317-MO) was made June 2017 making federal assistance available to supplement state and local recovery efforts. Repetitive flood damages in the Meramec River Basin are attributed to many factors including increased frequency of heavy rainfall and severe storms (rainfall during the four wettest days of the year in Missouri has increased approximately 35 percent, resulting in a 20 percent increase in stream flows, USEPA 2016), geology, topography, land use changes, increase in storm water runoff, loss of wetlands and open space. Development in the Lower Meramec floodplain and other flood-prone areas of the watershed has reduced storage and cumulatively results in unintended and potentially unknown consequences for neighboring properties and communities. These factors collectively contribute to repetitive damages in the Lower Meramec Basin to include water and wastewater treatment plants (WWTP), electric substations, closure of Interstates 44 and 55 (10 days total within 16 months), as well as over a thousand homes and hundreds of businesses directly flooded.

The Lower Meramec Basin is identified as highly vulnerable based on socio-economic conditions, location of communities and school districts, repetitive loss claims, and hazard event history. The Project Area is identified in **Figure 1**.[2]

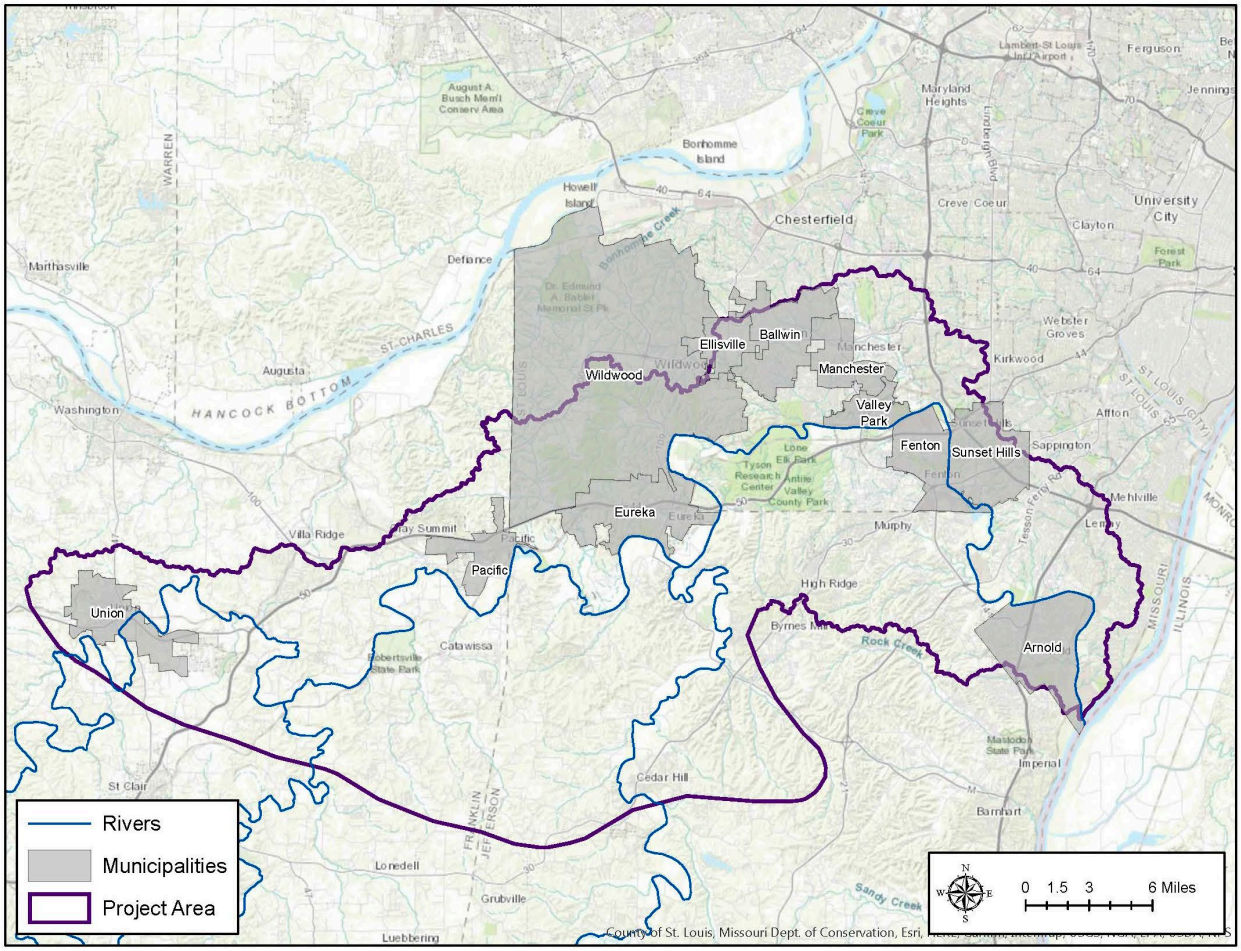


Figure 1. Map of the Lower Meramec Basin Project Area

## 1.3 History and Previous Studies

There have been extensive studies done in the watershed to assess flooding hazards and mitigation techniques. The following sub-sections describe various studies performed in the basin by federal, state, and local interests.

### 1.3.1 Gage Data

There are six gages located in the project area. **Table 2** shows the location of these gages, all of which are on the Meramec River except Union on the Bourbeuse River and Byrnesville on the Big River. The Valley Park gage is the oldest gage and has nearly 80 years of data which has

[2] Missouri State Hazard Mitigation Plan, 2018. Accessed 20 November 2019.

been collected at that site. The flood of record for all gages in the basin has occurred within the last five years, most of which occurred during the 2015/2016 flood event.

*Table 2: Lower Meramec Flood Statistics*

| Gage Location | Period of Record | | Flood of Record | Days | Flood Stage[1] | Percentage of Days Above Flood Stage in Any Year Within the Period of Record |
|---|---|---|---|---|---|---|
| | Start | End | | | | |
| **Pacific** | 5/30/2002 | 12/31/2017 | 2015/2016 | 5,668 | 15.0 | 50.00% |
| **Eureka** | 1/1/1960 | 12/31/2017 | 2017 | 18,964 | 18.0 | 70.69% |
| **Valley Park** | 1/1/1938 | 12/31/2017 | 2015/2016 | 28,980 | 16.0 | 76.25% |
| **Arnold** | 4/2/1980 | 12/31/2017 | 2015/2016 | 11,188 | 24.0 | 81.58% |
| **Union (Bourbeuse River)** | 1/1/1970 | 12/31/2017 | 2015/2016 | 15,542 | 15.0 | 70.83% |
| **Byrnesville (Big River)** | 1/1/1970 | 12/31/2017 | 2017 | 16,576 | 16.0 | 85.42% |

[1] Flood stage is an elevation above gage zero where flood waters first impact surrounding roads, bridges, parks, etc. at a specific gage. Flood stage is different at every gage and is not a direct elevation.

### 1.3.2 Early Flood Studies in the Lower Meramec Basin (1881-1981)

Floods along the Lower Meramec River have been a frequent occurrence. Major floods were recorded in 1915, 1916, 1942, 1945, 1950, 1957, 1961, 1969, and 1979. In addition to federal studies, many state and private interest groups have also looked at flooding and other water related problems in the watershed.

In January 1964, the USACE – St. Louis District completed the “Comprehensive Basin Study – Meramec River” report. This report proposed a comprehensive water resources plan for the Meramec River Basin. The proposed plan consisted of five reservoirs and 19 angler use sites. The recommendations from this report served as the basis for House Document (HD) 525. HD 525 authorized 3 major reservoirs in the basin and 19 angler use sites as well as confirmed the need for two reservoirs previously authorized in the Flood Control Act of 1938.

The U.S. Environmental Protection Agency (EPA) Region VII wrote a report in 1978 titled “Final Environmental Impact Statement for Proposed Lower Meramec River Basin Wastewater Treatment Facilities”. This report was unable to be reviewed for this effort; however, due to the nature of the report, it is assumed to have little information regarding flood risk reduction measures for the basin.

In addition to these federal reports, the following studies were also completed by various state and local entities:

- "Out of Harm's Way" Lower Meramec Valley Flood Damage Reduction Study, November 1981, prepared by the Missouri Department of Natural Resources and the Upper Mississippi River Basin Commission
- "Lower Meramec River Management Study", August 1980, prepared by the St. Louis County Department of Parks and Recreation
- "Lower Meramec Greenway Study – Water Quality Considerations", 1980, prepared by the East-West Gateway Coordinating Council
- "St. Louis County Water Pollution Control Study, Phase I: Areas Tributary to the Meramec River", September 1972, prepared by the East-West Gateway Coordinating Council

### 1.3.3 1982 Flood Event

The December 1982 flood produced the highest recorded stage at the time for each of the Lower Meramec communities. As a result of persistent flooding within the basin, Congress directed USACE to study all possible measures to mitigate flood loss. The results were reported to Congress and published in the "Lower Meramec River Flood Damage Reduction Project: St. Louis and Jefferson Counties, Missouri Plan Formulation Report and General Design Memorandum" dated March 1987. The 1987 report estimates Lower Meramec communities sustained roughly $50 million in damages during the December 1982 flood. Perhaps more significantly, during the 1980s, the average flood damage per community was estimated at $2.7 million annually.

The 1987 report recommended a levee be constructed for the City of Valley Park, approximately 3 miles long and 15-20 feet high in most areas, offering risk reduction against the 1% Annual Chance of Exceedance (ACE) flood event plus 3 feet of "freeboard". The report also suggested flood control features such as pumps, drains, ponding areas, and closure structures, as well as the recommendation for the levee to include recreation features such as playgrounds and fishing lakes (developed from levee borrow areas). The project was authorized as part of Public Law (PL) 97-128 and was estimated to cost $11.8 million based on the October 1984 price level. The levee was built in several phases from 1994-2007 and is approximately 3.2 miles long and reduces flood risk for 435 acres.

PL 97-128 also de-authorized the Meramec River Reservoir/Dams project as it applied to all communities on the Meramec River in St. Louis, Jefferson, and Franklin Counties (by amendment).

### 1.3.4 1993 Flood Event

The Flood of 1993 was a historic event that devastated much of the Midwest, causing an estimated $18 billion in damages across nine (9) states. In Missouri alone, the National Weather Service (NWS) estimates that over $3.4 billion in damages occurred from this record flooding. After the floodwaters receded, the Federal Emergency Management Agency (FEMA) spent over $265 million on cleanup efforts and nearly $172 million over 5,321 National Flood Insurance

Program (NFIP) claims just in the State of Missouri. **Table 3** estimates the damages to various types of property and industry.

*Table 3: Damage Estimates for the Flood of 1993*

| Damages to: | Estimated Damages |
|---|---|
| **Commercial & Industrial Properties** | >$10 million |
| **Public Facilities** | $1-4.9 million |
| **Residential Properties** | >$5 million |
| **Transportation System** | $1-4.9 million |
| **Utilities** | $1-4.9 million |
| **Emergency Expenses** | >$1 million |

There are six gages in the project area: Arnold, Eureka, Pacific and Valley Park on the Meramec River, Union on the Bourbeuse River, and Byrnesville on the Big River. During the 1993 flood the Union and Byrnesville gages recorded their flood of record at the time, while the Arnold gage was above flood stage for 190 days. **Table 4** identifies the gages as well as their days above flood stage during that event.

*Table 4: Flood of 1993 gage data for project area*

| Gage Location | Days Above Flood Stage | Flood of Record |
|---|---|---|
| **Pacific**[1] | N/A | N/A |
| **Eureka** | 19 | 9th |
| **Valley Park** | 62 | 7th |
| **Arnold** | 190 | 3rd |
| **Union (Bourbeuse River)** | 14 | 1st |
| **Byrnesville (Big River)** | 3 | 1st |

[1]The gage at Pacific was not installed until 2002; thus there is no data for the 1993 flood at this location

### 1.3.5 2015/2016 Flood Event

Between December 2015 and January 2016, severe storms including tornadoes, straight line winds, and flooding hit large portions of Missouri, the hardest hit area being the Meramec Basin. Widespread flooding was seen in both the Missouri and Mississippi River basins and their tributaries. Locations from the Missouri Ozarks to St. Louis received 10-12 inches of rain, causing flash flooding and historic river flooding that exceeded previous records on multiple river gages across the state. There were 15 deaths attributed to the storms, hundreds of people were evacuated from their homes, and approximately 1,000 homes were either damaged or destroyed. Portions of three interstate highways (I-44, I-55 and I-70) were shut down, along with 285 state roads. Barge traffic was halted on the Mississippi River, which was closed for a five mile stretch at St. Louis. Amtrak and Union Pacific railroads suspended service, 11 post offices

were temporarily relocated in the St. Louis Metropolitan Area, and multiple water and wastewater treatment facilities were impacted.

The following records were broken during this event:

- Wettest year on record: 61.24" (old record was 57.96" in 2008)
- Wettest December on record: 11.74" (old record was 7.82" in 1982)
- December 26th record rainfall: 4.87"
- December 26th rainfall set daily rainfall record for December
- December 26th rainfall was 3rd wettest day ever recorded in St. Louis history
- December 28th record rainfall of 2.59"

The Governor of Missouri declared a state of emergency on December 27, 2015, and on January 2, 2016, the President approved an emergency declaration (FEMA-3374-EM) which provided public assistance for debris removal and emergency protective measures. On January 21, 2016, the President approved a major disaster declaration (FEMA -4250-DR-MO) for 33 counties (expanded to 37 counties on February 10, 2016) which allowed for individual assistance and appointed a Federal Coordinating Officer.

Following the storm events and throughout the short term recovery process, FEMA authored the Recovery Support Strategy for the disaster declaration which was finalized on August 19, 2016.[3] This report states that through July 19, 2016 there were 1,236 NFIP claims received for a total of $66,685,383 in damages related to this weather event. A breakdown of damages by community is below in **Table 5**; this only lists the communities within the study area and therefore, the total damages in this table will not sum up to $66.6 million.

*Table 5: DR-4250 Damages by Community*

| Community | Residential Damages | Infrastructure Damages | Homes Impacted |
|---|---|---|---|
| **Arnold** | $2.6 million | Unknown | 3% |
| **Eureka** | $2.2 million | $2 million | 4% |
| **Fenton** | $3 million | $1.2 million | 11% |
| **Pacific** | $1.4 million | $945,043 | 5% |
| **Union** | $800,269 | $263,600 | 1% |
| **Valley Park** | $422,097 | $346,700 | 2% |

The State of Missouri Emergency Management Agency (SEMA) Hazard Mitigation Plan dated 2018 identifies riverine flooding (major and flash) as having a high probability of occurring and a high severity statewide. Missouri has had 42 flooding related presidentially declared disasters in

[3] This document is not included in this report, but can be found on FEMA's website at https://www.fema.gov/media-library-data/1456156042403-a782770e6f1a66d9aec33526def72ce3/PDAReportFEMA4250DRMO.pdf .

the 45-years since 1975. Jefferson County is specifically called out in the plan as being heavily affected by flooding and has more presidentially declared-flooding related disasters in the state than any other county (1975-2017).[4] **Figure 2** illustrates the December 2015 storm's total rainfall according to the National Weather Service.

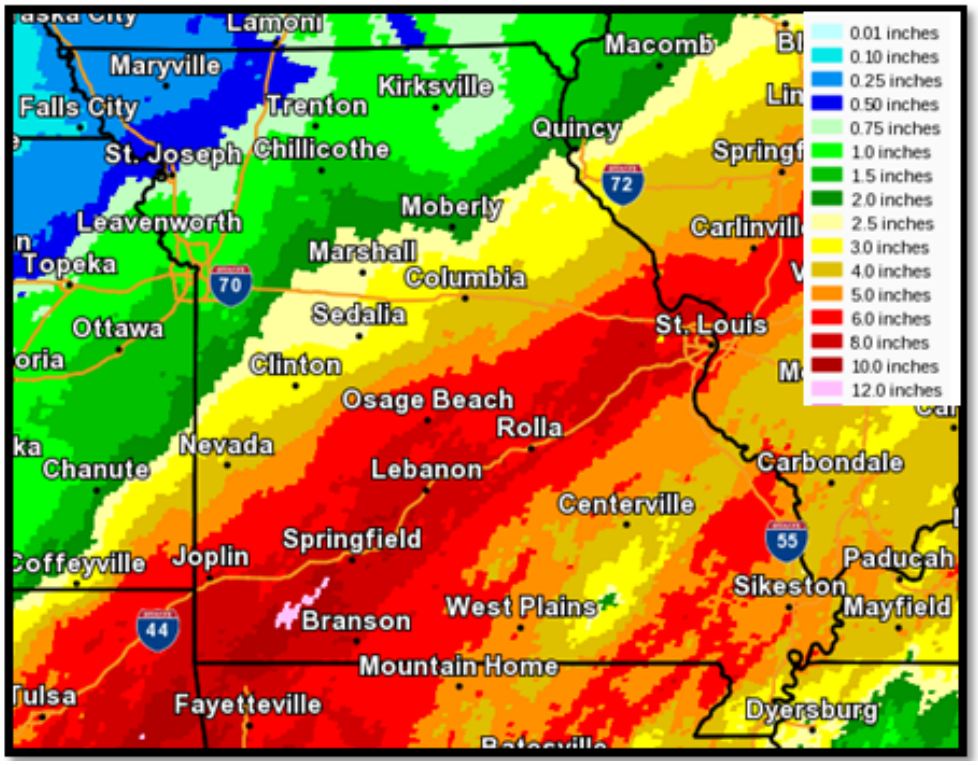


Figure 2. Storm total rainfall for end of December 2015 storm event (National Weather Service)

### 1.3.6 Other Recent Flood Events

There have been several recent flood events as shown in **Table 6**. The data in the column titled "Event Details" is based upon National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Estimates[5]. It is important to note that while the flood events were significant, they were not attributed to the high water of the Meramec River. Instead, they were caused by significant rain events overwhelming interior drainage systems, some of which are tributaries of the Meramec River. There is the potential that these drainage issues could compound flooding if they occur while the Meramec River is at or above flood stage, which increases the likelihood that damage to property and loss of life could occur.

[4] Available online at https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf. Accessed on 20 September 2019.
[5] Available online at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=pa. Accessed on 14 November 2019.

*Table 6. Other Recent Flood Events*

| Flood Event Date | Flood Source | Community Impacted | Event Details |
|---|---|---|---|
| 3 July 2019 | Intense rainfall | City of Eureka | 1.3 inches in 30 minutes; equates to 20% AEP event and 2.1 inches in 1 hour; equates to 10% AEP |
| 22 July 2019 | Intense rainfall | City of Eureka | 3.6 inches in 3 hours; equates to 3% AEP event |
| 21 August 2019 | Intense rainfall | City of Valley Park | 4.72 inches in 6 hours; equates to 2.2% AEP event |
| 21 August 2019 | Intense rainfall | City of Fenton | Use nearby gage at Valley Park |
| 26 August 2019 | Intense rainfall | City of Eureka | 3.8 inches in 3 hours; equates to slightly more rare than 2.5% AEP event |
| 30 August 2019 | Intense rainfall | City of Eureka | 3.4 inches in 6 hours; equates to 10% AEP event |

# 2 Development of the Floodplain Management Plan

## 2.1 Purpose

The purpose of a FMP is to foster comprehensive floodplain management and enhance a community's flood resilience. Flood resilience refers to the ability of a community to withstand a flooding event, minimize damages, and rapidly recover. An effective FMP offers options to lessen the impacts of flooding to the community's economy and the lives of those living near areas prone to flooding. Once adopted, the FMP should be maintained as a living document that is continually updated as new information arises or as additional goals and strategies are developed.

The goals of a FMP include:

- Reducing loss of life, injury and hardship due to floods;
- Reducing flood-related damages;
- Reducing public expenditures for construction of additional flood damage reduction measures, emergency response actions, and post-disaster assistance; and
- Preserving and enhancing natural floodplain values for fish and wildlife habitat along with their attendant benefits of groundwater recharge, moderation of floods, water quality improvement, and reduced erosion and sedimentation.

A FMP attempts to balance benefits obtained from use of the floodplain with potential losses arising from such use. The comprehensive nature of such a plan stresses consideration of the full range of structural and non-structural measures potentially useful in achieving these objectives. The concepts contained in this FMP were developed to closely follow the 1994 Unified National Program for Floodplain Management.

Local, state, and federal partners have prepared this FMP in accordance with federal standards originating from Executive Order 11988. The standards are consistent with Public Law 104-303 of the Water Resources Development Act (WRDA) of 1996, which amends Section 402 of the WRDA of 1986 (also see 33 U.S.C. 701b-12; 100 Stat. 4133). More importantly, this FMP meets the minimum standards for FEMA's Community Rating System (CRS), Section 510 as described in the CRS coordinator's manual (FEMA, 2007).

## 2.2 Participants

The communities and their respective governing bodies throughout the Lower Meramec Basin are the primary partners in the development of the Lower Meramec Multi-Jurisdictional FMP because of their statutory authority to carry out or implement the major elements (Section 7) of this FMP. Other partners, listed in Section 2.5, contributed to the effort in terms of technical expertise, public outreach, as well as other support.

The cities and counties involved in the FMP adopted a resolution agreeing to participate in the Floodplain Management Planning effort with the exception of Franklin County, Missouri. While Franklin County did not pass a resolution, county officials provided input and participated throughout the process. Resolutions from the City of Arnold, City of Eureka, City of Fenton, City of Pacific, City of Sunset Hills, City of Union, City of Valley Park, City of Wildwood, Jefferson County, and St. Louis County are compiled in Appendix C – Floodplain Management Plan Participation Resolutions by Community.

Both the City and County Floodplain and Emergency Managers were actively involved in the planning process. **Table 7** lists the respective City and County departments and employees who participated in the planning process.

*Table 7. City and County Participants*

| Name | Department | Unit of Government |
|---|---|---|
| David Bookless | Community Development Director | City of Arnold |
| Christie Hull-Bettale | Floodplain Administrator | City of Arnold |
| Mike Wiegand | Chief of Police/Emergency Manager | City of Eureka |
| John Boggs | Building Commissioner/Floodplain Administrator | City of Eureka |
| Dan Howard | Code Enforcement/Public Works/Floodplain Administrator | City of Fenton |
| Nikki Finkbiner | City Administrator | City of Fenton |
| Steve Roth | City Administrator | City of Pacific |
| Josiah Holst | HrGreen, contractor for City of Pacific | City of Pacific |
| Bryson Baker | City Engineer/Director of Public Works | City of Sunset Hills |
| Gerald Brown | Director of Parks and Recreation | City of Sunset Hills |
| Jonathon Zimmerman | Building and Engineering/Floodplain Administrator | City of Union |
| Russell Rost | City Administrator | City of Union |
| Gerald Martin | Public Works Department | City of Valley Park |
| Gil Denormandie | Parks and Recreation Department | City of Valley Park |
| Joe Vujnich | Director of Planning and Parks | City of Wildwood |
| Rick Brown | Public Works Director | City of Wildwood |
| Tori Karim | Planning and Zoning Department/Floodplain Administrator | Franklin County |
| Warren Robinson | Director of the Office of Emergency Management | Jefferson County |
| Eric Larson | Director of County Services and Code Enforcement/ Community Planning/Floodplain Administrator | Jefferson County |
| Debi Salberg | Planning Department | St. Louis County |
| TBD | St. Louis County Police Department/Emergency Manager | St. Louis County |

## 2.3 Project Study Outcomes

The FMP serves as a blueprint that can be implemented by the cities and counties. The FMP will include and foster:

- Flood risk reduction strategies that are current, technically sound, and consider all possible mitigation alternatives and the consequences of those alternatives
- Prioritization of resources to reduce risk to the furthest extent and minimize effect on natural floodplain functions
- Public and political support for activities and projects and a constituency that wants to see the plan's recommendations implemented

The FMP documents meetings and public involvement activities, and it lists goals and objectives that each community has identified as important to its leadership. In addition, the FMP identifies strategies and tools that can be implemented to achieve the goals and objectives and whether those strategies and tools are being recommended for implementation by the communities. Finally, the FMP details the Action Plan for implementation of efforts to reduce and/or improve the management of flood risk. The Plan also considers primary strategies to modify human susceptibility to flood damage and disruption through floodplain and floodwater management recommendations such as land use regulations, public development and redevelopment policies, and flood damage reduction measures informed by a partial nonstructural assessment, as well as preservation and restoration of habitat functions of floodplains.

## 2.4 Public Involvement Process

For the purpose of this FMP, the term "public" includes residents, businesses, property owners, and tenants in the floodplain and other known hazard areas as well as other stakeholders in the community, such as developers and contractors, civic groups, environmental organizations, academia, non-profit organizations, private companies, and staff from governmental agencies, such as a levee district, housing authority, and federal agencies. See **Table 9**, Section 2.5, for a complete partner list.

Public involvement was vital during the development of the Lower Meramec Multi-Jurisdictional FMP. Local governments assisted in hosting public workshops and soliciting local property owners interested in participating in USACE NNC's assessments. These governments also contributed time and effort by reserving the venue for the public workshops, promoting the public comment opportunity, and providing data.

In addition, USACE introduced the Floodplain Management Planning effort to the public by hosting three public workshops in the Lower Meramec Basin. The purpose of the workshops were to gather information on historic and existing conditions, flooding locations, local opinion on possible solutions, and community flood procedures. **Table 8** shows the location of the workshops and attendees at each location.

Table 8. Lower Meramec Public Workshops

| Workshop Date/Location | Attendance | | | | |
|---|---|---|---|---|---|
| | Public | Partners | Congressional | Media | Total |
| March 22, 2018 – Pacific City Hall | 15 | 14 | 2 | 3 | 34 |
| March 29, 2018 – Sunset Hills Community Center | 44 | 16 | 2 | 4 | 66 |
| April 11, 2018 – Arnold City Hall | 49 | 14 | 2 | 0 | 65 |

During a 45-day public review period, the USACE received 17 comments. Appendix A, Public Involvement Results – 27 June 2018, documents the comments received.

In late November of 2018, the USACE NNC sent two of its staff to the Lower Meramec Basin in order to perform nonstructural assessments on 17 homes and businesses that were identified by local government and whose owners volunteered to have NNC members enter their residences and businesses, take pictures, and collect data about flood depths and damages. The NNC's report can be found in Appendix D – National Nonstructural Committee Assessment with Enclosures. The objective of the assessments was to identify potential opportunities for flood risk adaptive measures, generally referred to as nonstructural mitigation measures.

From the initial public workshops in March and April of 2018, USACE - St. Louis District has maintained a live website with information for the public including the Information Paper, Public Comment Periods results, relevant contact information for federal, state, and local officials, the draft FMP, and the public meeting presentation. USACE - St. Louis District also posted information about the public workshop and public meetings on its social media page. The various communities advertised the USACE website to spread information about the FMP status. **Figure 3** is a clip of USACE's webpage, which can be accessed using the following link: https://www.mvs.usace.army.mil/missions/programs-project-management/lower-meramec-basin/.

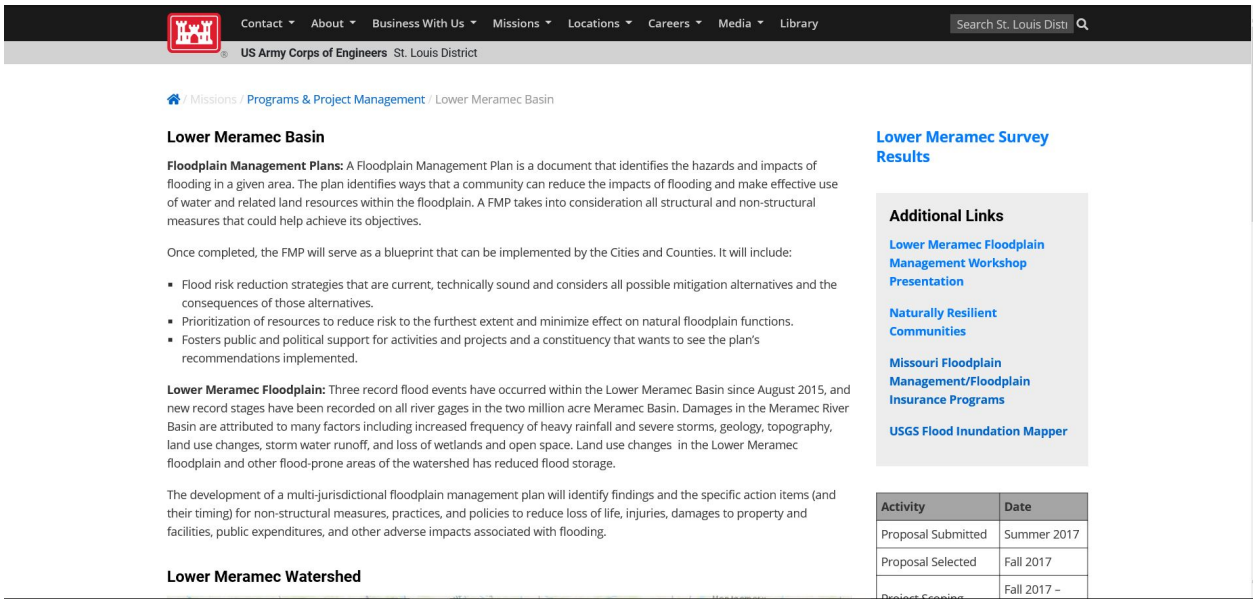


Figure 3. USACE - St. Louis District Webpage

In January and February of 2020, USACE hosted three public meetings to share the draft FMP with the public. Public meeting locations included the Cities of Eureka, Sunset Hill, and Arnold, and representatives from the Planning Group and the Advisory Group were present to answer any questions from the public and to share technical resources with the public. This FMP has been revised to incorporate comments or issues of clarity and concern shared by the public.

## 2.5 Partner Coordination and Communication

There has been continuous coordination and communication between the various partners throughout the development of the Lower Meramec Multi-Jurisdictional FMP. **Table 9** lists the FMP Partners as well as each one's level of government, their grouping (Planning / Advisory / NGO / Public), and the activities and tasks that each performed during FMP development.

Because of the size of the Meramec Watershed and the regional interests in the FMP, the potential partners and stakeholders were placed in one of three groups: 1) Planning Committee, 2) Advisory Group, and 3) the Public.

The Planning Committee is comprised of stakeholders who are vital not only to the development of the FMP but also capable of implementing elements of the plan. The Planning Committee members have contributed resources either in the form of providing data and/or labor.

An Advisory Group was established to supplement the development of the FMP by providing technical expertise, developing components of the FMP within their respective fields, and acting as a resource to the communities.

USACE is the initial facilitator of this FMP and has participated in both the Planning Committee as well as the Advisory Group.

It is important to note that the roles, responsibilities, activities, and tasks have evolved over time through coordination and communication among the partners.

*Table 9. Complete Partner List*

| PARTNER | Level of Government | GROUPING | ACTIVITIES/TASKS |
|---|---|---|---|
| Arnold | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Eureka | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Fenton | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Pacific | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Sunset Hills | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Union | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Valley Park | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Wildwood | City | Planning Committee | Participation in work sessions, meetings, and other activities in support of the regional floodplain management effort |
| Franklin | County | Planning Committee | The county will provide existing GIS and LiDAR data and advise on local floodplain management strategies and policy. |
| Jefferson | County | Planning Committee | The county will provide existing GIS and LiDAR data and advise on local floodplain management strategies and policy. |
| St. Louis | County | Planning Committee | The county will provide existing GIS and LiDAR data and advise on local floodplain management strategies and policy. |
| USACE | Federal | Facilitator | Facilitate and assist in the development of a multi-jurisdictional floodplain management plan |

| | | | |
|---|---|---|---|
| USGS | Federal | Advisory Group | Provide Flood Inundation Mapping along 50 miles of the lower Meramec River to provide a publicly available tool used by community planners and emergency and flood plain managers for risk communication and consequence purposes. |
| FEMA | Federal | Advisory Group | Provide Recovery Support Strategy, a strategic level document that describes the approach and direction to identify and sequence a wide range of recovery support activities and resources. Accordingly, the document and related tools are critical to the effective management and implementation of the recovery support strategies. |
| EPA | Federal | Advisory Group | Provide funding for the WSU EFC component of the FMP; provide funding for the USACE's MR/BR UWFP ambassadors; participate in FMP development via advisory group calls and by reviewing the documents |
| TNC | NGO | Public | Update Meramec Basin Conservation Action Plan with Soil and Water Assessment Tool (SWAT) model analysis of subwatershed inputs of sediment, nitrogen and phosphorus, participate in FMP development and review; assist in development of environmental considerations for nonstructural recommendations; develop an online floodplain conservation/restoration prioritization tool, |
| East-West Gateway Council of Governments (EWG) | NGO | Public | Develop Lower Meramec Watershed Management Plan to improve water quality and increase public awareness through riparian buffer restoration, green infrastructure projects, agriculture best practices, and waste water treatment plant (WWTP) controls. Design St. Louis Regional Hazard Mitigation Plan to reduce risk to existing and future development and to prevent damage to each community's unique economic, cultural and environmental assets. |
| Wichita State University – Environmental Finance Center (WSU - EFC) | NGO | Advisory Group | Through an EPA grant secured by TNC and partners, WSU Environmental Finance Center was contracted to produce funding opportunities, case studies and cost-benefit information for implementing healthy watershed practices components of the FMP. |

| | | | |
|---|---|---|---|
| Public | Public | Public | Give public input during workshop and attend public meetings. |
| SEMA | State | Advisory Group | SEMA will contribute by participating in partnership meetings, providing repetitive loss data, providing model ordinances, and providing additional technical assistance as needed. |
| MoDNR | State | Advisory Group | MoDNR, St. Louis Regional Office (SLRO), will contribute by participating in 9 partnership meetings, assist in hosting (non –logistical) the 6 community meetings, provide technical review by Water Quality and SLRO staff on floodplain management plan, and the Water Resources Center will engage as required and provide technical assistance as needed. |
| Legislative / Congressional Staff | Public | Public | Provide input of draft document and attend meetings to keep legislators aware of the status of the FMP |

USACE hosted and facilitated a series of webinars, in-person meetings, and coordination calls with the Planning Committees, individual Partners within the Planning Committee, and the Advisory Group. These meetings served to update the various groups on the progress of the Floodplain Management Planning effort and, at times, led to specific requests for data or input on the various components of the Plan. **Table 10** is a summary of the various coordination meetings.

*Table 10. Project Partner Coordination Meetings*

| Meeting Number | Meeting Date | Attendees | General Purpose | Delivery Type/ Location |
|---|---|---|---|---|
| **1.** | 7 February 2018 | Planning Committee | Kick-off Meeting | In-person (Eureka, MO) |
| **2.** | 22 March 2018 | Public | Public Workshop | In-person (Pacific, MO) |
| **3.** | 29 March 2018 | Public | Public Workshop | In-person (Sunset Hills, MO) |
| **4.** | 11 April 2018 | Public | Public Workshop | In-person (Arnold, MO) |
| **5.** | 17 April 2018 | USACE, USGS, SEMA, EWG, TNC | H&H Webinar | Webinar |
| **6.** | 20 April 2018 | USACE, MoDOT | Coordination | In-person (@MoDOT) |
| **7.** | 25 April 2018 | Planning Committee | Update | Webinar |
| **8.** | 23 May 2018 | Advisory Group | Update | Webinar |
| **9.** | 25 July 2018 | Planning Committee | Update | In-person (Fenton, MO) |
| **10.** | 16 January 2019 | Advisory Group | Update | In-person (@ The Nature Conservancy) |
| **11.** | 23 May 2019 | Planning Committee & Advisory Group | Update | Webinar |
| **12.** | 14 August 2019 | Planning Committee | Update | In-person (Eureka, MO) |
| **13.** | 14 January 2020 | Planning Committee & Advisory Group | Update | Webinar |
| **14.** | 27 January 2020 | Public | Present Findings to Public | In-person (Eureka, MO) |

| | | | | |
|---|---|---|---|---|
| **15.** | 29 January 2020 | Public | Present Findings to Public | In-person (Sunset Hills, MO) |
| **16.** | 12 February 2020 | Public | Present Findings to Public | In-person (Arnold, MO) |

# 3 Future Conditions

## 3.1 Current and Future Conditions

The following sub-sections discuss the current and anticipated conditions within the watershed as studied by various entities in recent years.

### 3.1.1 St. Louis Regional Hazard Mitigation Plan

The St. Louis Regional Hazard Mitigation Plan was developed by the EWG in 2004. The plan was developed with funding from Missouri's SEMA and is revised every 5 years. The current plan is in effect for 2015-2020 and covers the Missouri portion of the St. Louis region, including St. Louis City, Franklin, Jefferson, St. Charles and St. Louis counties, 135 municipalities, and 50 school districts. There is currently a 2019 draft Hazard Mitigation Plan Update for 2020-2025 under development, which has been submitted to SEMA/FEMA for approval.

According to the Missouri Office of Administration, Division of Budget and Planning, from 2010-2030, Jefferson County is expected to increase in population from 222,183 to 260,276 people, a 15% increase.

## 3.2 USACE – Climate Change and Hydrology Literature for the Upper Mississippi River Region

Climate change, as it relates to extreme precipitation events, has been the focus of numerous studies in recent years. **Figure 4** shows percent change based on linear trends in annual precipitation, 1895-2009, shown as a percent change per century. The Lower Meramec Watershed is included in the dark green category which shows an increase in annual precipitation of 5%-10% change per century.

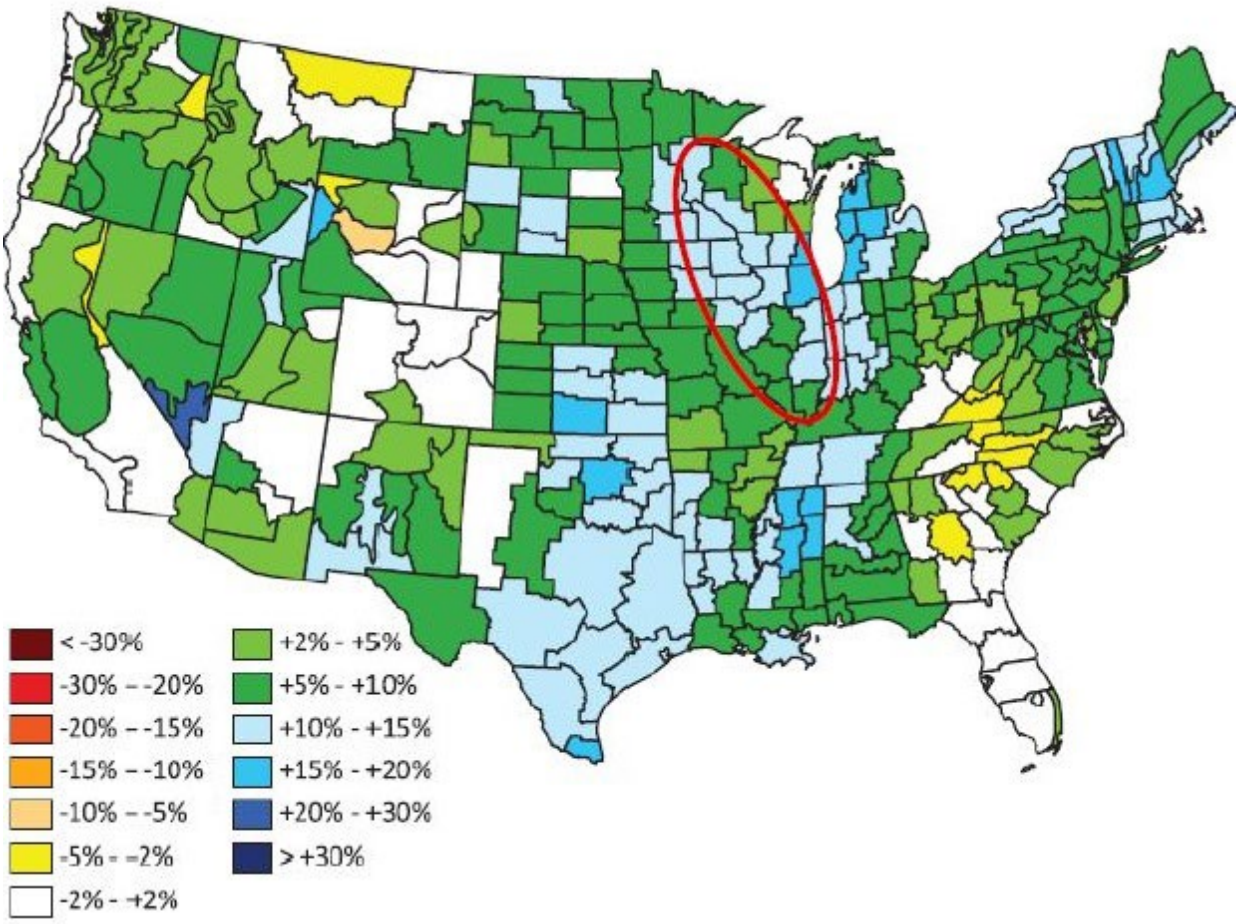


Figure 4. Linear trends in annual precipitation, 1895-2009, percent change per century

The red oval indicates the Upper Mississippi River Region (McRoberts and Nielsen-Gammon, 2011)

**Figure 5** comes from the USACE Institute for Water Resources (IWR) publication titled “Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions - Upper Mississippi Region 07”, published in June 2015. The figure shows the observed and projected trends and literature consensus for environmental factors such as temperature, precipitation, and hydrology/streamflow. Observations have shown a large increase in precipitation, while a small increase is projected for the future. When it comes to extreme precipitation, trends have shown a small increase, which is also projected for the future. The observed and projected trends indicate increased average and extreme precipitation and a variable trend in hydrology and streamflow.

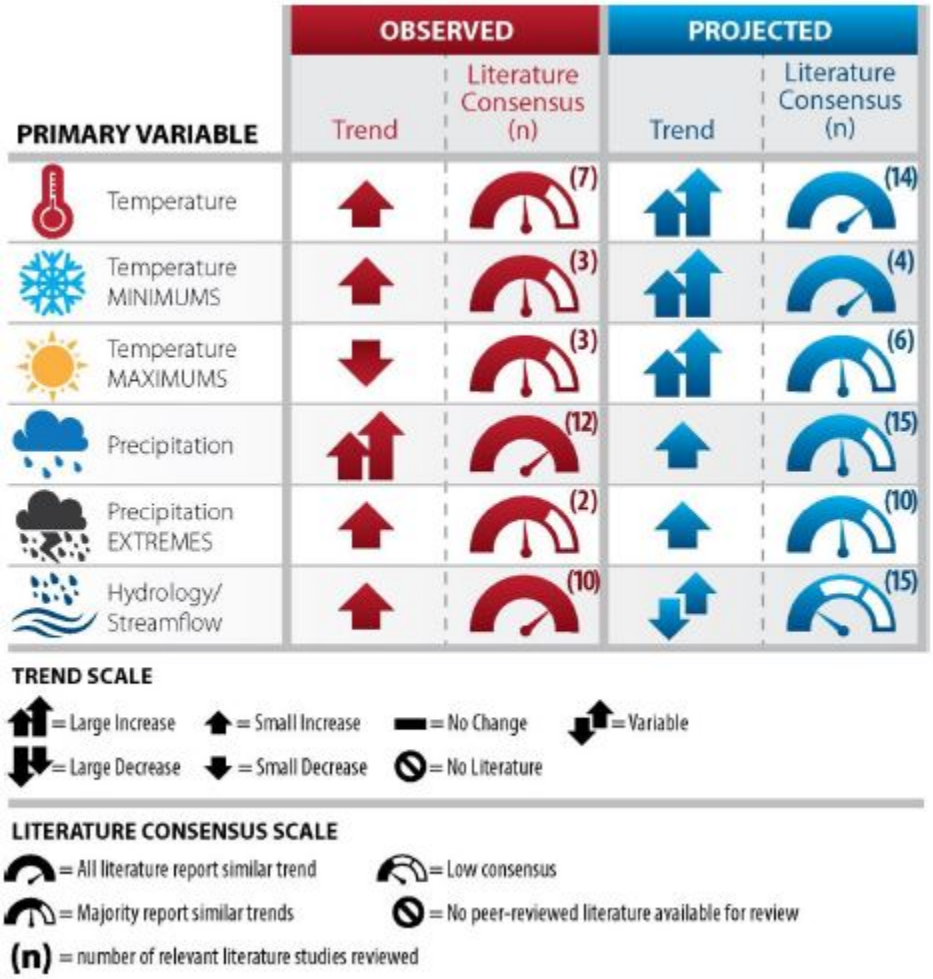


Figure 5. Summary matrix of observed and projected climate trends and literary consensus (USACE Institute for Water Resources)

This study considered the potential flood extent of a hypothetical 10% increase to 1-percent AEP discharge to determine potential future flood conditions. FEMA's calibrated Hydrologic Engineering Center - River Analysis System model and 1-percent AEP discharge (used to develop 2019 Flood Insurance Study or FIS) were used for this effort.

"Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions - Upper Mississippi Region 07", published in June 2015, was used as the report noted 5-10% increase in annual precipitation percent change per century. For hypothetical purposes of this FMP, this annual precipitation increase was directly related to 10% increase in discharge (runoff).

Assuming a 10% increase to FEMA's 100-year discharge, the average depth of flooding in the Lower Meramec Basin would increase by approximately 0.9 to 1.6 feet. **Table 11** displays the 100-year discharge plus a 10% increase. These potential future increases in flooded footprint and depth are presented for consideration only and are not utilized in any of the FMP's other analyses or recommendations. **Figures 6 through 15** demonstrate the flood footprint of the

Lower Meramec communities with an estimated 10% increase in flows, which shows wider and/or deeper flooding levels in some areas.

Table 11. 100-year discharge plus 10%

| City | FIS – Date Effective | 1-Percent AEP (cfs) | Flood Stage (ft) | 1-Percent AEP (cfs), plus 10% | Flood Stage (ft) | Flood Increase (ft) |
|---|---|---|---|---|---|---|
| Confluence of Big River (Eureka, MO) | 2/4/2015 | 133,000 | 42.08 | 146,300 | 43.63 | 1.55 |
| Upstream of Confluence of the Bourbeuse River (Sullivan, MO, Upper Meramec) | 9/14/2018 | 78,900 | 33.75 | 86,790 | 35.06 | 1.31 |
| Union, MO, Gage at Hwy 50 (Bourbeuse River) | 9/14/2018 | 39,600 | 28.17 | 43,560 | 29.29 | 1.12 |
| Bymesville, MO (Big River) | 6/20/2019 | 58,200 | 29.42 | 64,020 | 30.30 | 0.88 |
| *Currently effective Flood Insurance Study (FIS) was used to obtain 1-Percent AEP. | | | | | | |
| ** Latest USGS Rating Table was used to obtain discharge/stage relationship | | | | | | |

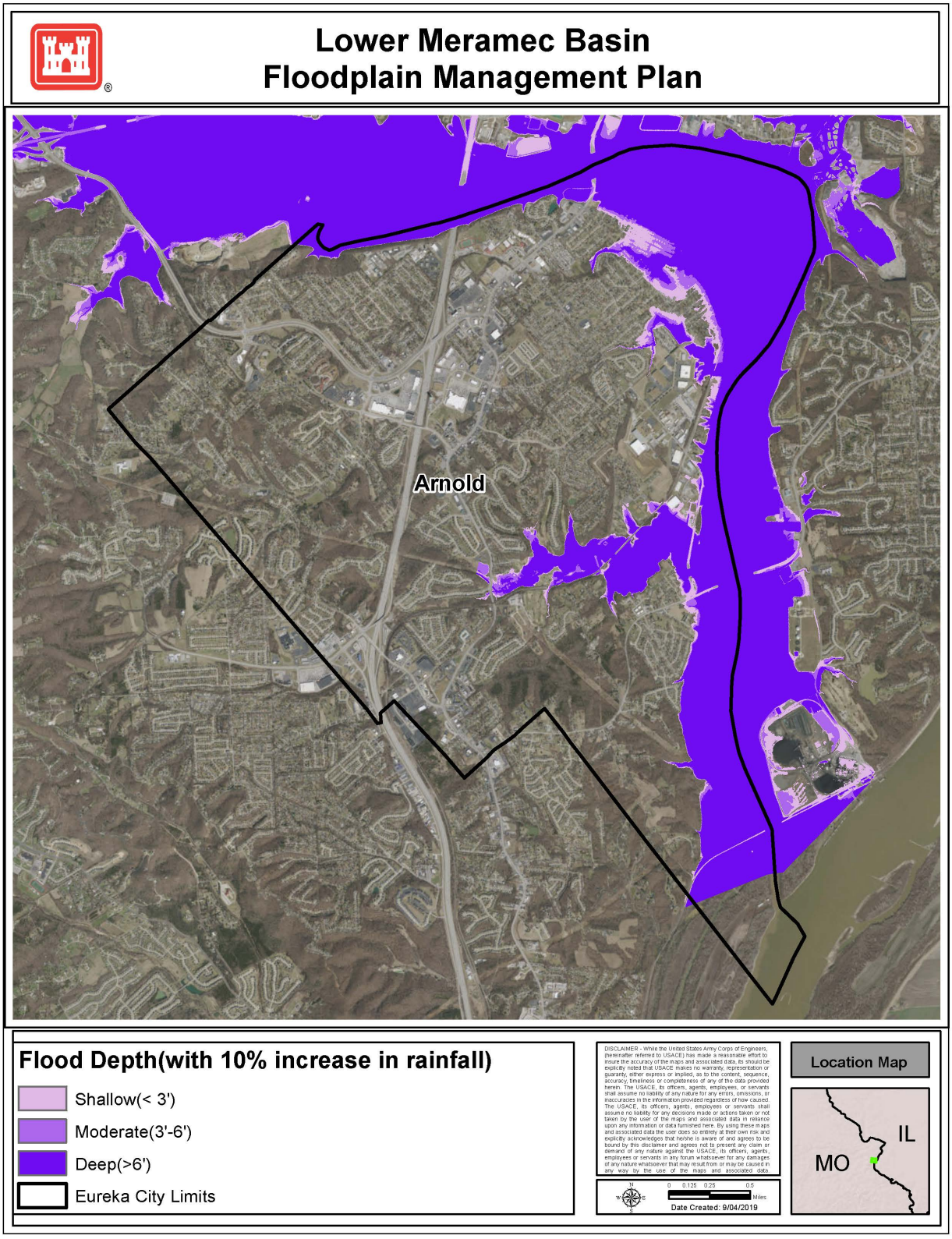


Figure 6. Flood Depth with 10% Increase in Rainfall - City of Arnold

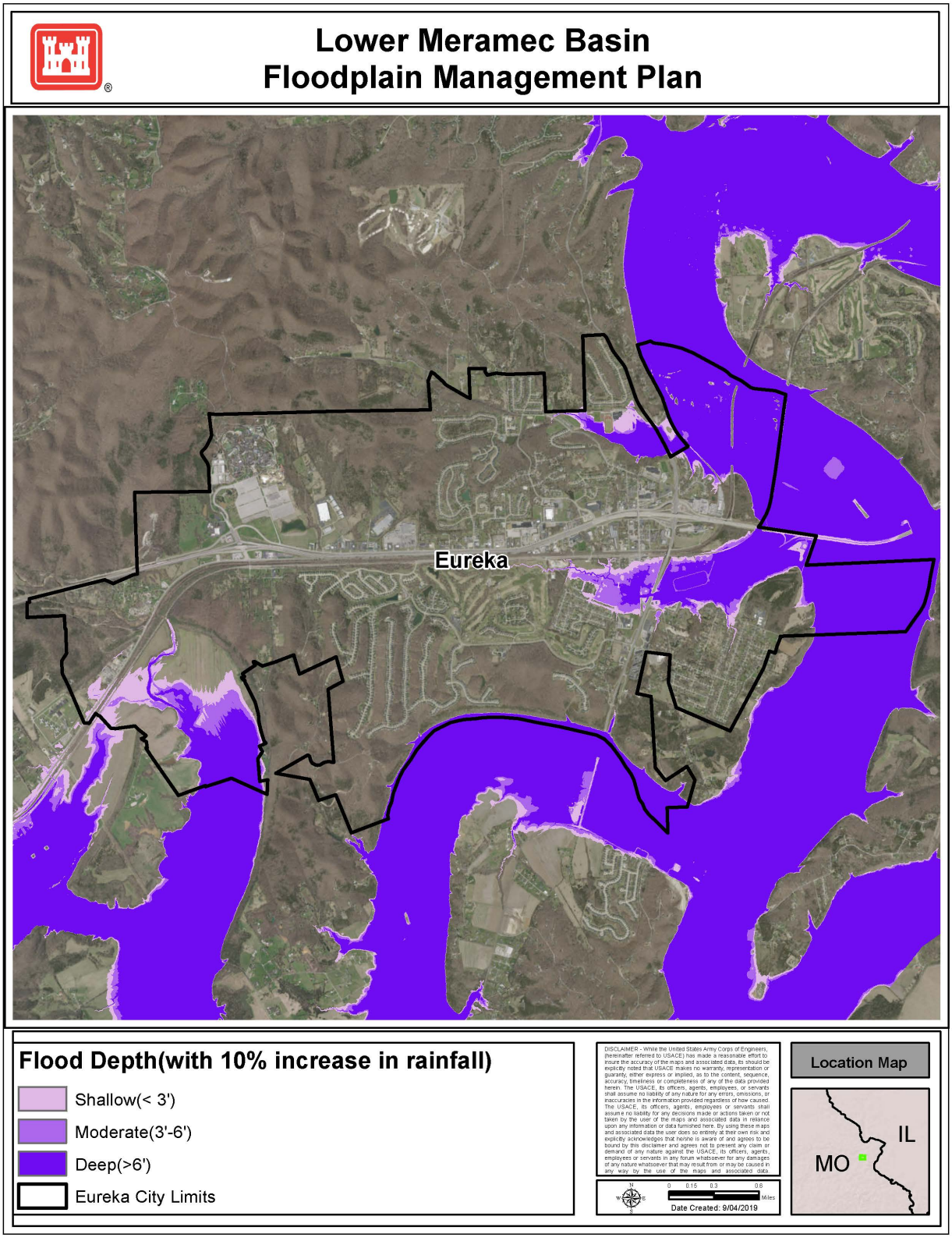


Figure 7. Flood Depth with 10% Increase in Rainfall - City of Eureka

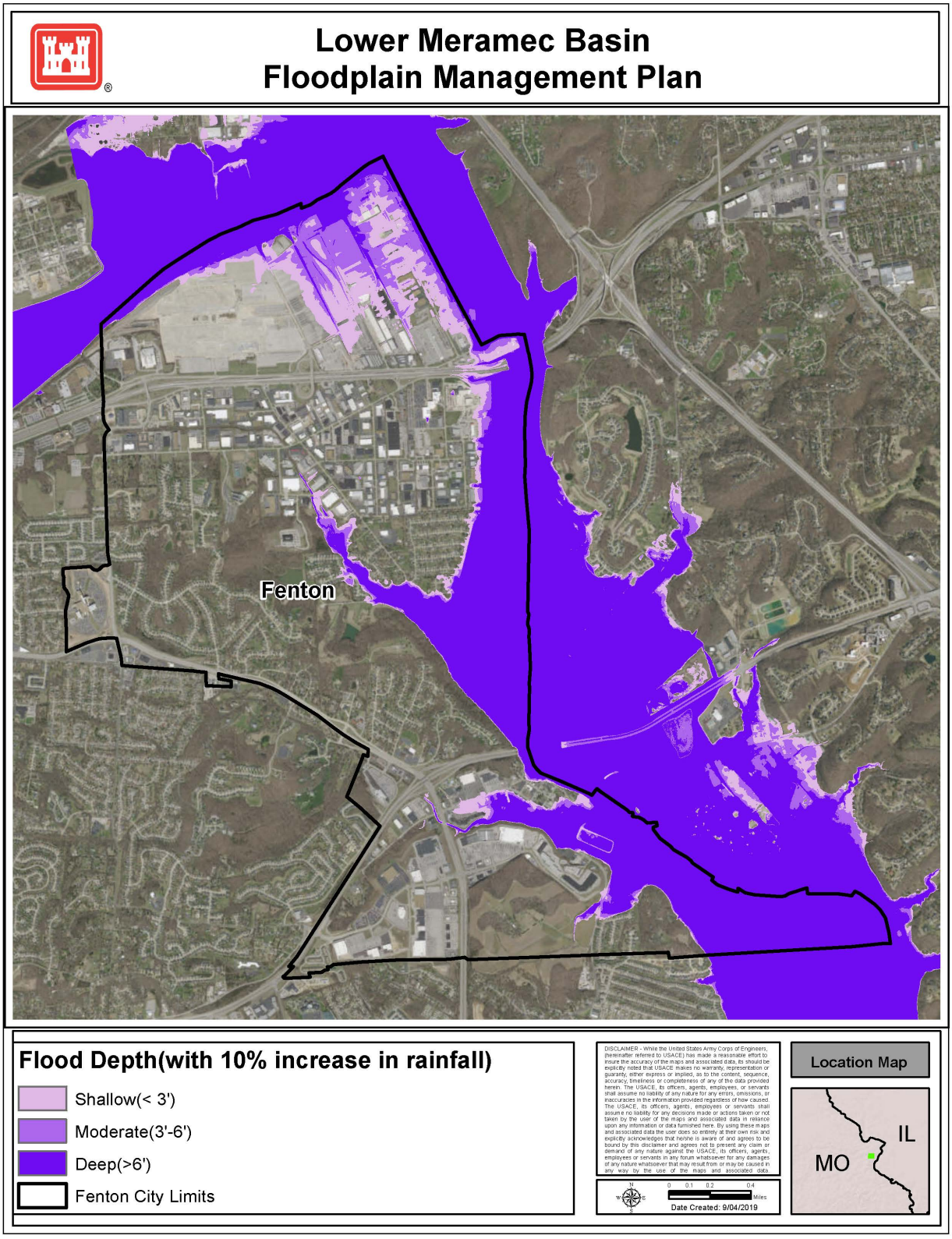


Figure 8. Flood Depth with 10% Increase in Rainfall - City of Fenton

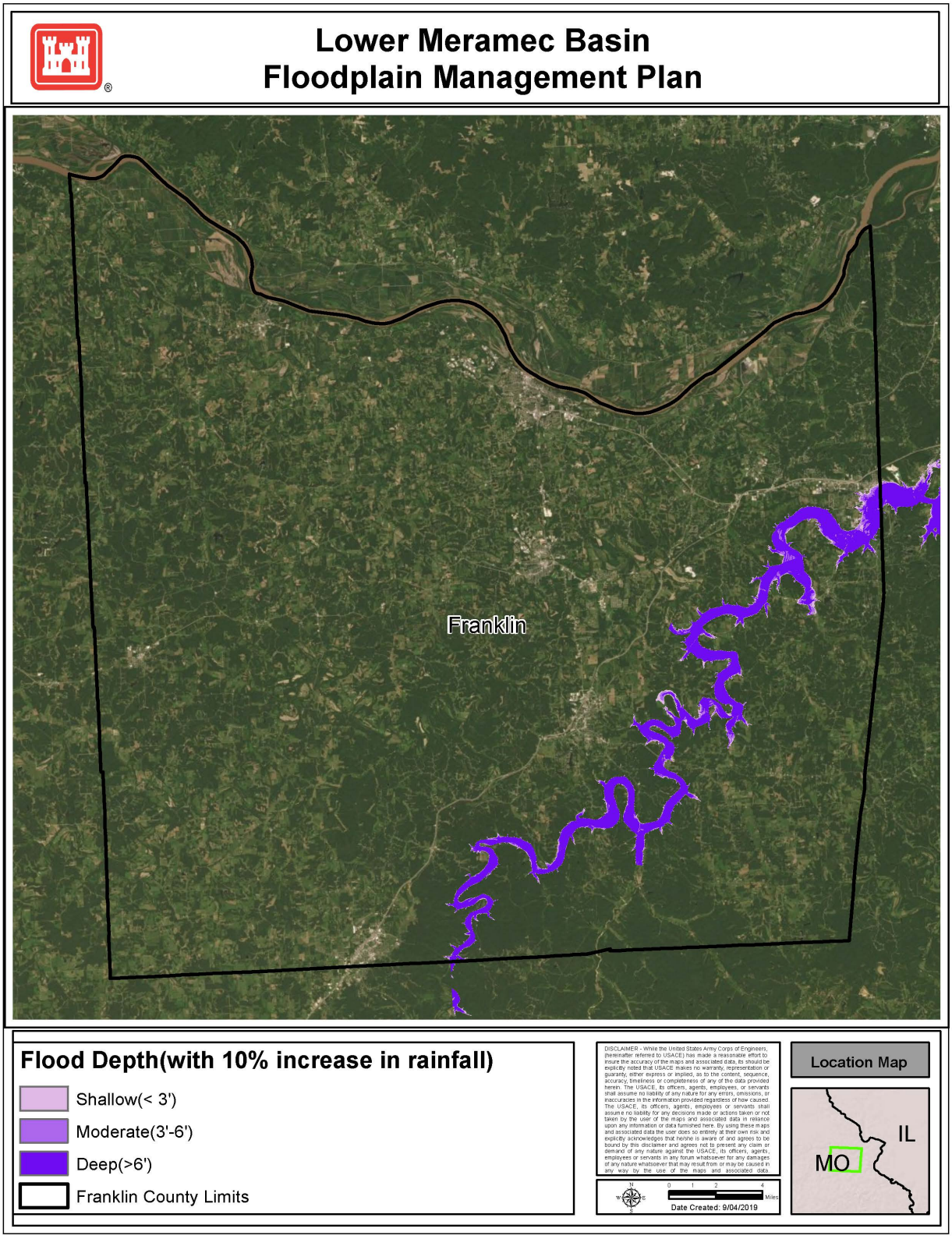


Figure 9. Flood Depth with 10% Increase in Rainfall - Franklin County

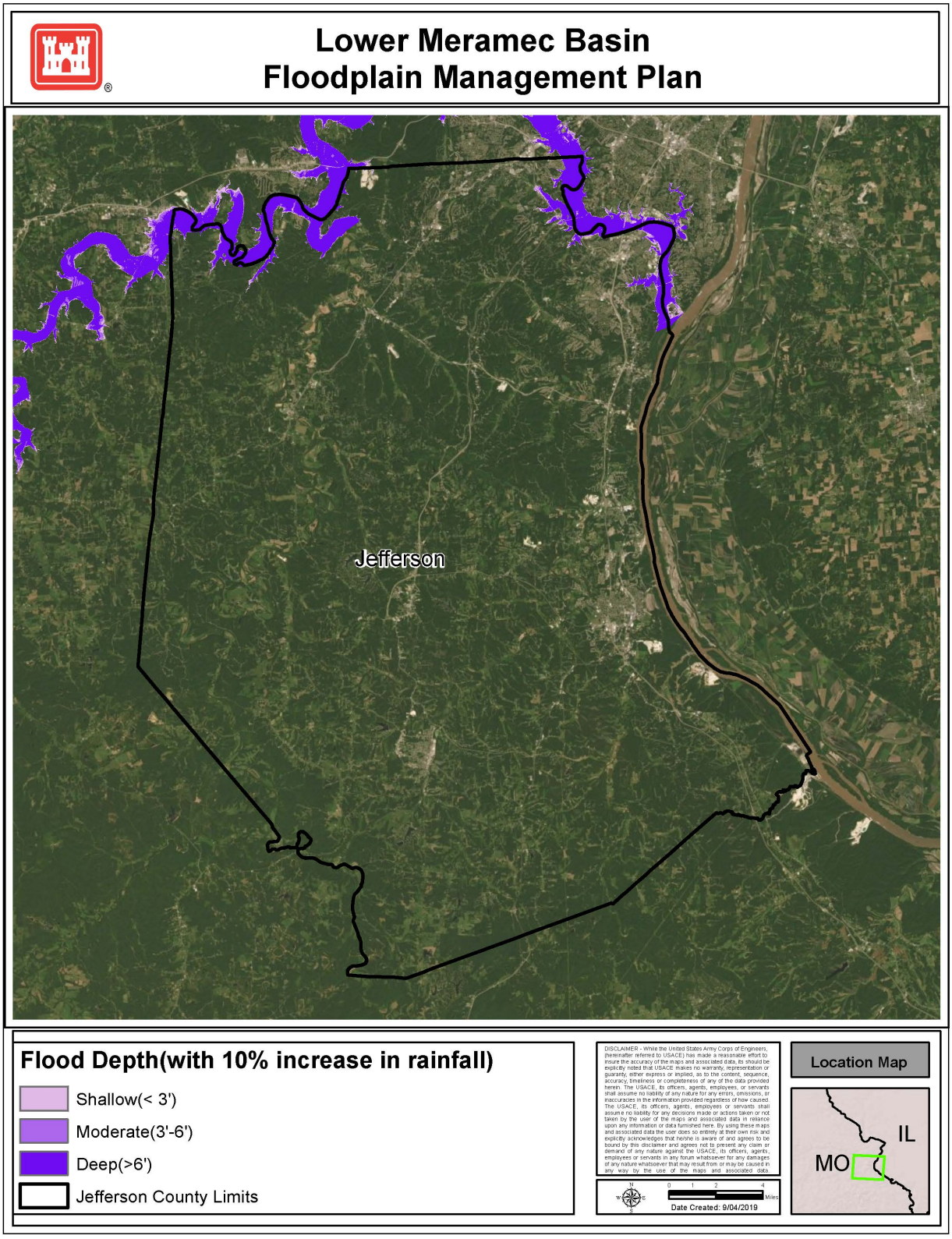


Figure 10. Flood Depth with 10% Increase in Rainfall - Jefferson County

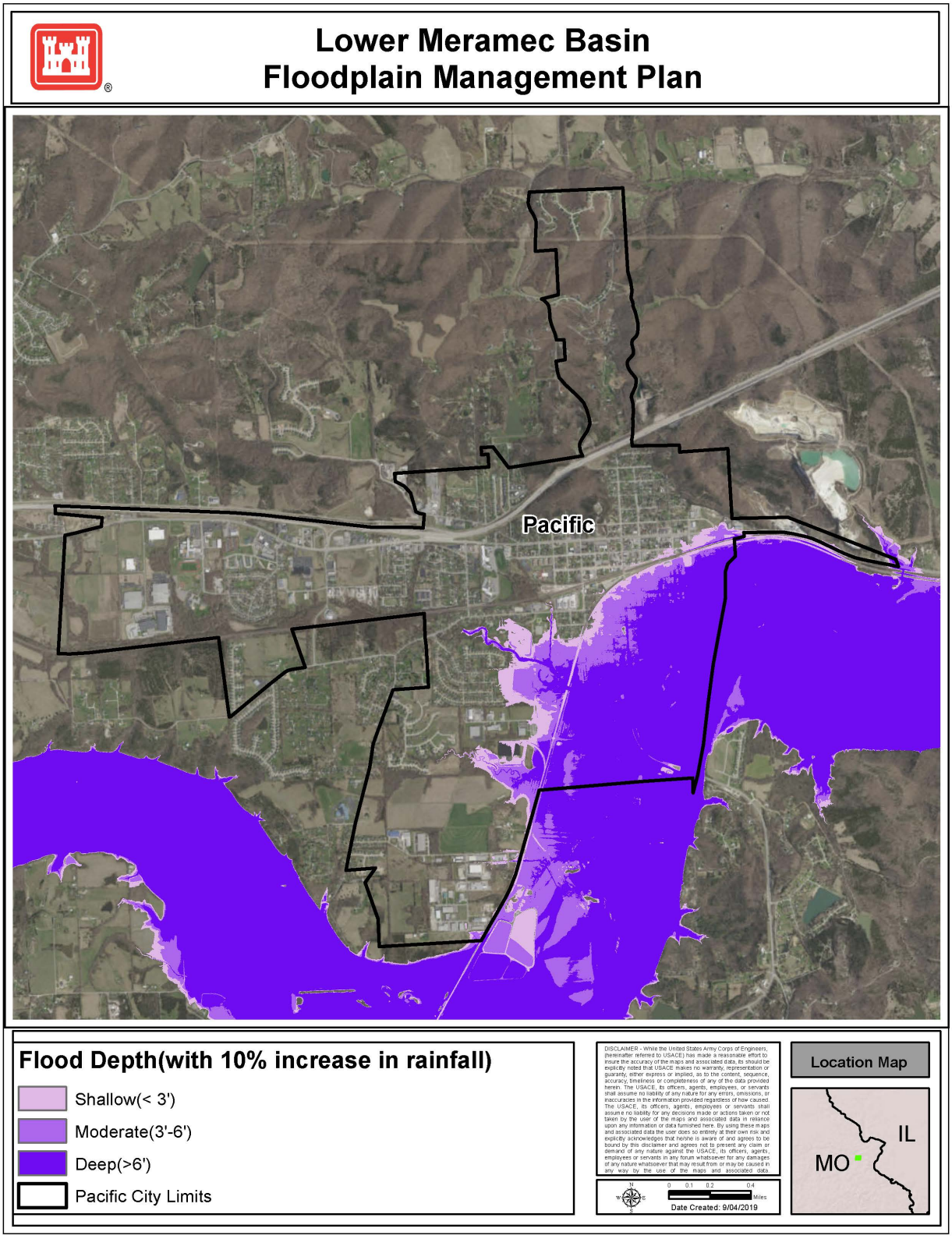


Figure 11. Flood Depth with 10% Increase in Rainfall - City of Pacific

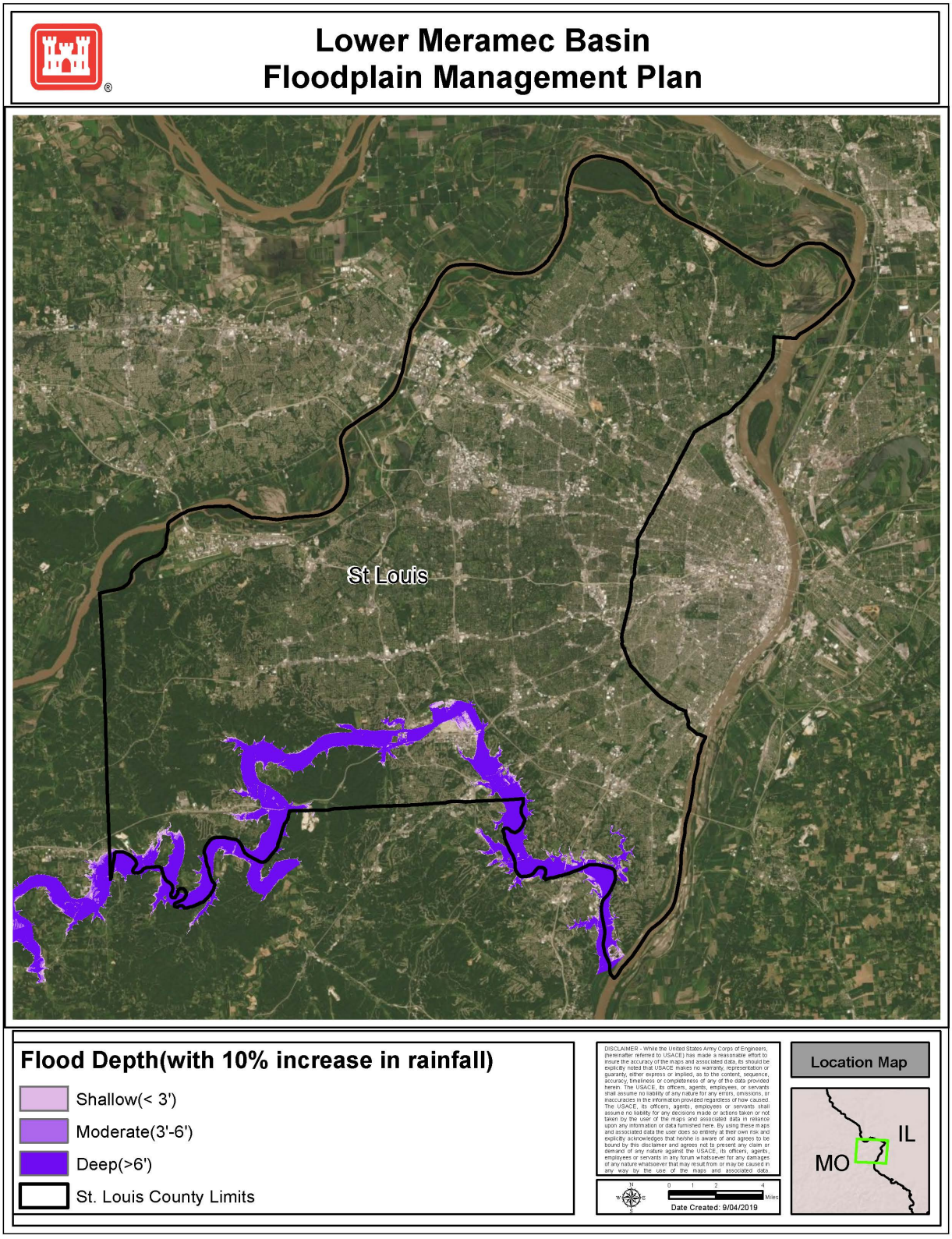


Figure 12. Flood Depth with 10% Increase in Rainfall - St. Louis County

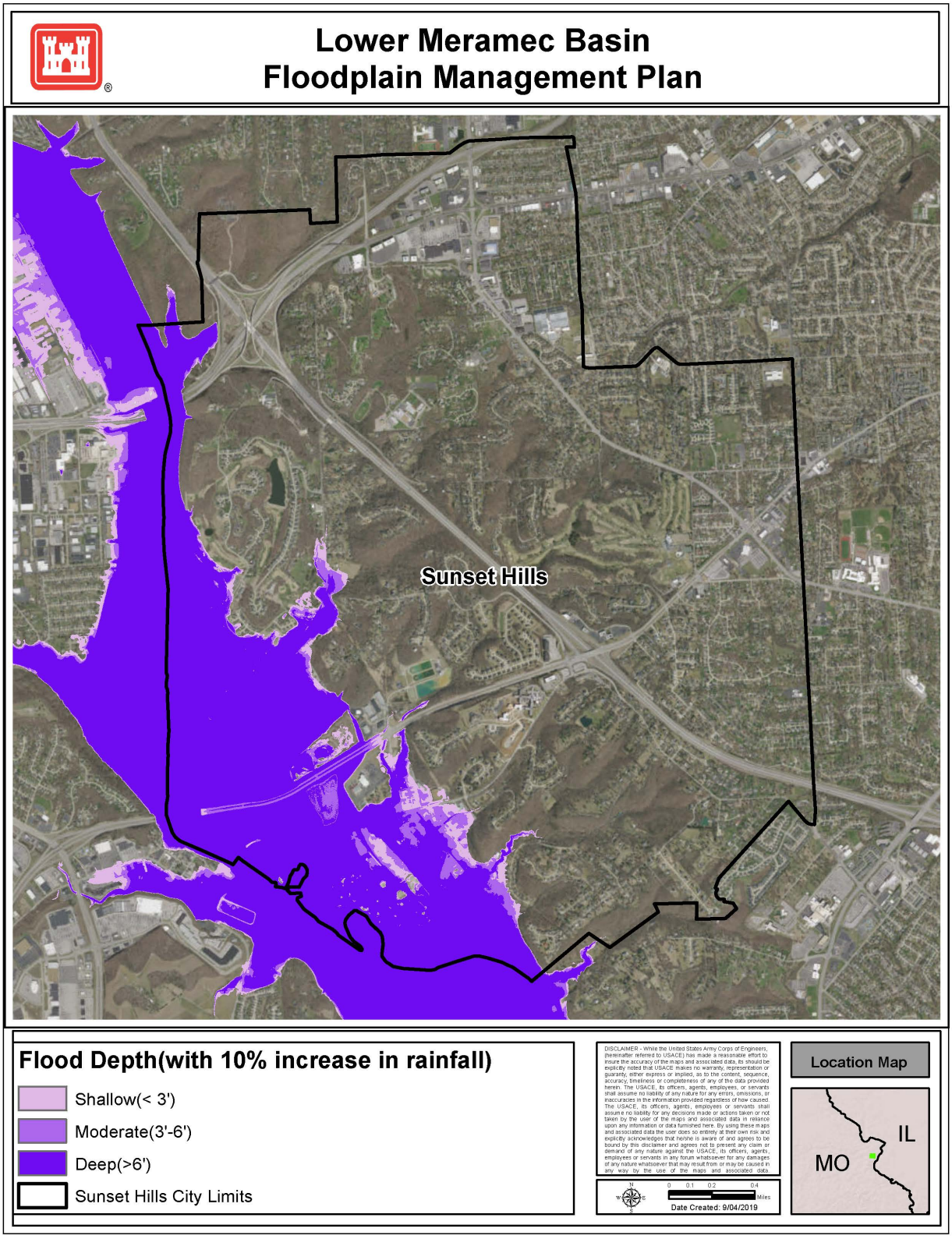


Figure 13. Flood Depth with 10% Increase in Rainfall - City of Sunset Hills

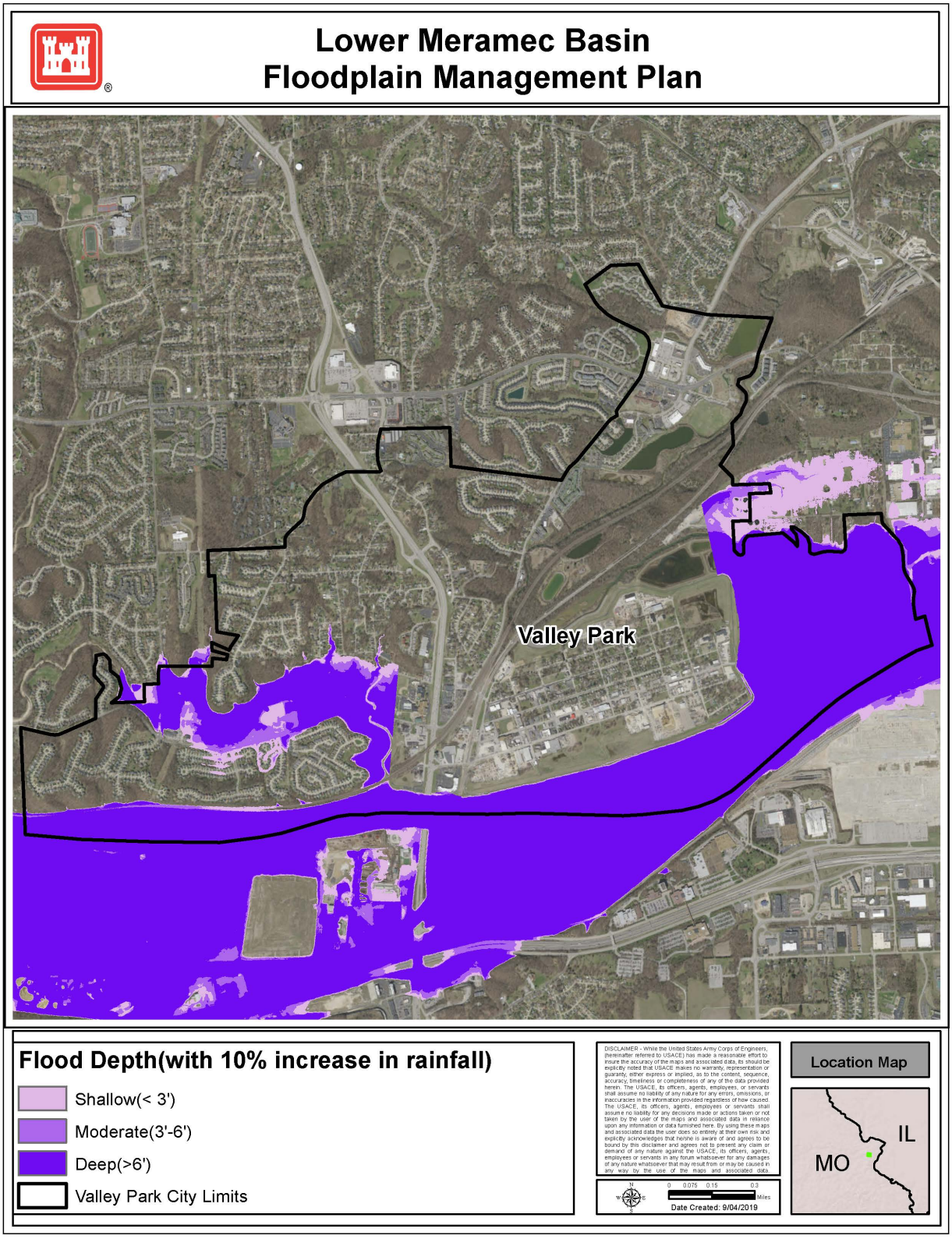


Figure 14. Flood Depth with 10% Increase in Rainfall - City of Valley Park

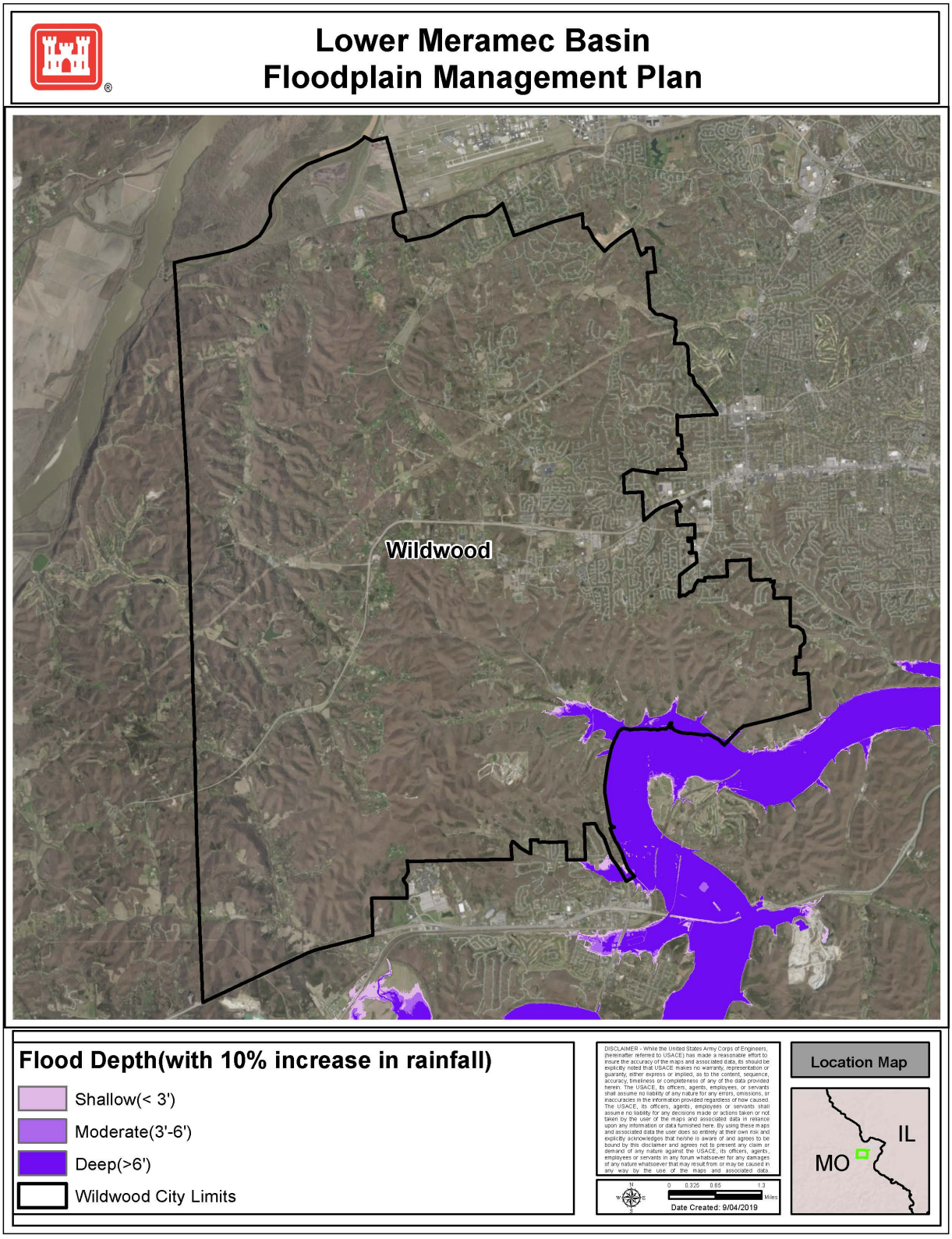


Figure 15. Flood Depth with 10% Increase in Rainfall - City of Wildwood

If trends and literature studies are accurate, the watershed will see increased precipitation in the coming decades, likely worsening the flooding conditions. The structures will continue to regularly flood and annual damages will continue to put a strain on the City's and County's residents and businesses, economies, resources, and capacities. In addition to the economic damages, there will continue to be a risk to the health and safety of Lower Meramec Basin communities.

### 3.2.1 Meramec River Basin

Based on the St. Louis Regional Hazard Mitigation Plan dated July 2015 and approved by FEMA, flooding potential is identified as a high probability of occurrence and is demonstrated by the frequency of recent record setting floods in the Lower Meramec Basin resulting in two Federal Disaster Declarations within sixteen months. For this section, future flood conditions will be more severe based on current climate trend and warrant public and political support to align and carryout recommendations of this regional floodplain management plan. It is worth noting that the updated Hazard Mitigation Plan covering years 2020-2025 is currently awaiting FEMA/SEMA approval.

#### 3.2.1.1 City of Pacific

The City of Pacific, located on the Meramec River 40 miles southwest of St. Louis in Franklin County, has a population of 6,047. The median home value is $146,800, and median household income is $41,054. The unemployment rate is 10 percent. Five percent of the homes sustained flood damage in 2015 with a total verified loss of $1.4 million. Estimated infrastructure damage was $945,043. The city has a nine-member Planning and Zoning Commission that approves and maintains the City's Comprehensive Plan, Zoning Code and Zoning Map. The 2014 Comprehensive Plan update included an extensive public participation program designed to identify community values and build consensus. Pacific sustained significant flood damage in 2015 and 2017 floods.

#### 3.2.1.2 City of Eureka

The City of Eureka, located less than 30 miles from St. Louis along the Meramec River, has a population of 10,375. The median home value is $220,000, and the median household income is $82,596. Eureka is located within the 11th wealthiest zip code in the St. Louis Region and is also the fastest growing municipality in the county. The unemployment rate is 3.5 percent. Since 2015, more than four percent of the homes have sustained flood damage with a total verified loss of $2.2 million. The estimated infrastructure damage is $2 million. Two-thirds of the historic downtown district has been impacted by 5 flood events since 2015. Properties in Eureka were flooded that had not previously flooded in the former 1982 flood of record. There is a nine-person Planning and Zoning Commission but no planning staff. The city owns and operates its own water and sanitary sewer systems. In April 2018, voters passed Proposition E, a ½ percent sales tax allowing the City of Eureka to generate $15.9 million for public safety projects over 20 years, of which $2 million is identified towards flood mitigation projects to build resilience. The City of Eureka has a floodplain ordinance in place that requires a permit "for all proposed construction or other development, including the placement of manufactured homes" within the city limits if that property is identified as a numbered or unnumbered A or AE Zone on the Flood Insurance Rate Map (FIRM) (See Appendix G for additional information on flood zone

definitions and descriptions.) The ordinance also formally establishes the Building Commissioner as the Floodplain Administrator and allows a maximum of 1 foot of surcharge from any project. The full language of this ordinance can be found in Appendix B.

#### 3.2.1.3 City of Wildwood

No data was provided.

#### 3.2.1.4 City of Valley Park

The City of Valley Park, located 30 miles southwest of St. Louis along the Meramec River, has a population of 6,980. The median home value is $169,300, with a median household income of $57,252. The labor force participation is 72 percent. In the 2015 flood, nearly two percent of the homes were damaged with a total verified loss of $422,097. The estimated infrastructure damage is $346,700. Meramec River flooding caused major interstate and state highway closures. The city is protected by a levee, but FEMA analysis has revealed that sections of the levee system are below the elevations required by FEMA for accreditation, meaning the levee cannot reasonably exclude the base flood. The 44.1-foot gage level recorded on the Valley Park gage in December, 2015, was approximately the top of the floodwall, near the Railroad Gate Closure.

#### 3.2.1.5 City of Fenton

The City of Fenton, a suburb of St. Louis located along the Interstate 44 corridor, has a population of 4,037. The median home value is $238,900, and the median household income is $92,321. In the 2015 flood, almost 11 percent of the homes sustained flood damage with a total verified loss of $3 million. The estimated infrastructure damage is $1.2 million. The city experienced the loss of their sewage treatment plant and closure of a major transportation link - Interstate 44. The Community Development Department, which includes 3 staff, is responsible for residential and commercial zoning approval, zoning information, and economic development.

#### 3.2.1.6 City of Sunset Hills

No data was provided.

#### 3.2.1.7 City of Arnold

The City of Arnold, a city located 28 miles south of St. Louis along Interstate 55, has a population of 21,020. The median home value is $145,900, and median household income is $56,329. Less than three percent of the total homes were impacted with more than $2.6 million in damages. While substantial structure acquisitions have removed at-risk structures from flood hazard areas (approximately 589 structures impacted by the 1.0% and 0.2% AEP flood events) almost all remaining structures are occupied. The city government is well staffed with economic development, community development, and planning and zoning departments. **Figure 16** shows the parcels that have been acquired by the City of Arnold.

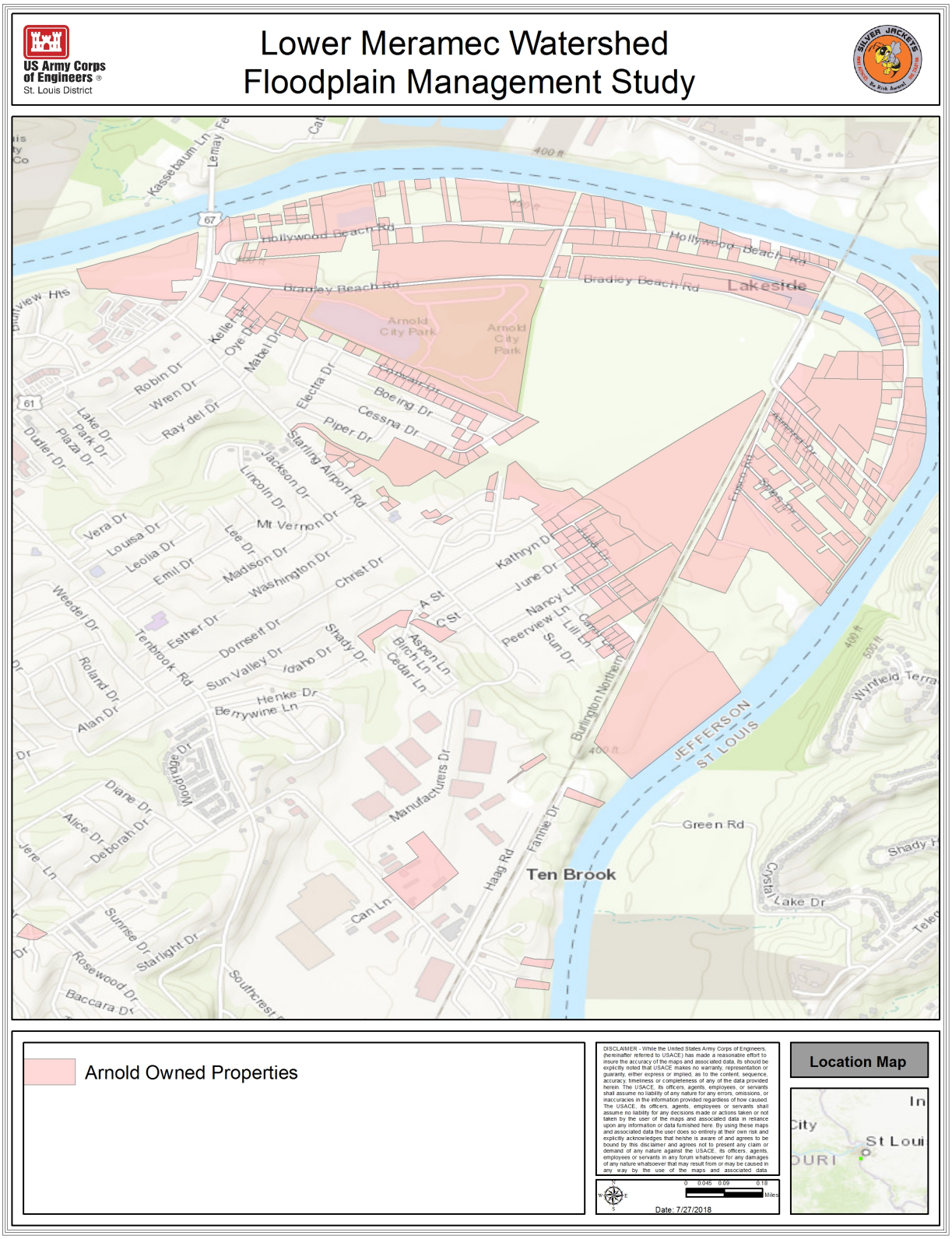


Figure 16: Parcels owned by the City of Arnold to mitigate for flood impacts

### 3.2.2 Big River Sub-Basin

#### 3.2.2.1 Eureka

The City of Eureka is the only community that touches the Big River within the Project Area and has been included as part of the Meramec River Basin. The City experienced two floods of record within a 16-month period which damaged homes, businesses, schools, and critical infrastructure. The flood in December 2015, located within the declared area for federal disaster assistance (DR-4250-MO), impacted more than 4% of homes in the City with more than $2.2M in documented damages and estimated infrastructure damages of approximately $2M. Two-thirds of the historic downtown district were impacted. Approximately sixteen months later in May 2017, record flood levels were recorded in the City, which was again located within the declared area for federal disaster assistance (DR-4317-MO). Several flood events from intense rainfall not attributable to Meramec River flooding have occurred in addition to the 2015 and 2017 events.

### 3.2.3 Bourbeuse River Sub-Basin

#### 3.2.3.1 City of Union

The City of Union, located on the Bourbeuse River in Franklin County 50 miles southwest of St. Louis, has a population of 10,517. The median home value is $138,900, and the median household income is $42,315. The labor force participation rate is 71 percent. In 2015, one percent of the homes were damaged with a total verified loss of $800,269. The estimated infrastructure damage is $263,600. Many businesses were impacted when the Bourbeuse River rose to approximately 20 feet above flood stage. Union's 2020 Comprehensive Plan was adopted in 2011. Union has a 10-member Planning and Zoning Commission and an Economic Development Department. Additionally, the Union Development Corporation, a non-profit volunteer corporation, was formed in 1955 to aid the city in the recruitment of industrial development assistance for existing businesses. Union sustained moderate flood damage and appears to have sufficient capacity to manage its recovery.

## 4 Floodplain Hazard Assessment

In their natural state, rivers are "designed" to flood into their floodplains in approximately half of all years (American Rivers 2019). Flooding is defined by the rising and overflowing of a body of water onto normally dry land. As defined by FEMA, a flood is a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties. Flooding can result from an overflow of inland waters or an unusual accumulation or runoff of surface waters from any source.

Certain health hazards are also common to flood events. While such problems are often not reported, three general types of health hazards accompany floods. The first comes from the water itself. Floodwaters carry anything that was on the ground that the upstream runoff picked up, including dirt, oil, animal waste, and lawn, farm and industrial chemicals. Pastures and areas where farm animals are kept or their wastes are stored can contribute polluted waters to the receiving streams.

Floodwaters also saturate the ground, which leads to backflow into sanitary sewer lines. When wastewater treatment plants are flooded, there is nowhere for the sewage to flow. Inundation

and lack of treatment can lead to overloaded sewer lines that can back up into low-lying areas and homes. Even when it is diluted by flood waters, raw sewage can be a breeding ground for bacteria such as *Escherichia coli* (E. coli) and other disease causing agents.

The second type of health problem arises after most of the water has gone. Stagnant pools can become breeding grounds for mosquitoes, and wet areas of a building that have not been properly cleaned breed mold and mildew. A building that is not thoroughly cleaned becomes a health hazard, especially for small children and the elderly.

Another health hazard occurs when heating ducts in a forced air system are not properly cleaned after inundation. When the furnace or air conditioner is turned on, the sediments left in the ducts are circulated throughout the building and are breathed in by the occupants. Additionally, if the local water system loses pressure, a boil order may be issued to protect people and animals from contaminated water.

The third problem is the long-term psychological impact of having been through a flood and seeing one's home damaged and personal belongings destroyed. The cost and labor needed to repair a flood-damaged home puts a severe strain on people, especially the unprepared and uninsured. There is also a long-term problem for those who know that their homes can be flooded again. The resulting stress on floodplain residents takes its toll in the form of aggravated physical and mental health problems.

Areas susceptible to flooding along the Lower Meramec River Basin include industrial, commercial, urban, and rural developments. The largest source of information on flooding hazards in the area comes from the FEMA FIRMs. These maps are updated by county, and a summary of the ongoing updates in each county within the project area are summarized in **Table 12**, below. Appendix G contains the effective FIRMs for each community.

*Table 12. Status of Initial and Updated Countywide Flood Insurance Rate Maps (FIRMs)*

| County | Initial Countywide Effective Date | Revised Countywide Effective Date(s) | Anticipated Countywide Updates |
|---|---|---|---|
| **Franklin** | October 18, 2011 | | 2021-2022 |
| **Jefferson** | April 5, 2006 | June 20, 2019 | |
| **St. Louis** | August 2, 1995 | August 23, 2000<br>February 4, 2015 | 2021 |

## 4.1 FEMA Hazard Mitigation Assistance Program and Repetitive Loss Structures

FEMA administers three programs that provide funding for eligible mitigation planning and projects that reduces disaster losses and protect life and property from future disaster damage. The three programs are the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance Program, and the Pre-Disaster Mitigation Program. FEMA also encourages integration of Sections 404 (HMGP) and 406 (PA) of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (Stafford Act), to promote more resilience during the recovery and mitigation process.

A state with a FEMA approved Enhanced State Mitigation Plan at the time of a disaster declaration is eligible to receive increased funds under HMGP, based on 20 percent of the total estimated eligible Stafford Act disaster assistance. As an Enhanced State Mitigation Plan, the Missouri plan update continues to build upon Missouri's commitment to reduce or eliminate the impacts of the effect of natural hazards. This designation recognizes current and ongoing proactive efforts in implementing a comprehensive mitigation program. The enhanced status acknowledges the coordinated effort the state is taking to reduce losses, protect life and property, and create safer communities. The HMGP exists "to help communities implement hazard mitigation measures following a Presidential Major Disaster Declaration in the areas of the state, tribe or territory requested by the Governor or Tribal Executive". Since 1989 there have been 1,485 major disaster declarations resulting in the availability of $13.8 billion in HMGP funds (as of February 2017). There have been 979 properties purchased by HMGP in the project area.

Flood mitigation projects continue to be the State's highest priority. While buyouts are not the only mitigation projects considered and undertaken by the State and local governments, they have been the type of project most frequently executed. Missouri has been proactive with regards to buyouts. SEMA maintains a database of potential mitigation projects from around the state. These potential project submittals are accepted at any time and are not limited to a certain period of time after disasters. This ensures a pool of potential projects from around the state from which to choose from when funding is available.

The Missouri SEMA and FEMA keep track of properties that have been acquired due to repeated flooding as well as those that are considered "repetitive loss" properties. FEMA defines a repetitive loss property as "any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978".

There are 455 repetitive loss structures in the project area, none of which have been mitigated, and 279 (61%) of these structures are no longer insured.

- There are 88 repetitive loss structures in the project area in Franklin County, most of which are within the Pacific city limits (60 properties), the remaining 23 are spread throughout the area.
- There are 199 repetitive loss structures in the project area in Jefferson County.
- There are 168 repetitive loss structures in the project area in St. Louis County, most of which are in the Fenton/Valley Park/Sunset Hills area.

## 4.2 Franklin County Flood Insurance Rate Maps

The majority of Franklin County within the project area is rural land. The two urban areas are Union, on the Bourbeuse River, and Pacific, on the Meramec River. FEMA's FIRMs for Franklin County can be found in Appendix G.

Most of the structures in the floodplain in Union are commercial properties. A total of 538.74 acres within the Union City limits are currently designated as either A or AE zoned floodplain. This accounts for approximately 9.2% of the city. As Union is in the uppermost reaches of the watershed, this flooding is due to runoff from extreme rainfall events. Union does not see backwater effects from the Meramec River.

The main-stem Meramec River is the source of flooding in Pacific. Since the City of Pacific is considerably upstream from the mouth, the city does not see backwater flooding from the Meramec River. The City of Pacific is mostly within the Franklin County boundary with portions of the city's easternmost boundary lying in St. Louis County. As of the 2011 floodplain maps for Franklin County and 2015 floodplain maps for St. Louis County, 821.9 acres within the city limits are delineated floodplain, accounting for nearly 22% of the city's footprint.

For the portion of the county that was recently remapped, the maximum depth of flooding for the 1% AEP event is nearly 43 feet with a maximum velocity of approximately 16 feet per second. With numerous gages and forecasted points along the Meramec and Bourbeuse Rivers, residents usually have 24 hours warning prior to a flood event. There are 88 repetitive loss structures in the project area in Franklin County, most of which are within the Pacific city limits (60 properties); the remaining 23 are spread throughout the area.

## 4.3 Jefferson County Flood Insurance Rate Maps

The majority of Jefferson County within the project area is suburban and rural land. The Meramec River forms the northern county boundary while the Big River runs south to north in the western third of the county. FEMA's FIRMs for Jefferson County can be found in Appendix G.

Most of the structures in the floodplain are in the northeast portion of the county along the Meramec River. Over 15,000 acres within the county limits are currently designated as either A or AE zoned floodplain within the project area. This accounts for almost 16% of the project area within Jefferson County. Due to the location of the Meramec River in the county, flooding on the lower end is highly impacted by Mississippi River stages. Backwater effects from a 1% AEP event on the Mississippi River can be seen 5.5 miles up the Meramec River, to nearly the Jeffco Boulevard/Highway 61/Highway 67 bridge. When there is a 1% AEP event on the Meramec River, effects can also be seen nearly 5.5 miles upstream. Further upstream on both the Meramec and Big Rivers, flooding is purely from rainfall within the basin.

For the portion of the floodplain in the county, which was recently remapped, the maximum depth of flooding for the 1% AEP event is 44.5 feet with a maximum velocity of approximately 8 feet per second. With numerous gages and forecasted points along the Meramec and Big Rivers, residents usually have multiple days warning prior to a flood event. There are 199 repetitive loss structures in the project area in Jefferson County.

It should also be noted that Jefferson County is designated as an EPA Superfund site due to historic mining practices in the county that have left large deposits of lead and trace amounts of other heavy metals such as arsenic and cadmium in the soil and waterways. Lead is classified by the EPA as a probable carcinogen and is a cumulative toxicant (a toxic metal that is harmful if inhaled or swallowed). Particularly vulnerable populations include young children, pregnant women, and nursing mothers.

## 4.4 St. Louis County Flood Insurance Rate Maps

The majority of St. Louis County within the project area is developed urban/suburban with the exception of the area around Castlewood State Park, West Tyson County Park, and the Forest 44 Conservation Area. FEMA's FIRMs for St. Louis County can be found in Appendix G.

For the portion of the county that was recently remapped, the maximum depth of flooding for the 1% AEP event is 66 feet with a maximum velocity over 11 feet per second. With numerous gages and forecasted points along the Meramec River, residents usually have multiple days warning prior to a flood event. There are 168 repetitive loss structures in the project area in St. Louis County, most of which are in the Fenton/Valley Park/Sunset Hills area.

## 4.5 Critical Facilities

In addition to the previously discussed hazards, there are also critical facilities within the watershed that would be vulnerable to flooding, possibly causing life-safety concerns should these facilities be inundated with flood water. Due to security issues, the exact location of these facilities is not included in this report, but the number of each type of facility within 500 feet of a mapped floodplain is included in **Table 13** below. This data source was last updated in 2012.

*Table 13: Critical and hazardous facilities in the watershed*

| Facility Type | Within 500 feet of a mapped floodplain in the Lower Meramec River Watershed |
|---|---|
| **Chemical industry** | 29 |
| **EPA FRS Facility**[1] | 241 |
| **Cellular Towers** | 0 |
| **Day care centers** | 6 |
| **Schools (K-12)** | |
| **Private Schools** | 6 |
| **Public Schools** | 17 |
| **Public Schools for the Severely Disabled** | 0 |
| **Emergency Medical Services** | 8 |
| **Urgent Care Facilities** | 2 |
| **Hospitals** | 1 |
| **Blood and Organ Banks** | 1 |
| **Law enforcement** | 2 |
| **Cemeteries & crematories** | 4 |
| **Nursing homes** | 6 |
| **Pharmacies** | 11 |
| **Veterinarian** | 27 |
| **Wastewater treatment plant** | 2 |

[1]EPA Facility Registry Service (FRS) identifies facilities, sites or places subject to environmental regulations or environmental interests.

## 4.6 Dams

The MoDNR keeps records of all of the dams in the State of Missouri for inclusion in the National Inventory of Dams. There are 79 dams in the project area, which are listed below in **Table 14**. **Figure 17** is a map of the dams or "water flow structures" as they are referenced due to the fact that they are not large-scale dam structures.

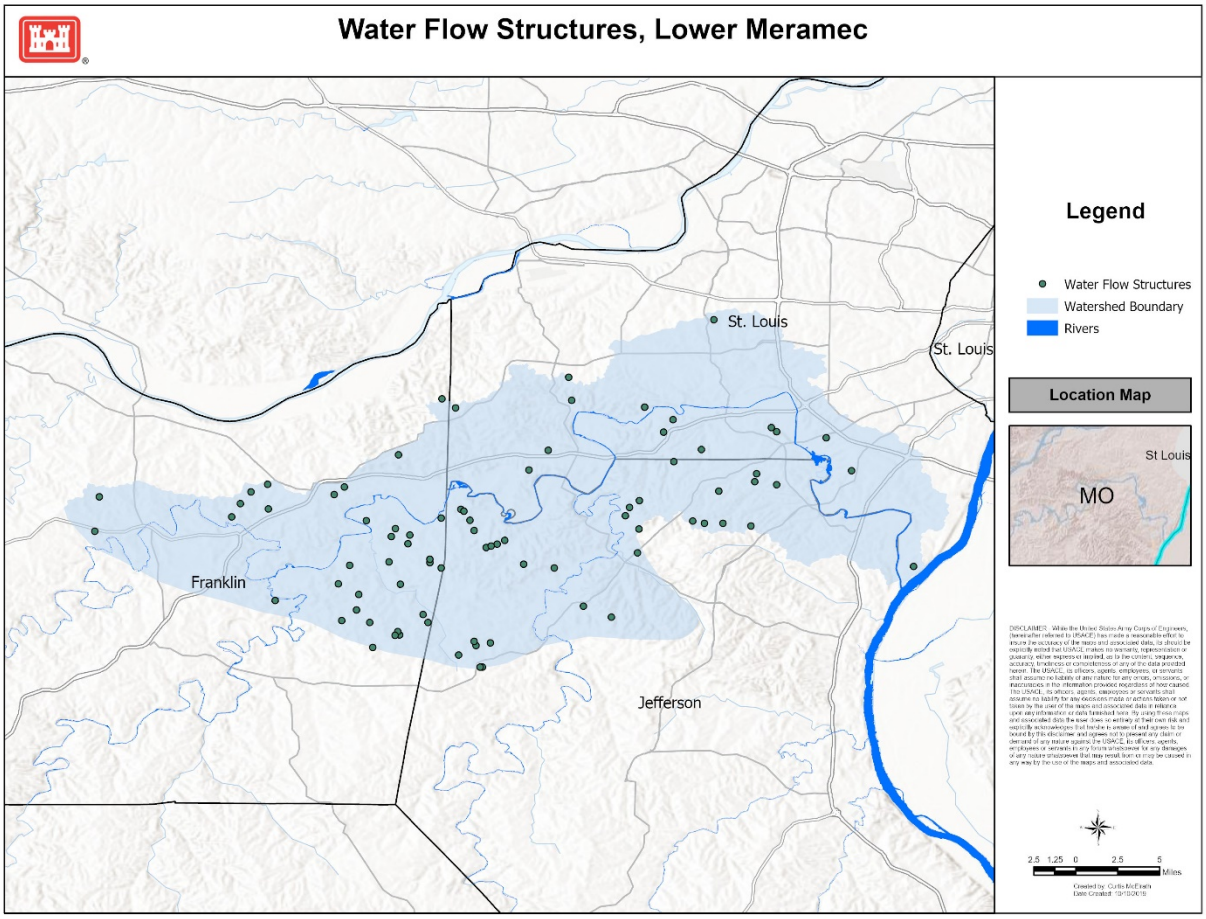


Figure 17. Lower Meramec Water Flow Structures (Dams)

*Table 14: Dams in the Project Area*

| Dam Name | NID ID (MO) | River | Year Completed | County |
|---|---|---|---|---|
| **Adriatic Lake Dam** | 30763 | Tributary to Meramec River | 1969 | Franklin |
| **Adriatic Lake Dam** | 30763 | Tributary to Meramec River | 1969 | Jefferson |
| **Anich Dam** | 40125 | Tributary to Fox Creek | 2003 | Franklin |

| Dam Name | NID ID (MO) | River | Year Completed | County |
|---|---|---|---|---|
| **Anich Dam** | 40125 | Tributary to Fox Creek | 2003 | Jefferson |
| **Bee Tree Lake Dam** | 3137 | Tributary to Meramec River | 1972 | St. Louis |
| **Boston Lakewood Park Dam** | 30804 | Tributary to Pin Oak Creek | 1970 | Franklin |
| **Boston Lakewood Park Dam** | 30804 | Tributary to Pin Oak Creek | 1970 | Jefferson |
| **Brown Lake Dam** | 31251 | Sub-tributary to Pin Oak Creek | 1972 | Franklin |
| **Brown Lake Dam** | 31251 | Sub-tributary to Pin Oak Creek | 1972 | Jefferson |
| **Buckner Dam** | 31490 | Tributary to Winch Creek | 1970 | Franklin |
| **Buckner Dam** | 31490 | Tributary to Winch Creek | 1970 | Jefferson |
| **Camp Solidarity Lake Dam** | 30539 | Tributary to the Meramec River | 1960 | Franklin |
| **Camp Solidarity Lake Dam** | 30539 | Tributary to the Meramec River | 1960 | Jefferson |
| **Cedar Lake Dam** | 30800 | Tributary to the Meramec River | 1925 | Franklin |
| **Cedar Lake Dam** | 30800 | Tributary to the Meramec River | 1925 | Jefferson |
| **Cherry Hill Dam** | 3189 | Tributary to Hamilton Creek | 1988 | St. Louis |
| **City of Fenton Dam #1** | 4013 | | Unknown | St. Louis |
| **City of Fenton Dam #2** | 3208 | | Unknown | St. Louis |
| **Emmett Brison Dam** | 30765 | Little Calvey | 1970 | Franklin |
| **Emmett Brison Dam** | 30765 | Little Calvey | 1970 | Jefferson |
| **Evergreen Lake Dam** | 31056 | Tributary to Winch Creek | 1963 | Franklin |
| **Evergreen Lake Dam** | 31056 | Tributary to Winch Creek | 1963 | Jefferson |

| Dam Name | NID ID (MO) | River | Year Completed | County |
|---|---|---|---|---|
| **Evergreen Lakes-Lower Dam** | 31057 | Tributary to Winch Creek | 1963 | Franklin |
| **Evergreen Lakes-Lower Dam** | 31057 | Tributary to Winch Creek | 1963 | Jefferson |
| **General American Life Insurance Lake Dam** | 3139 | Tributary to Meramec River | 1976 | St. Louis |
| **Guilford Lake Dam** | 3113 | Tributary to Fox Creek | 1976 | St. Louis |
| **Gundaker, G Dam** | 30543 | Tributary to Brush Creek | 1966 | Franklin |
| **Gundaker, G Dam** | 30543 | Tributary to Brush Creek | 1966 | Jefferson |
| **High Meadow Lake Dam** | 30796 | Tributary to Meramec River | 1967 | Franklin |
| **High Meadow Lake Dam** | 30796 | Tributary to Meramec River | 1967 | Jefferson |
| **Howell Lake Dam** | 31745 | Tributary to Bourbeuse River | 1967 | Franklin |
| **Howell Lake Dam** | 31745 | Tributary to Bourbeuse River | 1967 | Jefferson |
| **Johns Lake Dam (Shallow)** | 31492 | Tributary to Winch Creek | 1960 | Franklin |
| **Johns Lake Dam (Shallow)** | 31492 | Tributary to Winch Creek | 1960 | Jefferson |
| **Johnson Lake Dam** | 31491 | Tributary to Winch Creek | 1970 | Franklin |
| **Johnson Lake Dam** | 31491 | Tributary to Winch Creek | 1970 | Jefferson |
| **Jusia J Weil** | 30806 | Tributary to Flat Creek | 1969 | Franklin |
| **Jusia J Weil** | 30806 | Tributary to Flat Creek | 1969 | Jefferson |
| **Lake LaSalle Dam** | 3113 | Tributary to Carr Creek | 1955 | St. Louis |

| Dam Name | NID ID (MO) | River | Year Completed | County |
|---|---|---|---|---|
| **Lake Marion Dam** | 30571 | Tributary to Clavey Creek | 1965 | Franklin |
| **Lake Marion Dam** | 30571 | Tributary to Clavey Creek | 1965 | Jefferson |
| **Lake Serene Dam** | 30542 | Tributary of Calvey Creek | 1957 | Franklin |
| **Lake Serene Dam** | 30542 | Tributary of Calvey Creek | 1957 | Jefferson |
| **Lake Torino Dam** | 30552 | Tributary to Little Calvey Creek | 1969 | Franklin |
| **Lake Torino Dam** | 30552 | Tributary to Little Calvey Creek | 1969 | Jefferson |
| **Lake Trails Dam** | 1110 | Tributary to Meramec River | 1975 | St. Louis |
| **Lake Von Der Rosa** | 30577 | Tributary to Brady Creek | 1976 | Franklin |
| **Lake Von Der Rosa** | 30577 | Tributary to Brady Creek | 1976 | Jefferson |
| **Las Brisas Dam** | 30541 | Tributary to Little Fox Creek | 1970 | Franklin |
| **Las Brisas Dam** | 30541 | Tributary to Little Fox Creek | 1970 | Jefferson |
| **Lone Elk Lower Dam** | 3085 | Tributary to Meramec River | 1966 | St. Louis |
| **Lone Elk-Upper Dam** | 1110 | Tributary to Meramec River | 1800 | St. Louis |
| **Lynch Lake Dam** | 30566 | Winch Creek | 1938 | Franklin |
| **Lynch Lake Dam** | 30566 | Winch Creek | 1938 | Jefferson |
| **McAdams Lake Dam** | 31751 | Little Calvey Creek | 1800 | Franklin |
| **McAdams Lake Dam** | 31751 | Little Calvey Creek | 1800 | Jefferson |
| **Milner Lake Dam** | 3204 | Meramec River | Unknown | St. Louis |
| **Missouri Botanical Gardens Lake Dam** | 30540 | Tributary to Brush Creek | 1960 | Franklin |

| Dam Name | NID ID (MO) | River | Year Completed | County |
|---|---|---|---|---|
| **Missouri Botanical Gardens Lake Dam** | 30540 | Tributary to Brush Creek | 1960 | Jefferson |
| **Mo No Name** | 31934 | Tributary to Calvey Creek | Unknown | Franklin |
| **Mo No Name** | 31934 | Tributary to Calvey Creek | Unknown | Jefferson |
| **Rainbow Lake Dam** | 30544 | Tributary to Pin Oak Creek | 1954 | Franklin |
| **Rainbow Lake Dam** | 30544 | Tributary to Pin Oak Creek | 1954 | Jefferson |
| **Strothmann Lake Dam** | 31493 | Tributary to Woods Creek | 1965 | Franklin |
| **Strothmann Lake Dam** | 31493 | Tributary to Woods Creek | 1965 | Jefferson |
| **Strumfels Lake Dam** | 3084 | Tributary to Glaize Creek | 1959 | St. Louis |
| **Top Notch Lake Dam** | 3115 | Tributary to Flat Creek | 1971 | St. Louis |
| **Von Der Ahe** | 31077 | Tributary to Cauley Creek | 1977 | Franklin |
| **Von Der Ahe** | 31077 | Tributary to Cauley Creek | 1977 | Jefferson |
| **Von DeRosa Number 2 Lake Dam** | 31487 | Tributary to Brady Creek | 1970 | Franklin |
| **Von DeRosa Number 2 Lake Dam** | 31487 | Tributary to Brady Creek | 1970 | Jefferson |
| **Von DeRosa Number 3 Lake Dam** | 31488 | Tributary to Brady Creek | 1970 | Franklin |
| **Von DeRosa Number 3 Lake Dam** | 31488 | Tributary to Brady Creek | 1970 | Jefferson |
| **Watson Lake Dam** | 30826 | Tributary to Winch Creek | 1969 | Franklin |
| **Watson Lake Dam** | 30826 | Tributary to Winch Creek | 1969 | Jefferson |

| Dam Name | NID ID (MO) | River | Year Completed | County |
|---|---|---|---|---|
| **Watters Lake Dam** | 31239 | Tributary to Little Calvey Creek | 1969 | Franklin |
| **Watters Lake Dam** | 31239 | Tributary to Little Calvey Creek | 1969 | Jefferson |
| **Winter Lake Dam** | 30805 | Tributary to Bourbeuse River | 1969 | Franklin |
| **Winter Lake Dam** | 30805 | Tributary to Bourbeuse River | 1969 | Jefferson |
| **Woodland Hills Subdivision Lake Dam** | 31750 | Tributary to Little Calvey Creek | 1800 | Franklin |
| **Woodland Hills Subdivision Lake Dam** | 31750 | Tributary to Little Calvey Creek | 1800 | Jefferson |

## 4.7 Levees

The only FEMA certified levee in the project area is the Valley Park levee. The project was authorized as part of PL 97-128, which de-authorized the Meramec River reservoir/dams. The levee reduces flood risk to 435 acres of land in Valley Park. This area accounts for less than 1% of the total mapped floodplain in the basin. The levee is 3.2 miles long and was built in several phases from 1994-2007. The Valley Park levee was designed and constructed in full compliance with all federal and state regulations and USACE policies in effect at the time of design. The design elevation varies along the length of the levee but is designed to reduce flood risk from a 1% AEP event plus three feet of “freeboard” and extra height to account for post-construction settlement of the levee and its foundation over time. According to FEMA, “freeboard” is defined as a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. The 1993 hydrologic and hydraulic analysis showed that the impact of the levee would be less than 0.4 feet for the 1% event, with no noticeable increase to water surface profiles for more than 6 miles upstream of Valley Park. St. Louis County, Fenton, Wildwood, and Eureka are not adversely impacted by this increase for the 1% event, and all communities signed an agreement indicating this fact. The levee does not increase flood heights downstream of Valley Park. The location of the levee and the extent of the land it protects are shown in **Figure 18**.

Preliminary FIRMs indicate that the Valley Park Levee System is freeboard deficient. The City of Valley Park is continuing to coordinate with FEMA /SEMA and USACE to explore options. There was a public meeting held on August 1, 2019, in the City of Valley Park to inform the public.

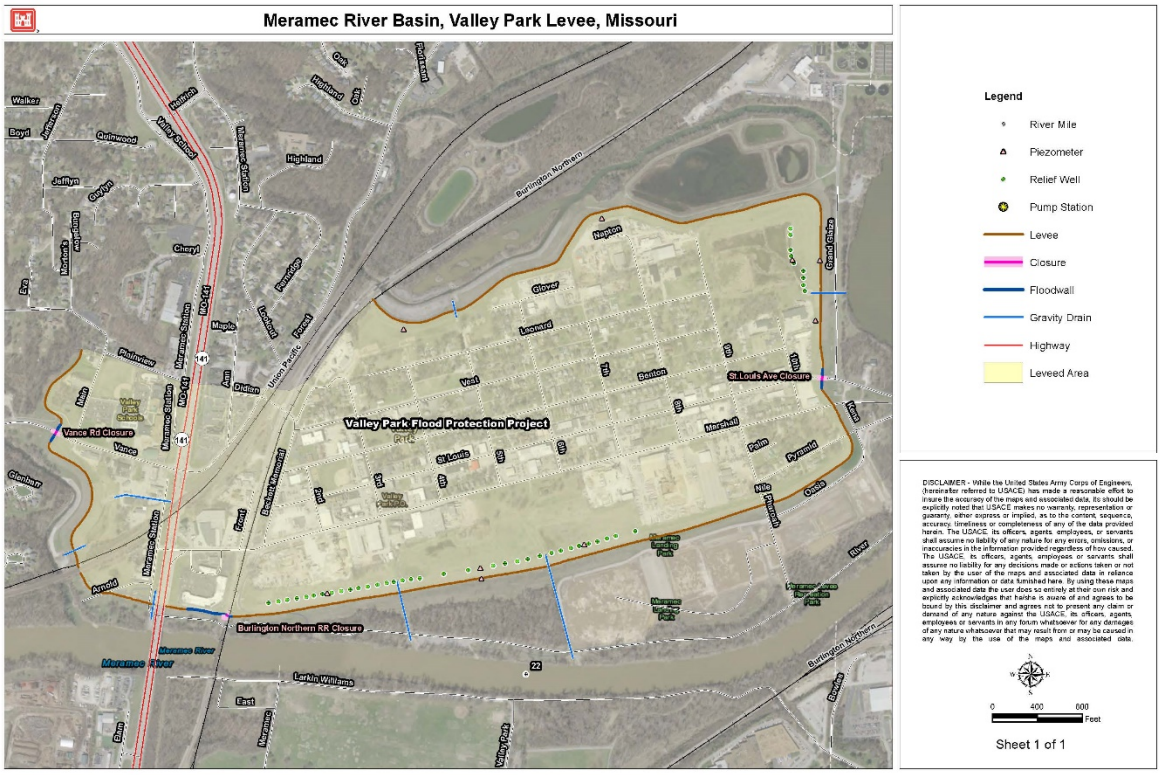


Figure 18. Valley Park Levee and Footprint of the Protected Area

# 5 Consequence Assessment

## 5.1 Consequence Elevation Analysis

**Figures 19 through 29** below show elevation maps of the communities in the Lower Meramec Watershed and rely on Light Detection and Ranging (LiDAR) data. LiDAR data displays the ground surface elevation across a spatial map. Ground surface elevation is a critical assumption of the consequence assessment. It shows 3-meter resolution LiDAR data for the communities in the Lower Meramec with the structures in the 1-percent AEP floodplain presented as white dots. The floodplain with the lowest elevation is the lightest green/opaque yellow. The areas with the highest elevation are shown in dark green.

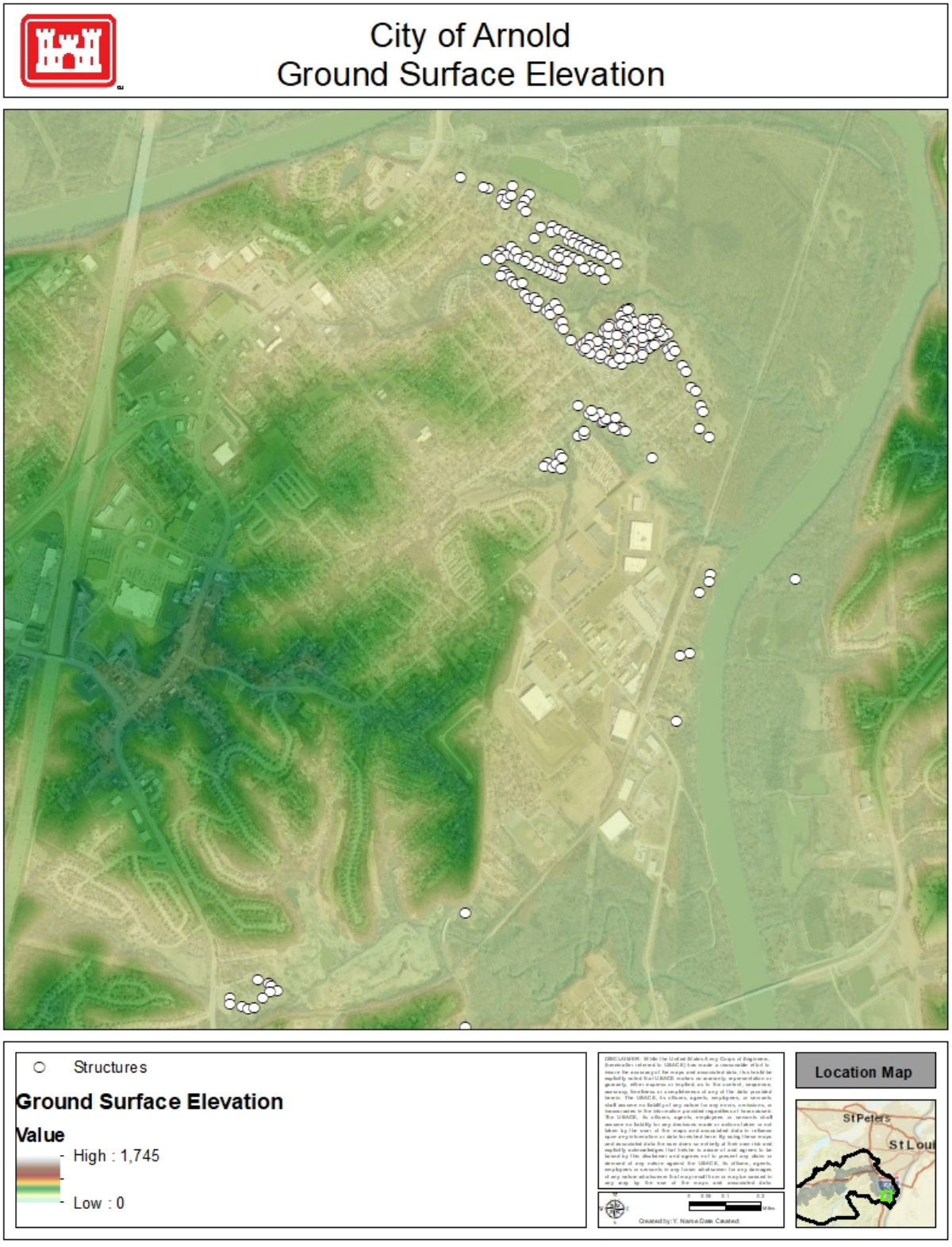


Figure 19. LiDAR Ground Surface Elevation Map - Arnold


Figure 20. LiDAR Ground Surface Elevation Map - Eureka

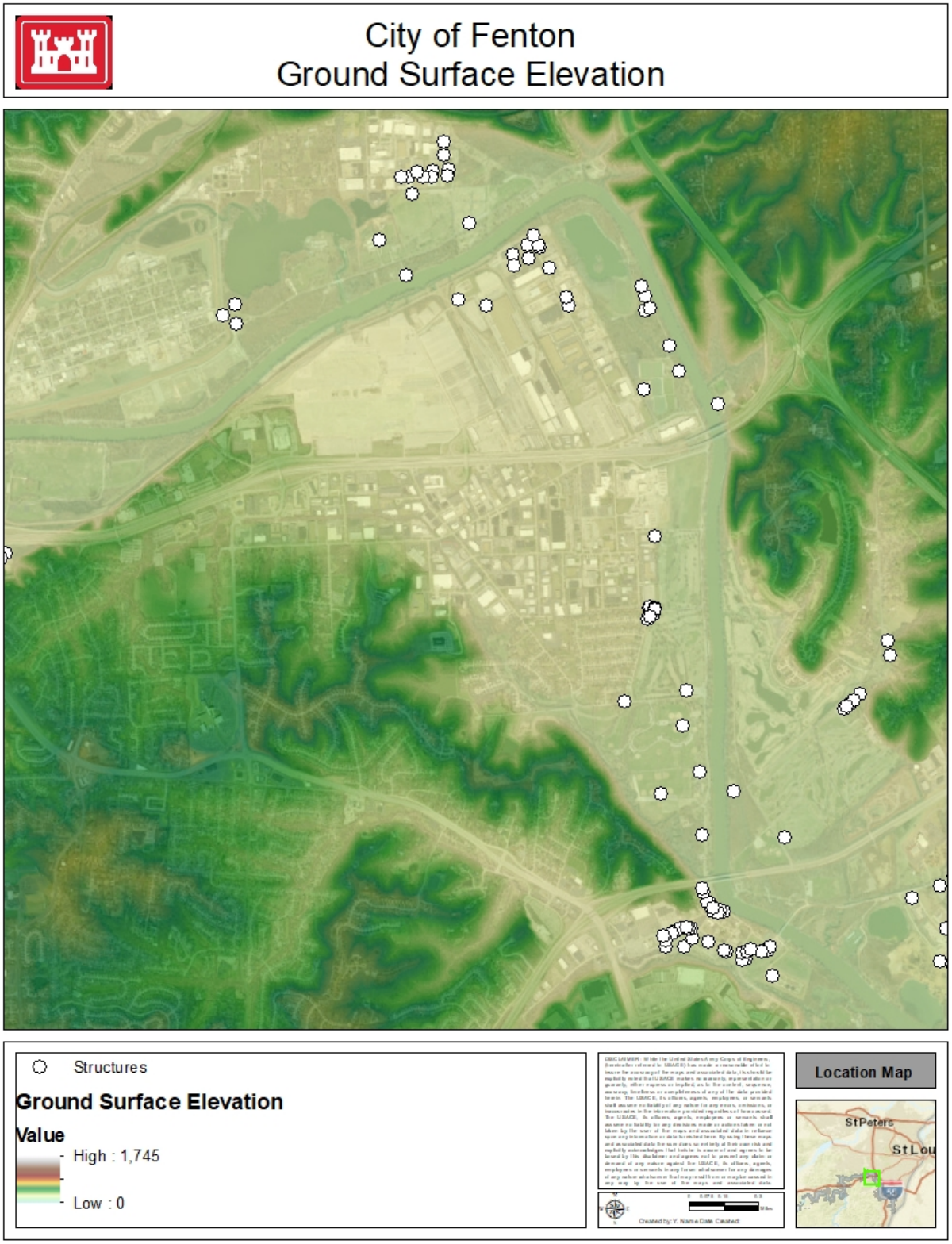


Figure 21. LiDAR Ground Surface Elevation Map - Fenton


Figure 22. LiDAR Ground Surface Elevation Map - Pacific


Figure 23. LiDAR Ground Surface Elevation Map – Sunset Hills


Figure 24. LiDAR Ground Surface Elevation Map - Valley Park

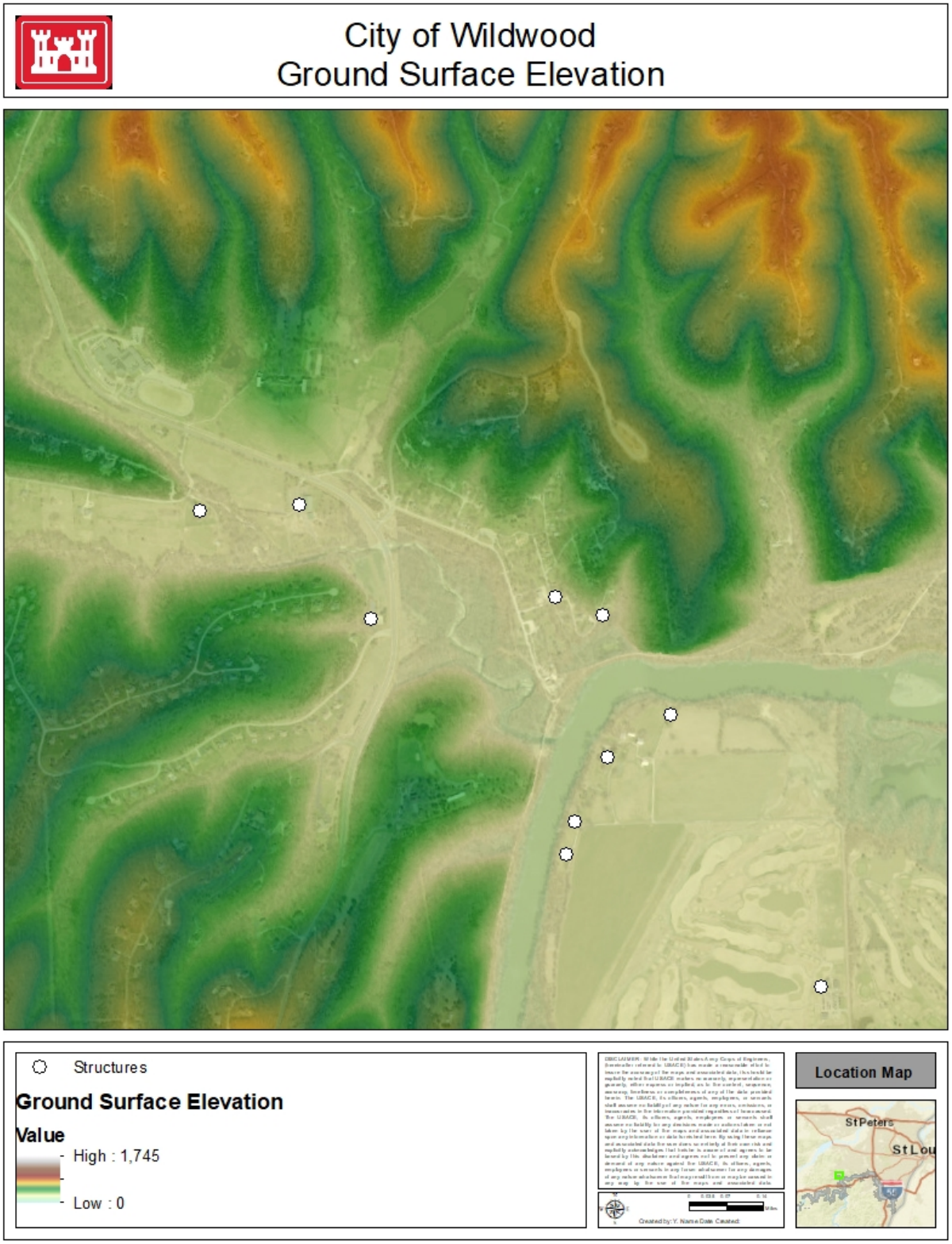


Figure 25. LiDAR Ground Surface Elevation Map - Wildwood

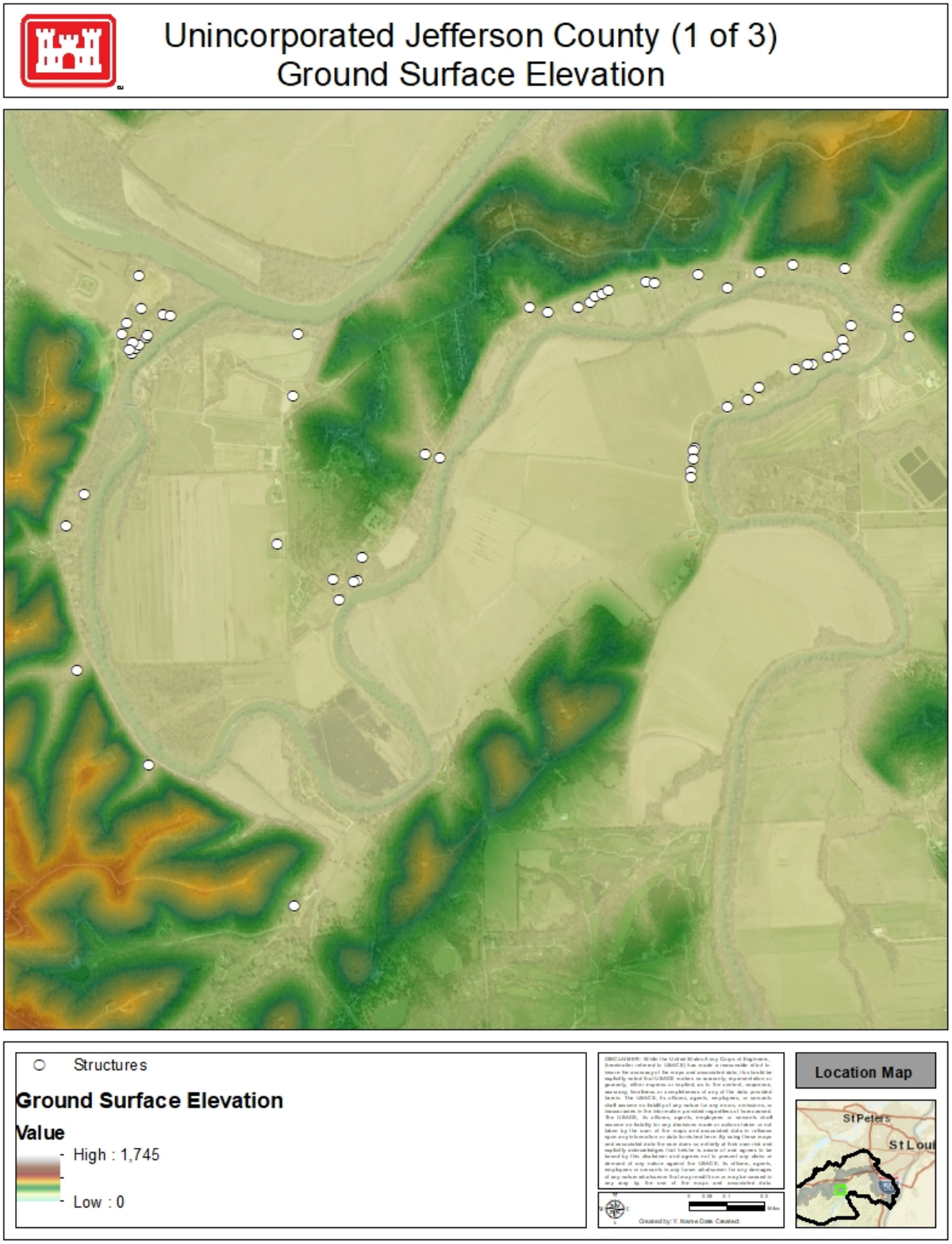


Figure 26. LiDAR Ground Surface Elevation Map - Jefferson County 1 of 3


Figure 27. LiDAR Ground Surface Elevation Map - Jefferson County 2 of 3

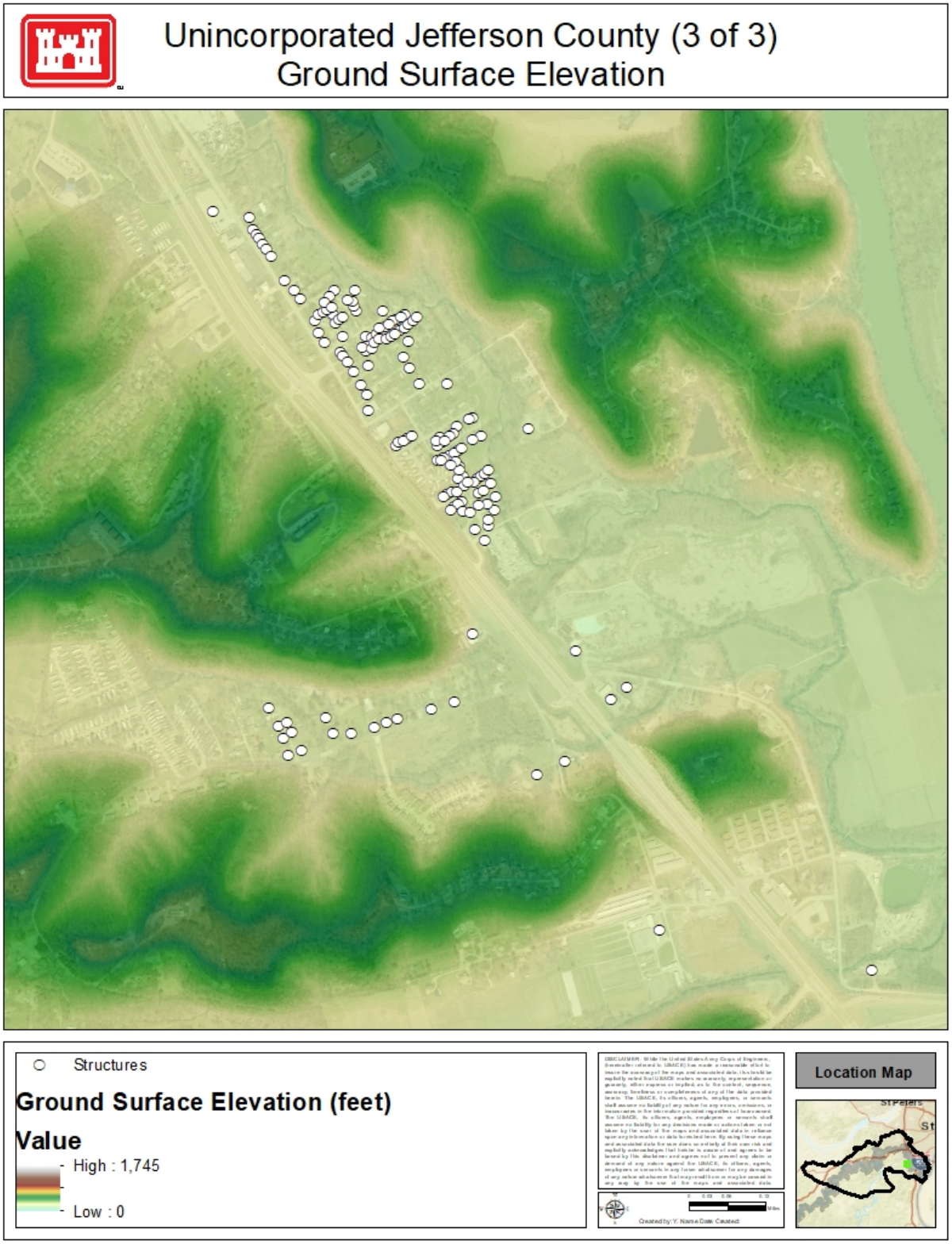


Figure 28. LiDAR Ground Surface Elevation Map - Jefferson County 3 of 3


Figure 29. LiDAR Ground Surface Elevation Map - St. Louis County

## 5.2 Consequence Elevation Description

There are three primary ways to measure flood susceptibility in structures:

1) First Floor Elevation
2) Beginning Damage Elevation
3) Depth of Flooding Relative to First Floor

For this study, structures' first floor elevations were not surveyed using traditional survey crews. Instead, first floor elevation was defined as the ground surface elevation plus the foundation height, which was estimated by utilizing a Google Street View windshield survey for each structure. This kind of survey consists of using existing street view software from applications such as Google or Bing to approximate the first floor elevation of a structure in lieu of an in-person, on-site survey. For structures with partial or blocked views, a subsequent survey was conducted in-person to determine the foundation of a structure.

First floor elevation can be used to quickly identify structures that are more likely to be flood-prone, relative to neighboring structures. Additionally, the first floor elevation signifies where the majority of damages to contents and the building envelope, or the outer shell of a structure (walls, roof, etc.), begin. While first floor elevation measurements provide an assessment of the elevation at which significant damages will begin, they do not properly illustrate where water enters the building or the depths of flooding given a particular flood event.

Beginning damage elevation is defined as the lowest point at which water begins to enter the building and is dependent on the building's foundation type. Beginning damage elevation is measured as ground surface elevation plus any distance up to a basement window, crawl-space vent, or door or window leading into the structure. Beginning damage elevation improves on the first floor elevation statistic because it takes into account each of the different kinds of foundations that a structure could have.

Depth of flooding relative to the first floor is the most precise indicator of flood susceptibility and goes beyond the normal measure of first floor elevation by indicating how high flood depths are expected to rise on a structure for a given flood event. A depth of flooding measurement of two feet would indicate that a given flood event would be expected to flood the structure two feet above the first floor. A depth of flooding measurement of negative two feet would indicate that flooding is not anticipated to reach the first floor but instead could cause damage in a subfloor space such as the basement or crawlspace. Since the ground surface elevation changes spatially, the depth of flooding estimate provides the best overall characterization of flood susceptibility by being able to compare flood prone structures across multiple floodplains, such as across the Lower Meramec Basin.

A table of summary statistics for each of the elevation categories is shown in **Table 15**. A detailed list of individual structure elevations can be found in Appendix E, the USACE Analysis of the National Nonstructural Committee Assessment. **Table 15** shows that the quantity of flood-prone structures within the basin are focused in Arnold, Pacific, and Unincorporated Jefferson County. The table also shows that communities such as Valley Park, Fenton, and Sunset Hills have the lowest average foundation heights, meaning these areas either historically have not

mitigated through elevating on higher foundations, or are predominately commercial and industrial areas that rely on short foundation heights for daily operations.

*Table 15. Lower Meramec Basin Elevation Statistics (feet, NAVD)*

| 1% AEP | Arnold | Eureka | Fenton | Pacific | Sunset Hills | Jefferson County | St. Louis County | Valley Park | Wildwood |
|---|---|---|---|---|---|---|---|---|---|
| Structure Count | 269 | 54 | 61 | 153 | 39 | 255 | 67 | 38 | 5 |
| Average Ground Surface Elevation | 417.5 | 446.5 | 442.5 | 459.7 | 422.1 | 425.4 | 425.5 | 431.6 | 440.0 |
| Average Foundation Height | 2.0 | 2.1 | 1.1 | 1.7 | 0.7 | 2.2 | 1.6 | 0.8 | 1.1 |
| Average First Floor Elevation | 419.6 | 448.6 | 443.5 | 461.4 | 422.8 | 427.6 | 427.0 | 432.4 | 441.2 |
| Average Beginning Damage Elevation | 416.8 | 447.2 | 421.2 | 457.7 | 422.0 | 425.9 | 424.8 | 431.9 | 440.2 |

## 5.3 Consequence Flood Depths & Velocities

As previously described in Section 4, flood depths and velocities were estimated utilizing a riverine hydraulic model. Flood velocities for each structure were generated, but, given the dissipating effects of vegetation covering most banks in combination with slow rising rivers, concerns about structural integrity due to water velocity was not an issue for the average structure in the Lower Meramec Basin. Once each structure in the floodplain was assigned a flood elevation for the 1% AEP frequency, it was related to the first floor elevation to determine the depth of flooding relative to the first floor. Depths of floodwaters are the primary driver of risk in the basin over velocity. **Table 16** shows the average depth of flooding relative to the first floor elevation for each of the communities within the Lower Meramec Basin.

*Table 16. Lower Meramec Basin Flood Depth Statistics (feet, NAVD)*

| 1% AEP | Arnold | Eureka | Fenton | Pacific | Sunset Hills | Jefferson County | St. Louis County | Valley Park | Wildwood |
|---|---|---|---|---|---|---|---|---|---|
| Structure Count | 269 | 54 | 61 | 153 | 39 | 255 | 67 | 38 | 5 |
| Average First Floor Elevation | 419.6 | 448.6 | 443.5 | 461.4 | 422.8 | 427.6 | 427.0 | 432.4 | 441.2 |
| Average 1% AEP Depth Relative to 1st Floor | 0.1 | 2.7 | 3.9 | 1.6 | 3.6 | 4.9 | 5.5 | 4.3 | 3 |
| Average 1% AEP Flood Elevation | 419.6 | 451.3 | 427.5 | 463.0 | 426.1 | 432.5 | 432.6 | 436.7 | 444.2 |

Flood depths relative to the first floor elevation are a key metric when determining a feasible flood mitigation recommendation in terms of engineering soundness. The USACE NNC determines generic engineering-based criteria for mitigating structures based on flood depth. The committee sets a break point at flood depths less than or equal to 3 feet, which determines the extent that dry floodproofing is effective given concerns about hydrostatic pressure. **Table 17** shows the statistical distribution of structures by flood depth for each of the communities in the Lower Meramec Basin. Since flood waters can enter basements and crawlspaces, flooding below the first floor is still a significant consideration during the analysis to determine flood mitigation approaches.

For structures with flooding that exceeds three feet, the mitigation approaches are limited to elevation, relocation, or acquisition due to hydrostatic pressures. With that said, it is not feasible to elevate or acquire many commercial and industrial structures, and therefore the only option is to allow floodwaters to enter the building to equalize hydrostatic pressure and elevate inventory, electrical, and other utilities to limit the damage to contents and the building. In these cases, there will be commercial and industrial structures with floodproofing recommendations. Even though floodproofing does not fully mitigate damages, it is more practical than assuming a large warehouse or commercial structure can elevate or will be willing to be acquired.

*Table 17. Lower Meramec Basin Flood Depth Categorization*

| 1% AEP | Arnold | Eureka | Fenton | Pacific | Sunset Hills | Jefferson County | St. Louis County | Valley Park | Wildwood |
|---|---|---|---|---|---|---|---|---|---|
| Flood Depths Exceeding 3 Ft | 13 | 21 | 29 | 43 | 13 | 160 | 39 | 19 | 1 |
| Flood Depths Between 0 and 3 Ft | 114 | 26 | 23 | 75 | 23 | 64 | 21 | 16 | 3 |
| Flood Depths Below 0 FT | 142 | 7 | 9 | 35 | 3 | 31 | 7 | 3 | 1 |

### 5.3.1 High Flood Risk (3+ Feet Inundation)

The communities of Fenton, Jefferson County, St. Louis County, and Valley Park all have the highest percentage of structures within the high flood risk category. These areas also typically have lower foundation heights and a higher concentration of commercial and industrial structures. Nonstructural mitigation activity for these kinds of structures is limited and relocating the industrial activity is generally infeasible. Unincorporated Jefferson County is the outlier of this category, and that is due to the high amount of single-family occupancy residential structures and mobile homes located along the Meramec River. Of note are the multiple mobile home parks located on Old Highway 141, which include approximately 100 mobile homes with an average flood depth of 8.5 feet.

### 5.3.2 Moderate Flood Risk (0 to 3 Feet Inundation)

The communities of Eureka, Sunset Hills, and Pacific all have the highest percentage of structures within the moderate flood risk category. These areas contain a mixture of structures that have a close approximation of appropriate foundation heights or have started to mitigate structures within the floodplain. The City of Pacific is an example of a community that has begun prioritizing elevating and acquiring flood-prone structures and as a result, the community's overall flood exposure has improved significantly since mitigation efforts began. The City of Eureka lags behind the efforts of Pacific, but since its passing of Proposition E in 2018, efforts have begun to also investigate feasible ways to reduce the existing flood risk.

### 5.3.3 Minor Flood Risk (Less than 0 Feet Inundation)

The City of Arnold is the only community with the majority of its structures experiencing an average flood depth that is below its first floor elevation. Flooding within this category is typically experienced as wet basements, damage to landscapes, or nuisance flooding. Examples of flood mitigation for this category of flood risk include filling subfloor areas such as basements, relocating utilities, and installing sewer check valves to prevent backflow. The highest density of flood-prone structures is the Starling Estates Mobile Home Park, which includes approximately 100 mobile homes with an average flood depth of 2.6 feet. Other locations in Arnold, such as along Convair Drive, show the considerable efforts that the City has taken over the years to acquire the city's most flood-prone structures.

**Figures 30 through 40** show the 1% AEP depth of flooding in each community within the Lower Meramec Basin by structure. In the figures, structures not colored are not estimated to be flood-prone or may be vacant land. There are also structures that are currently going through the flood mitigation process for either elevation or acquisition that may show up on the maps. For a detailed list of flood mitigation recommendations, see Appendix E. Note: The City of Union and Franklin County do not have maps as flood-prone structures have recently undergone mitigation.

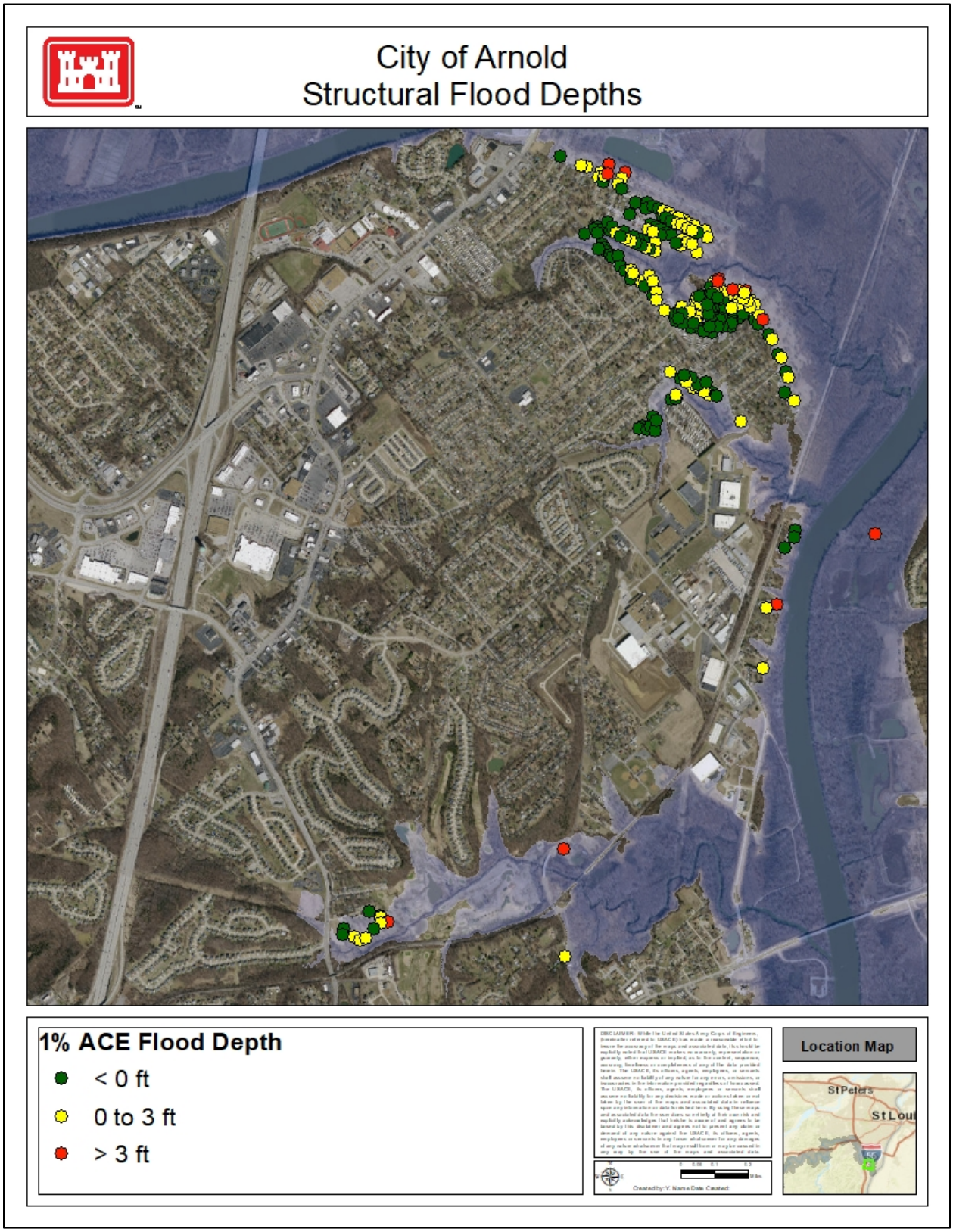


Figure 30. Arnold Depth of Flooding Relative to 1st Floor Elevation

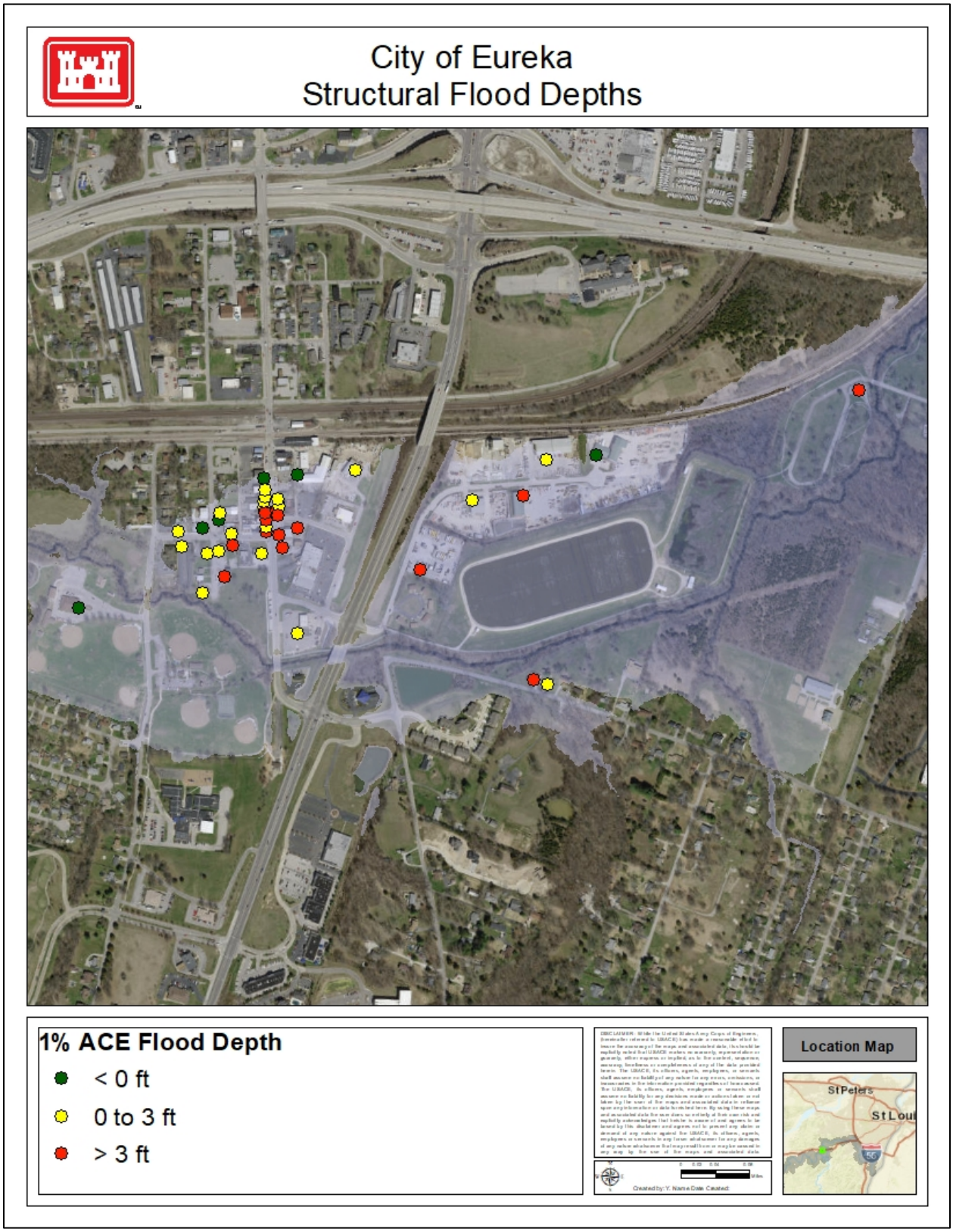


Figure 31. Eureka Depth of Flooding Relative to 1st Floor Elevation

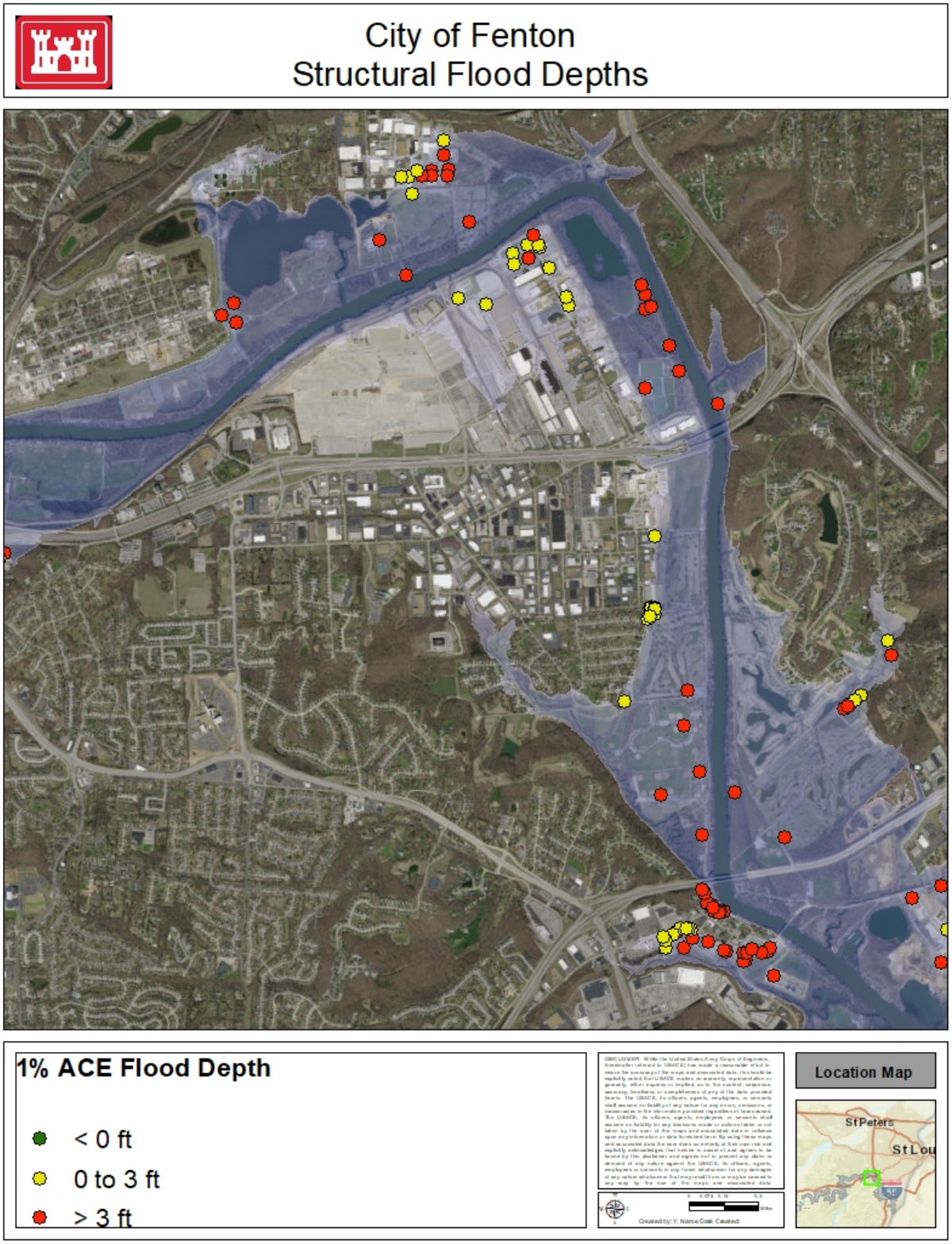


Figure 32. Fenton Depth of Flooding Relative to 1st Floor Elevation

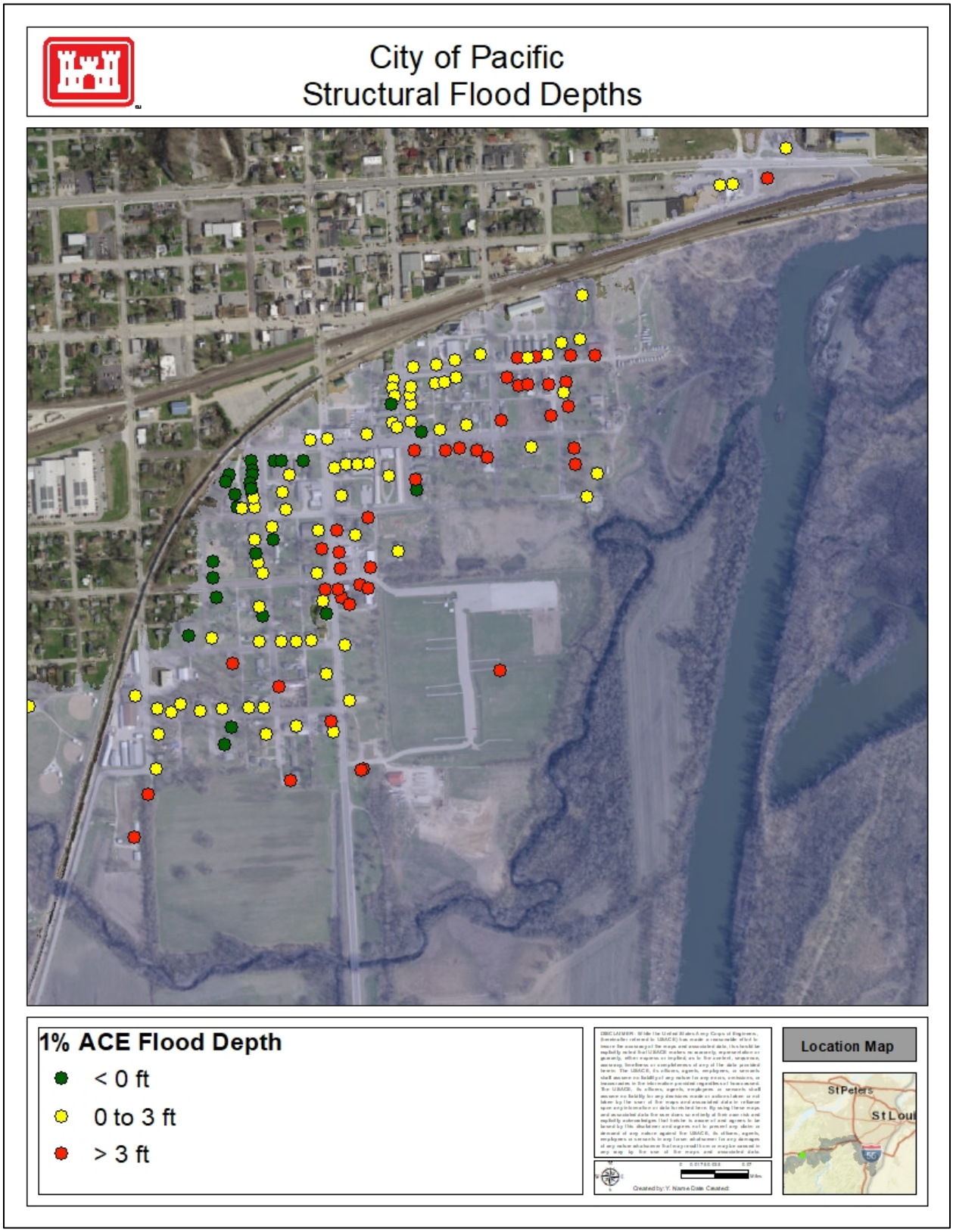


Figure 33. Pacific Depth of Flooding Relative to 1st Floor Elevation

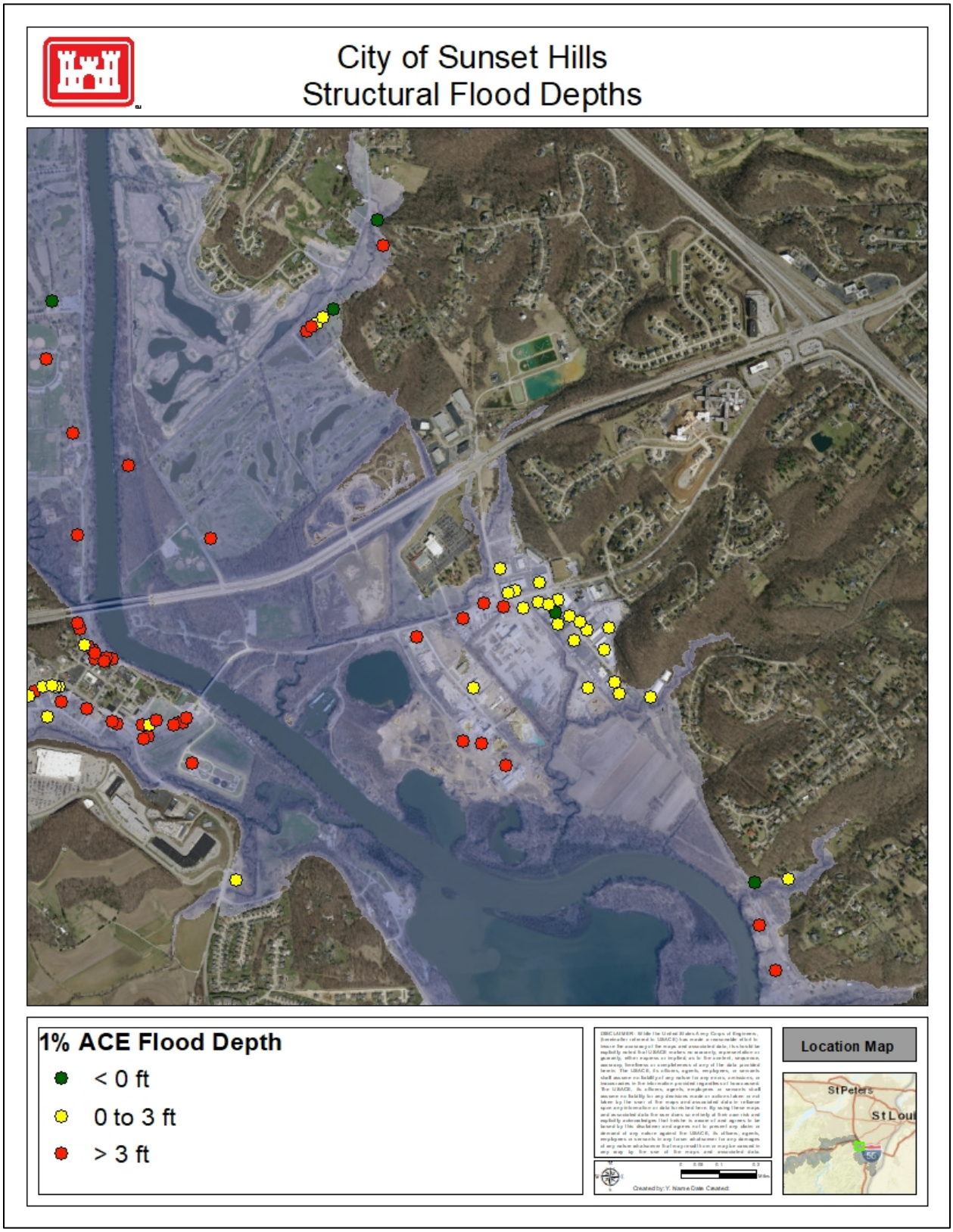


Figure 34. Sunset Hills Depth of Flooding Relative to 1st Floor Elevation


Figure 35. Valley Park Depth of Flooding Relative to 1st Floor Elevation


Figure 36. Wildwood Depth of Flooding Relative to 1st Floor Elevation

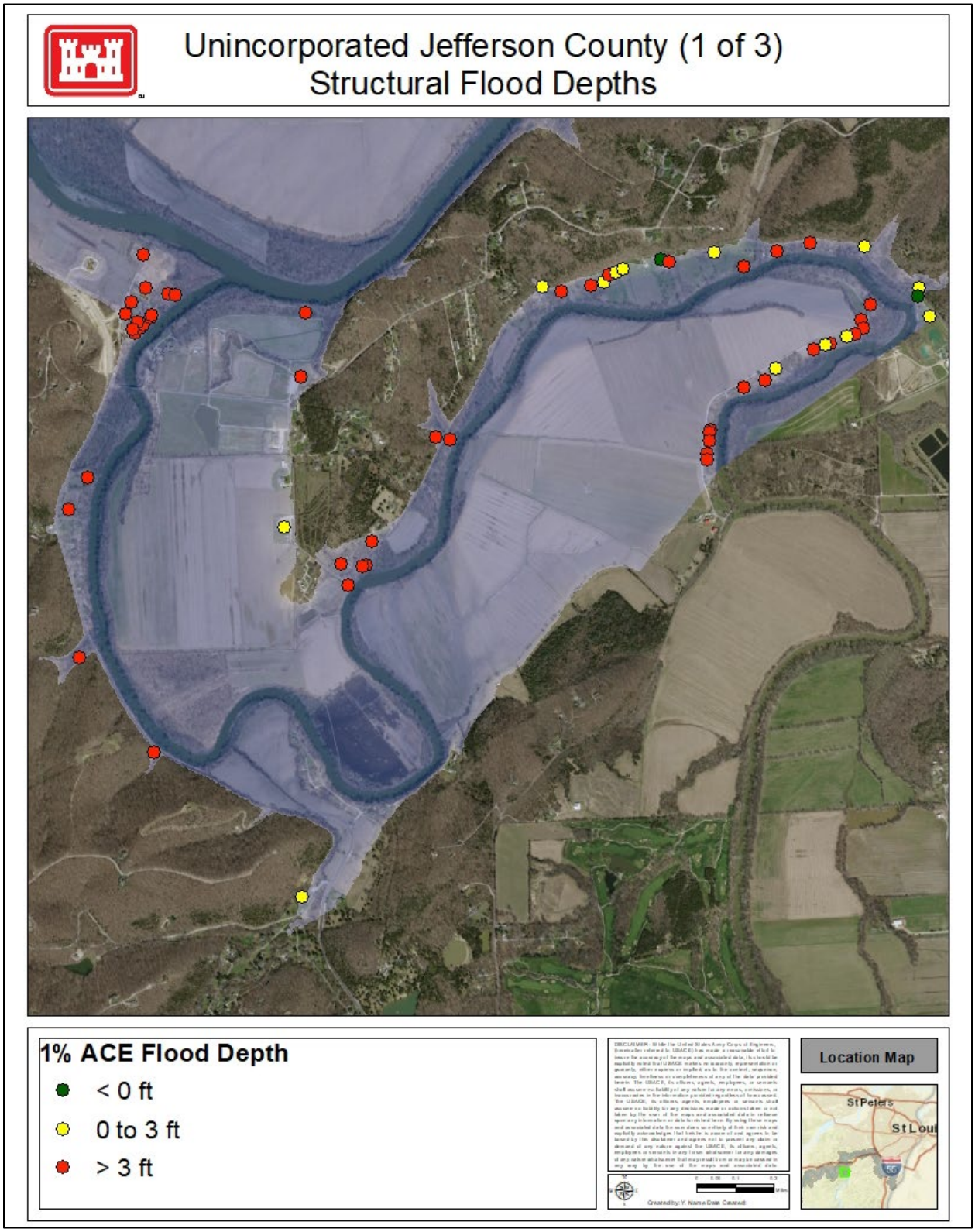


Figure 37. Unincorporated Jefferson County Depth of Flooding Relative to 1st Floor Elevation (Area 1 of 3)

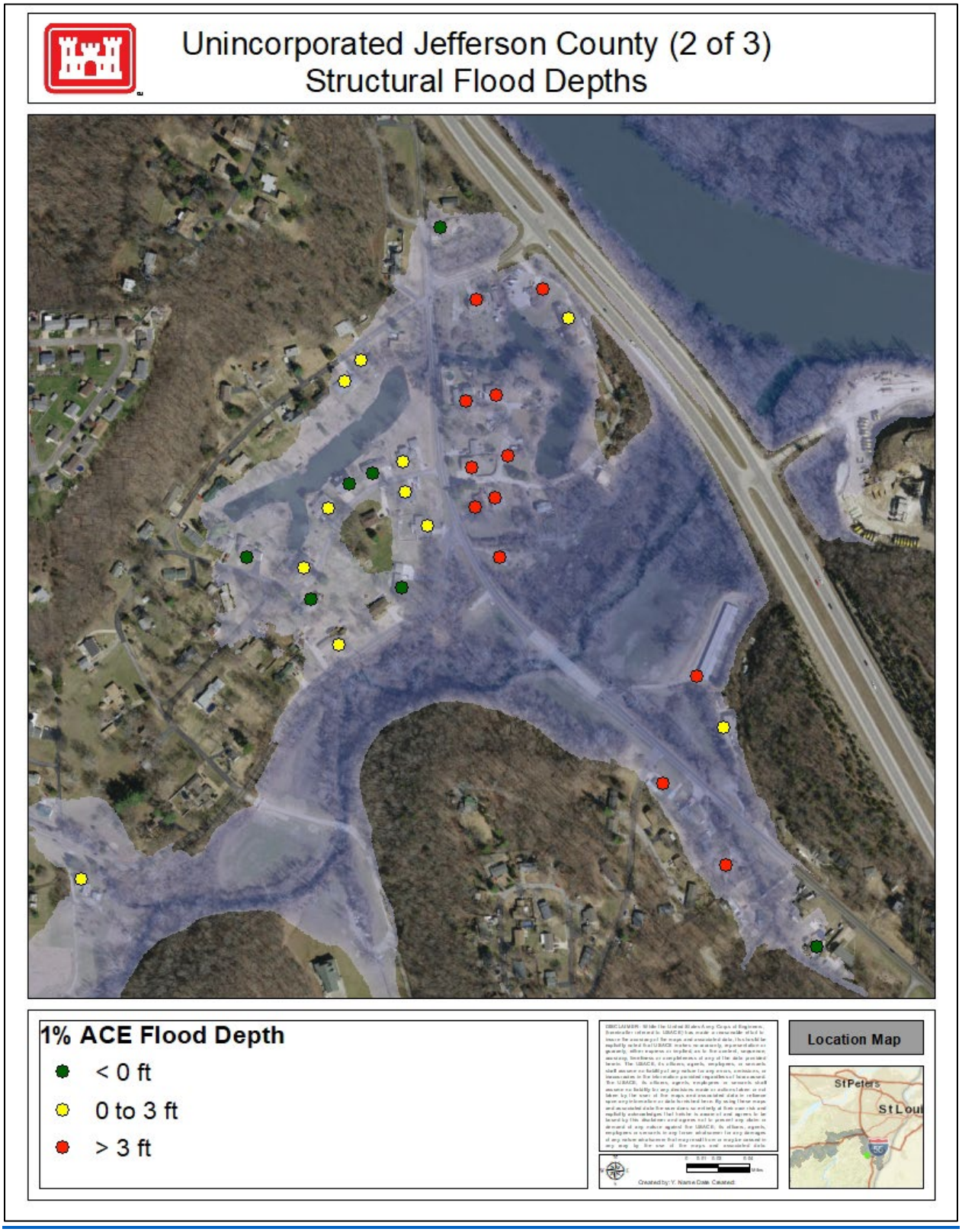


Figure 38. Unincorporated Jefferson County Depth of Flooding Relative to 1st Floor Elevation (Area 2 of 3)

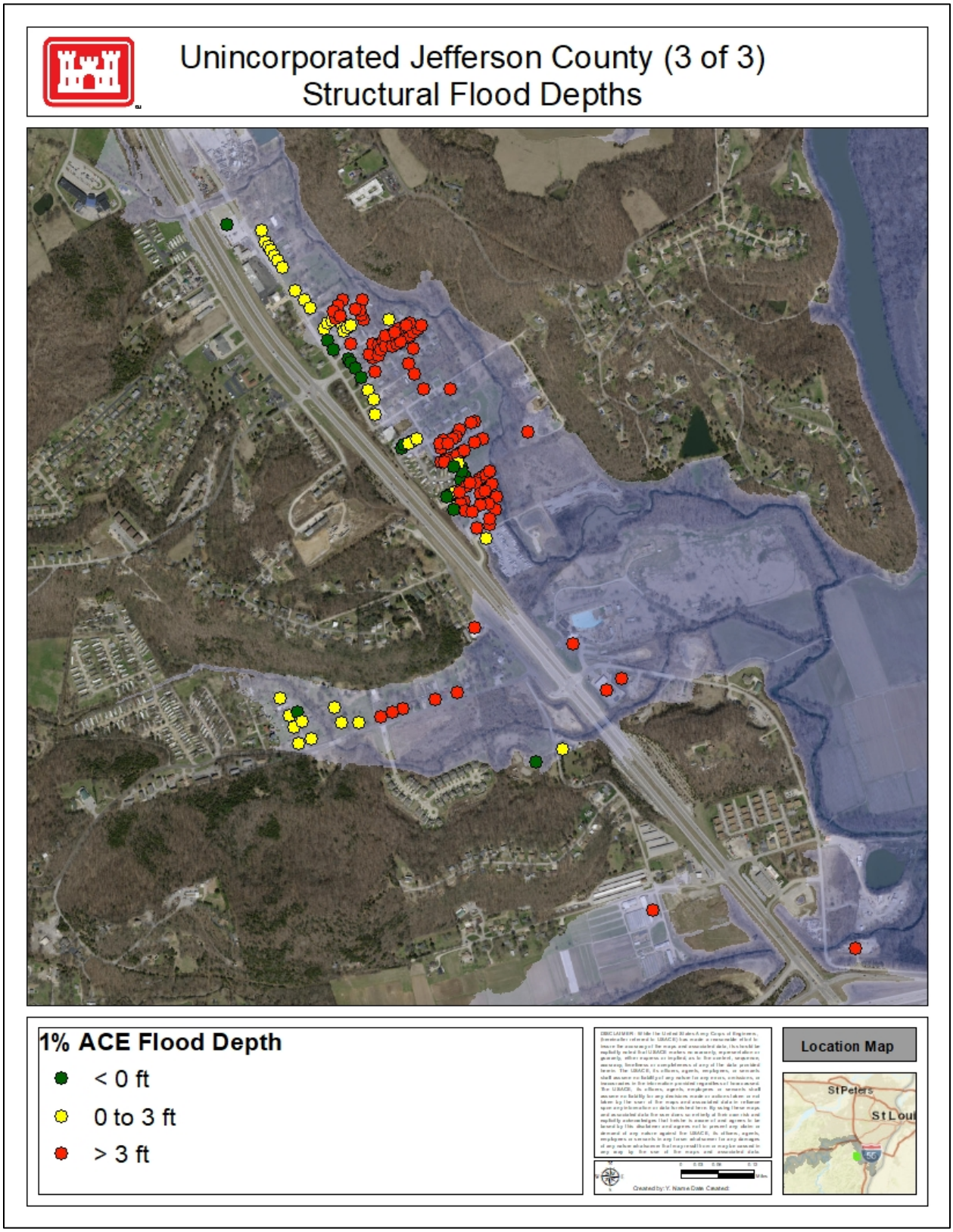


Figure 39. Unincorporated Jefferson County Depth of Flooding Relative to 1st Floor Elevation (Area 3 of 3)


Figure 40. Unincorporated St. Louis County Depth of Flooding Relative to 1st Floor Elevation

## 5.4 Structure Valuation

The Lower Meramec Basin's 1% AEP floodplain encompasses 942 flood-prone structures spread over 2,750 square miles. A windshield survey in combination with Google Street View were utilized to view all flood-prone structures in the basin. A windshield survey involves USACE staff either utilizing online street view or driving to each structure in the inventory and recording structural attributes such as foundation type and foundation height. The accuracy of determining foundation types (slab, crawlspace, or basement) and foundation heights may vary due to building setbacks, large vegetation, or general inaccessibility. Structure square footage, building type, address, and assessed structure and land values were gathered using Jefferson County, Franklin County, and St. Louis County Tax Assessor data. The assessor valuations provided by the county assessor's office were multiplied by three (per county assessor policy) to determine the appraised (market) value.

**Table 18** shows the distribution of structures by occupancy type, which reveals that each community experiences different issues as it relates to the type of structures within the 1% AEP floodplain boundaries. The communities of Arnold, Jefferson County, Valley Park, and Wildwood are predominately residential, whereas Eureka, Fenton, Pacific, Sunset Hills, and St. Louis County are more highly mixed between residential and commercial. As previously described, the communities of Arnold and Unincorporated Jefferson County have a large number of mobile homes. These areas are concerning given the social implications of tenants renting pads to park their mobile homes on, combined with the likelihood of a willing land owner selling the land, thus leaving tenants uncompensated. This topic is further discussed in the Appendix E.

*Table 18. Lower Meramec Basin First Floor Flood Depth Statistics*

| 1% AEP | Arnold | Eureka | Fenton | Pacific | Sunset Hills | Jefferson County | St. Louis County | Valley Park | Wildwood |
|---|---|---|---|---|---|---|---|---|---|
| Residential 1-2 Story Homes | 136 | 35 | 17 | 87 | 7 | 126 | 15 | 32 | 4 |
| Residential Mobile Homes | 133 | 1 | 0 | 13 | 0 | 108 | 0 | 0 | 0 |
| Commercial/Industrial/Agri | 0 | 17 | 39 | 53 | 32 | 21 | 51 | 6 | 1 |
| Public | 0 | 1 | 5 | 0 | 0 | 0 | 1 | 0 | 0 |

**Figures 41 through 51** demonstrate the nonstructural mitigation recommendations for the Lower Meramec Basin Study Area. Appendix E lists the recommendations by address. Further discussion on how the recommendations were derived can also found in Appendix E.

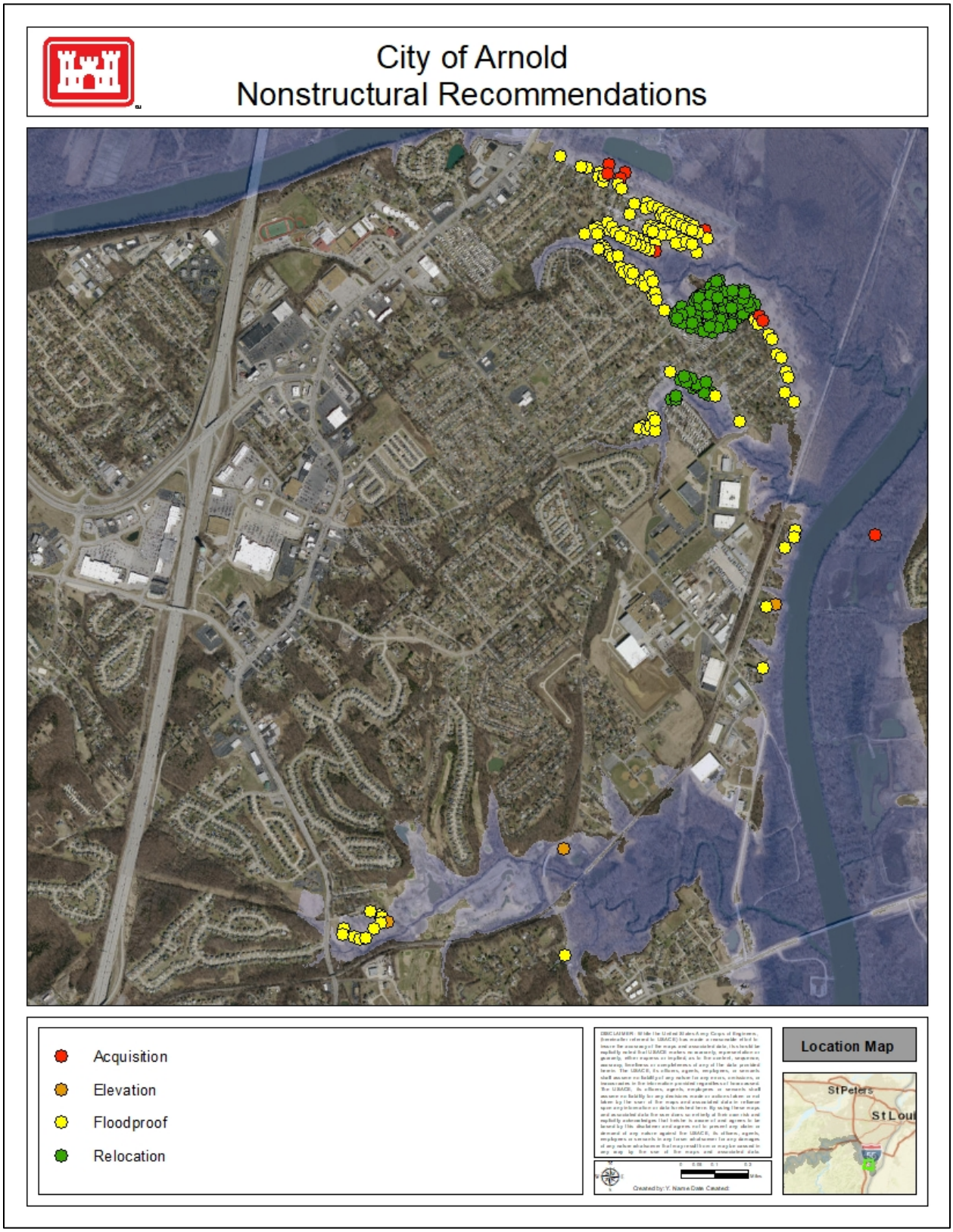


Figure 41. Arnold Nonstructural Recommendations

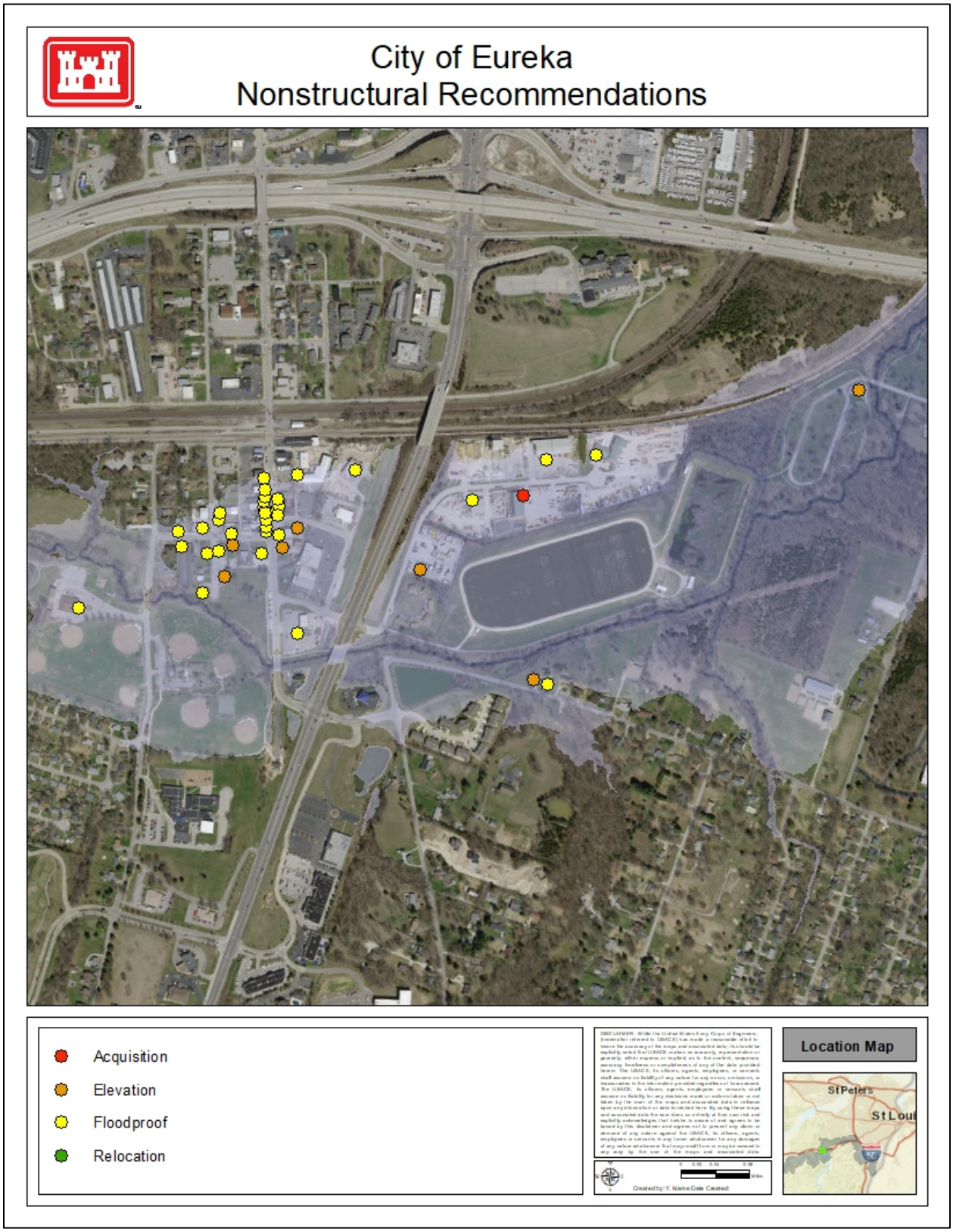


Figure 42. Eureka Nonstructural Recommendations

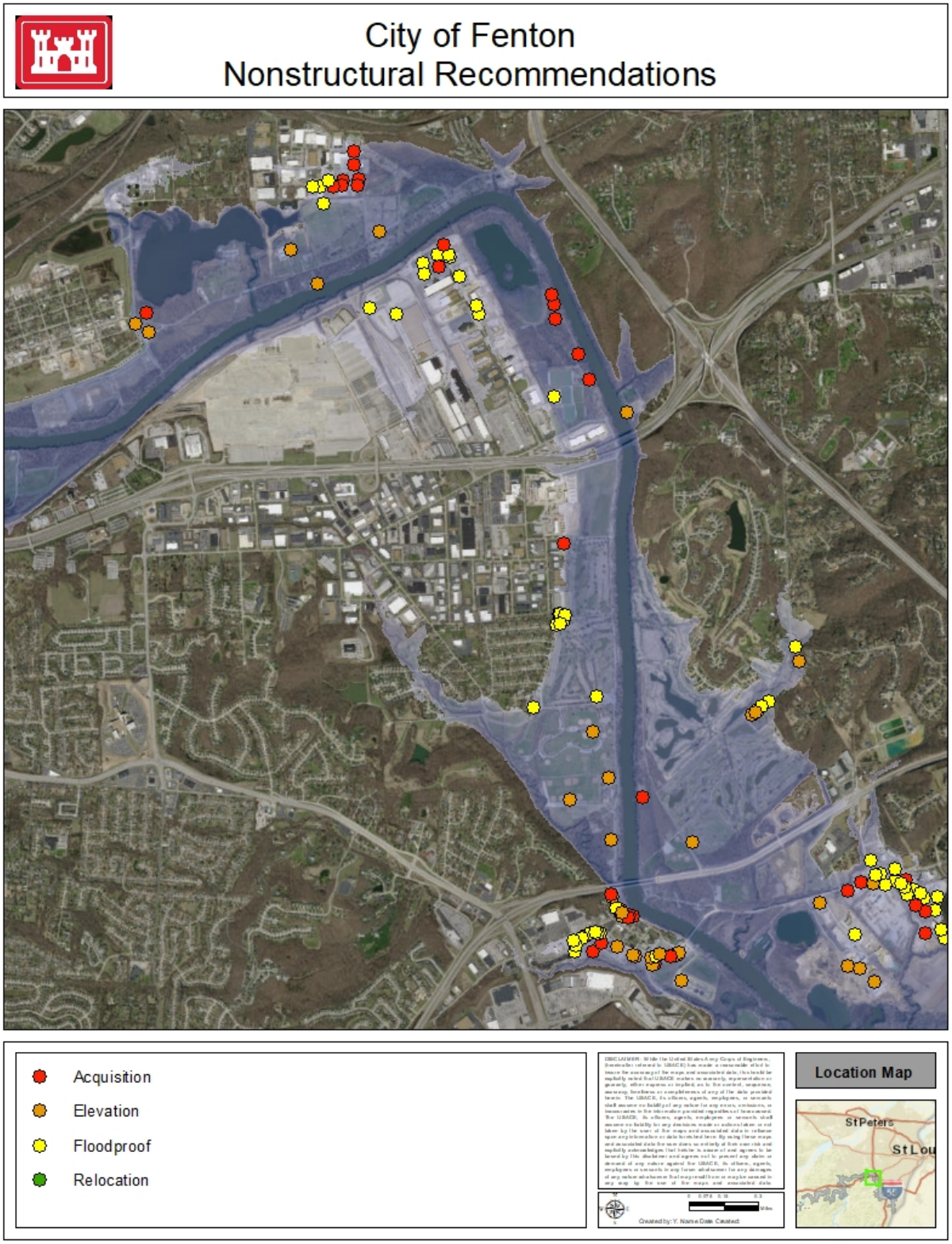


Figure 43. Fenton Nonstructural Recommendations

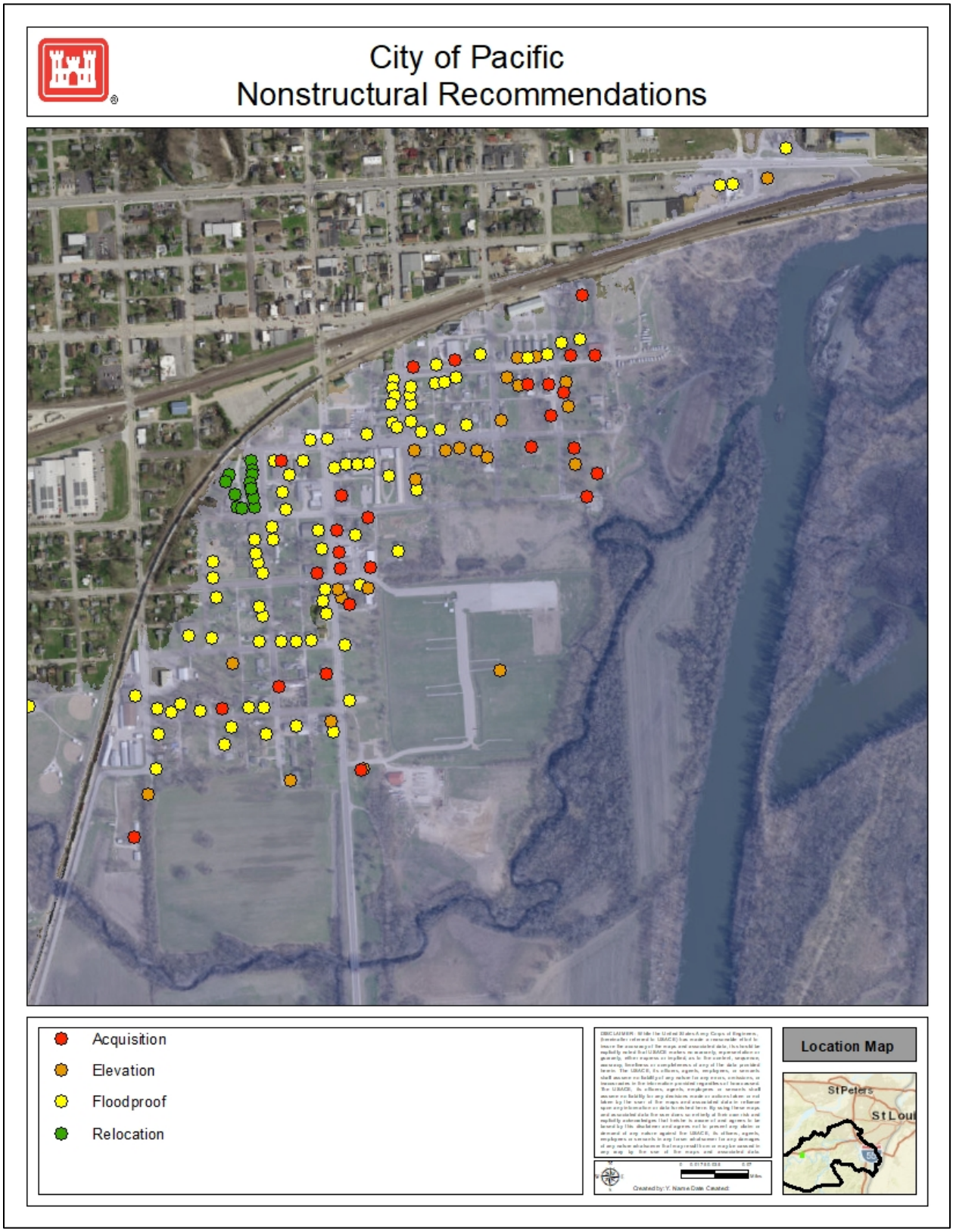


Figure 44. Pacific Nonstructural Recommendations

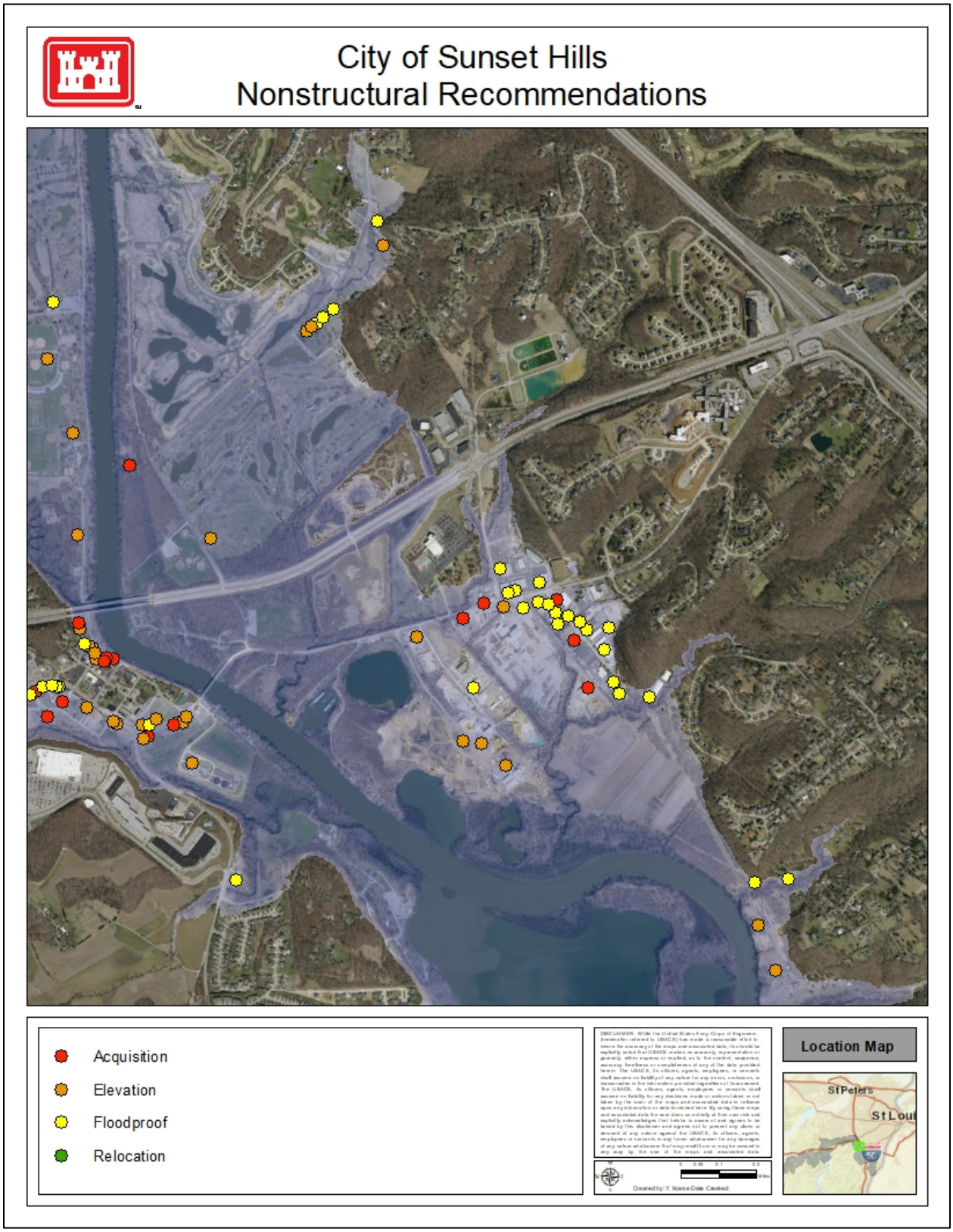


Figure 45. Sunset Hills Nonstructural Recommendations

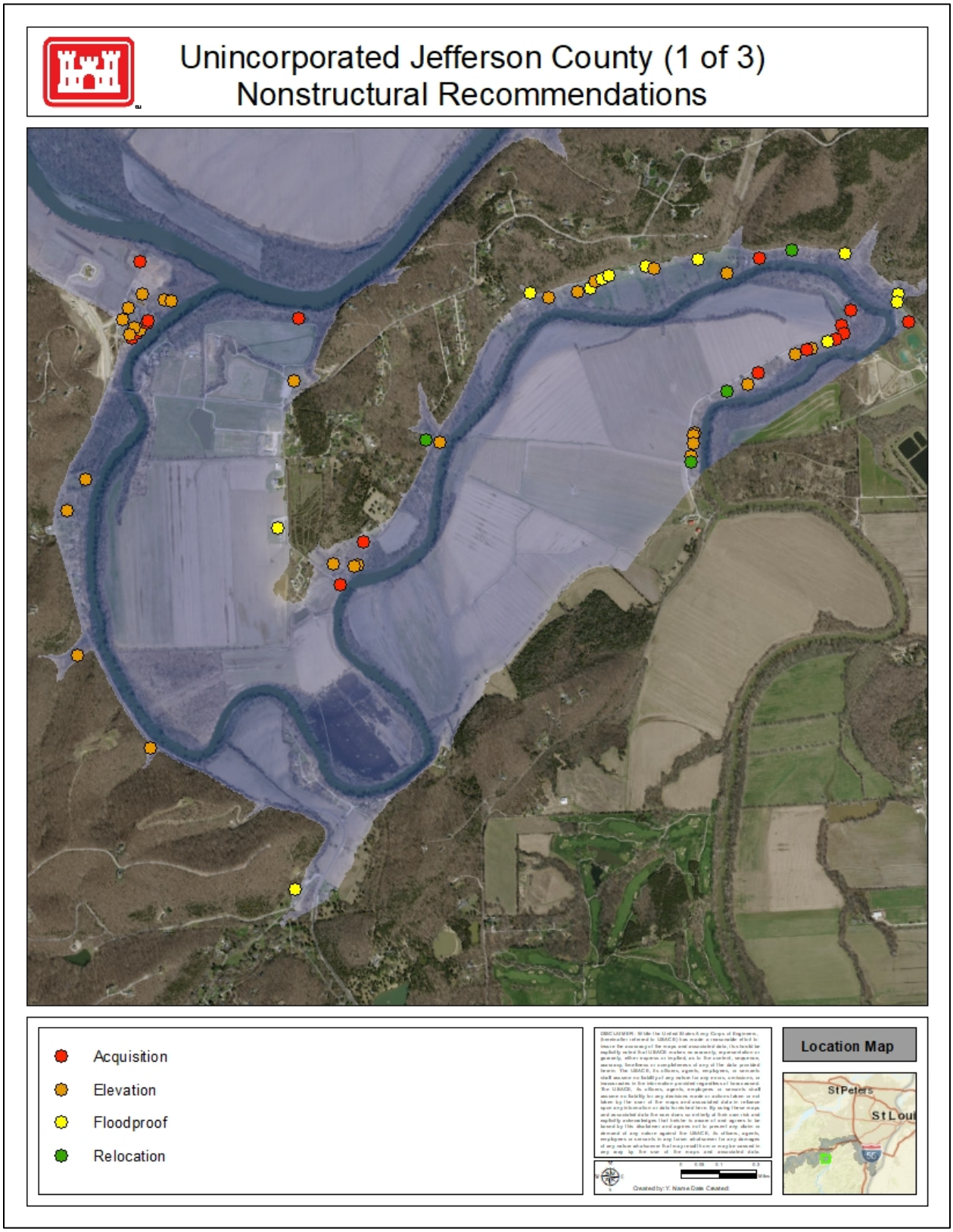


Figure 46. Unincorporated Jefferson County Nonstructural Recommendations (Area 1 of 3)

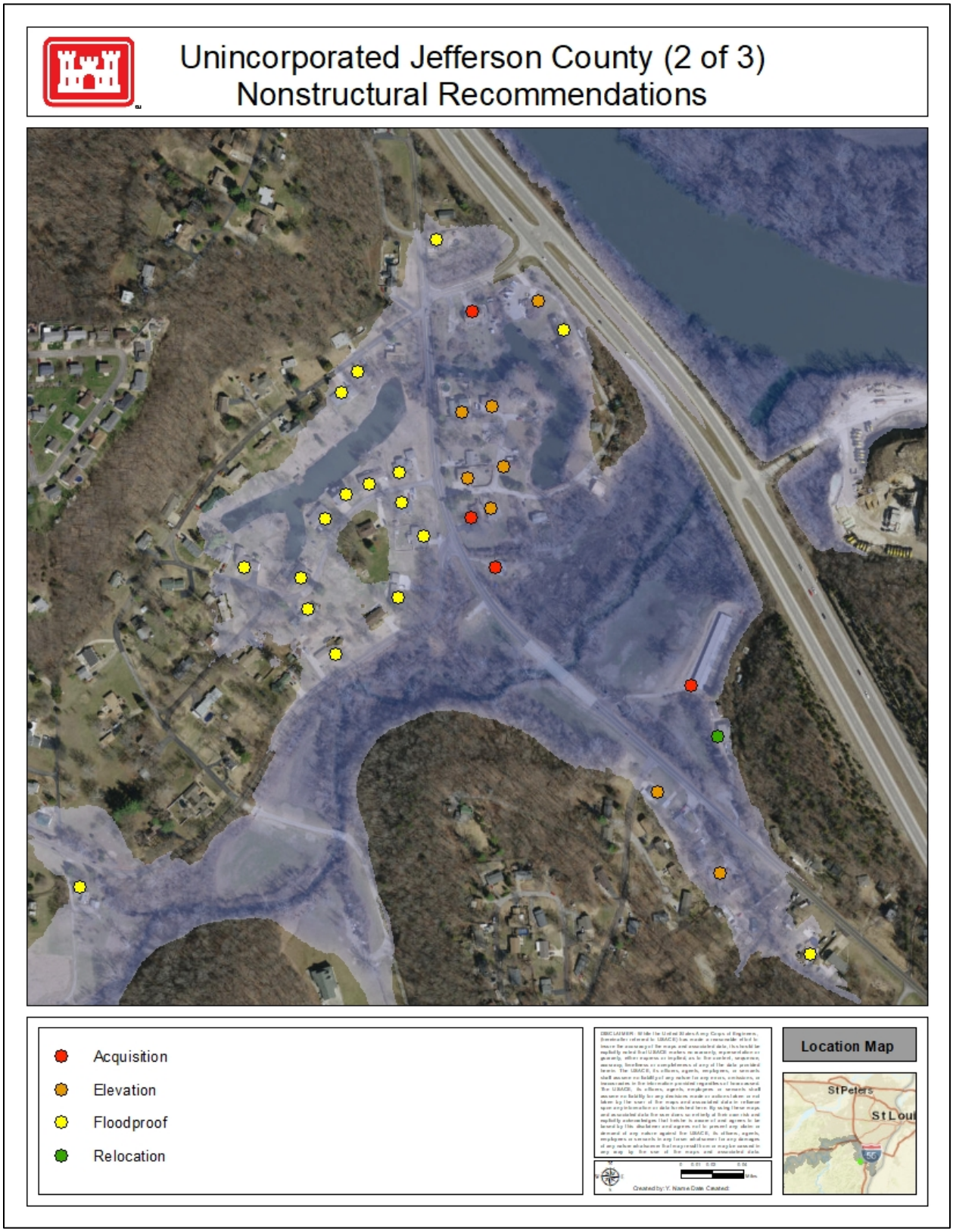


Figure 47. Unincorporated Jefferson County Nonstructural Recommendations (Area 2 of 3)

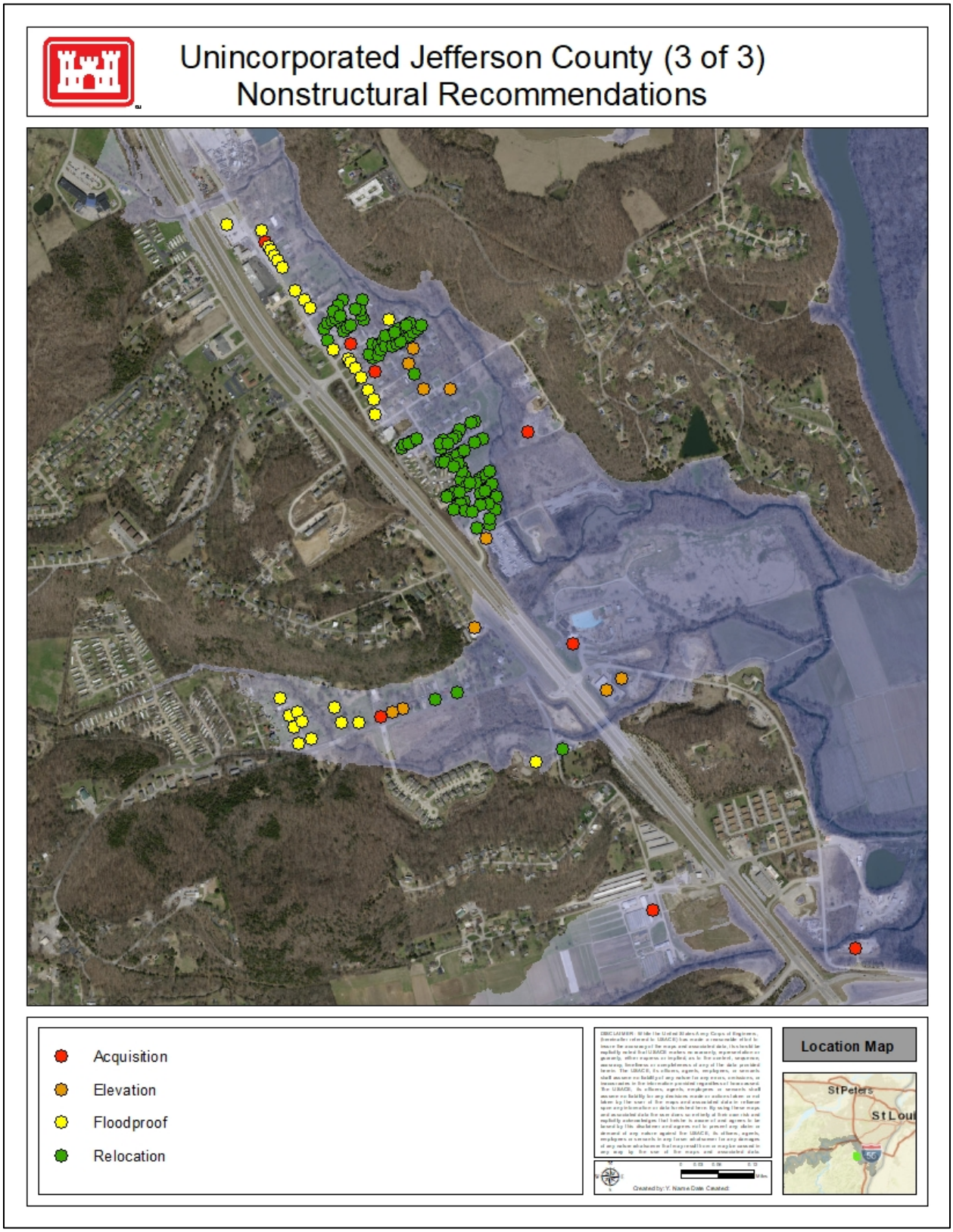


Figure 48. Unincorporated Jefferson County Nonstructural Recommendations (Area 3 of 3)

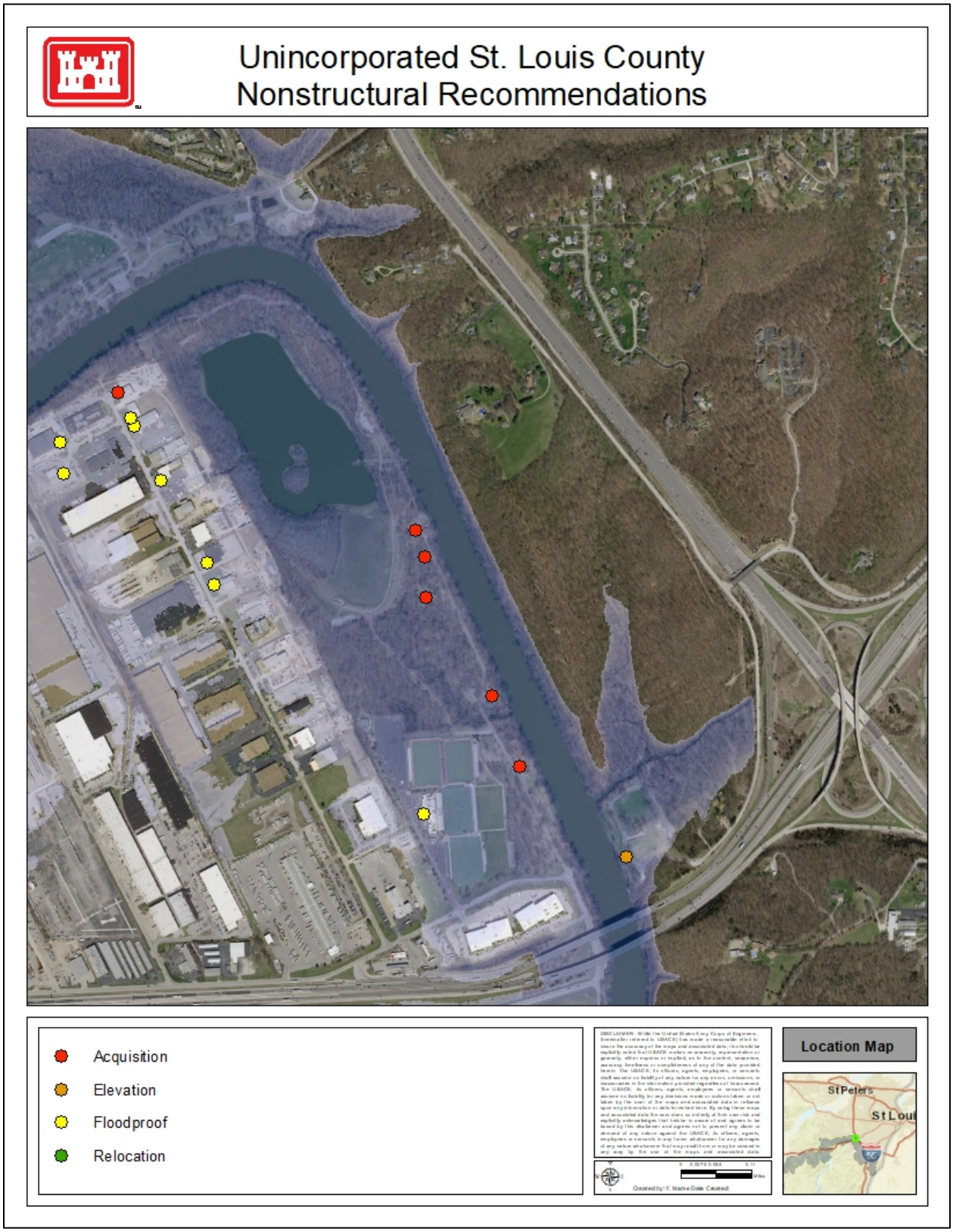


Figure 49. Unincorporated St. Louis County Nonstructural Recommendations


Figure 50. Valley Park Nonstructural Recommendations


Figure 51. Wildwood Nonstructural Recommendations

# 6 Goals and Objectives

Defining goals, objectives, and mitigation actions is an essential step in this planning process to establish and achieve a community's vision of what it wishes to accomplish as a result of the FMP effort.

- Goals are general guidelines and usually broad policy-type statements, long-term in nature, and represent the vision of the local jurisdictions. Goals guide decisions to address floodplain management and mitigation actions in the focus area.
- Objective(s) accompany goals and provide a more specific intent of the goal.
- Mitigation actions are specific efforts to implement any measure(s) (physical or non-physical) to mitigate flood hazards and help jurisdictions achieve goals and objectives.

This effort develops into an action plan that prioritizes the objectives and mitigation actions as well as guides the implementation of the FMP, including the responsible departments for each activity, timeframe for implementation, budget for the activity (if appropriate), and how it might be funded.

The goals address all flood-related problems, set the context for the subsequent review of floodplain management activities and drafting of the action plan, and are consistent with other regional and community goals for the affected areas.

During the development of the Lower Meramec Multi-Jurisdictional FMP, the local governing bodies in the watershed were responsible for identifying and refining their goals and objectives. Each of these cities and counties are partners in this FMP and are responsible for ultimately implementing the FMP. These communities each have elected officials who ultimately make decisions on altering city/county codes, expending resources, and voting on many actions that the FMP recommends.

## 6.1 Goal Identification

After a series of webinars and telecommunications with the cities and counties, the following eight goals and objectives were established (listed in no particular order):

1. Develop a collaborative multi-jurisdictional approach towards floodplain management to address the flooding concerns and impacts in the Lower Meramec Watershed;
2. Establish and implement an organizational framework for watershed management;
3. Coordinate, integrate and balance flood management activities, water quality improvement strategies, recreational improvements, sediment management, and ecological restoration activities;
4. Obtain a balance between development needs and the proper functions of the floodplain within the Lower Meramec Watershed;
5. Protect and preserve the natural riparian corridor environment to enhance habitat connectivity, water quality, erosion and sediment management, bank and channel stabilization, and provide compatible recreational opportunities;
6. Develop a comprehensive public education, advocacy, and outreach program to increase public awareness about, understanding of, and involvement in protecting and enhancing our natural and built environment;
7. Improve public understanding of flood risks within the Lower Meramec Watershed;

8. Proactively manage and reduce flood risk along the Lower Meramec and its tributaries to protect life and property.

For each goal, the cities and counties identified corresponding objectives that can be met in order to achieve those goals. Note: There are some objectives that the respective governments have already met in order to meet their goals.

### GOAL 1: DEVELOP A COLLABORATIVE MULTI-JURISDICTIONAL APPROACH TOWARDS FLOODPLAIN MANAGEMENT TO ADDRESS THE FLOODING CONCERNS AND IMPACTS IN THE LOWER MERAMEC WATERSHED.

Objective 1: Adopt and implement a Lower Meramec Multi-Jurisdictional FMP by the local governments in the Lower Meramec Watershed.

### GOAL 2: ESTABLISH AND IMPLEMENT AN ORGANIZATIONAL FRAMEWORK FOR WATERSHED MANAGEMENT.

Objective 1: Identify/create a sustainable funding mechanism to support multi-jurisdictional watershed planning and management.

Objective 2: Coordinate efforts with other agencies and stakeholders in planning, design, development, and implementation of projects.

Objective 3: Provide for watershed maintenance (ownership/easement, access, resources, staff, equipment, etc.).

Objective 4: Create and empower a cooperative, effective, multi-jurisdictional organizational framework to manage policy development and implementation within the watershed.

Objective 5: Establish an entity to provide security measures and features (e.g. emergency phones).

### GOAL 3: COORDINATE, INTEGRATE AND BALANCE FLOOD MANAGEMENT ACTIVITIES, WATER QUALITY IMPROVEMENT STRATEGIES, RECREATIONAL IMPROVEMENTS, SEDIMENT MANAGEMENT AND ECOLOGICAL RESTORATION ACTIVITIES.

Objective 1: Establish an entity to address flood risks.

Objective 2: Establish organization structure including representatives from diverse interests and city departments.

Objective 3: Identify/create sustainable funding mechanism to coordinate efforts with other agencies and stakeholders in planning, design, development, and implementation of projects.

Objective 4: Provide for watershed maintenance (ownership/easement, access, resources, staff, equipment, etc.).

### Goal 4: Obtain a balance between development needs and the proper functions of the floodplain within the Lower Meramec Watershed.

Objective 1: Implement appropriate Best Management Practices (BMPs) for public and private development projects. Encourage green infrastructure through incentives and development standards for redevelopment areas and with new development.

Objective 2: Continue to assess the performance of the basin as a complete system.

Objective 3: Implement appropriate policies and regulations that address needs of existing properties.

### Goal 5: Protect and preserve the natural riparian corridor environment to enhance habitat connectivity, water quality, erosion and sediment management, bank and channel stabilization, and provide compatible recreational opportunities.

Objective 1: Implement appropriate BMPs to stabilize channel and stream banks, protect wildlife and habitat, conserve open space, reestablish riparian corridors and potentially be compatible with recreation opportunities.

Objective 2: Identify and preserve undeveloped land that is critical to the integrity and maintenance of the various floodplain functions.

Objective 3: Take advantage of multipurpose solutions that improve aquatic ecosystems and the management of floodwaters.

Objective 4: Establish stream corridors to promote ecosystem connectivity.

Objective 5: Undertake riparian habitat and stream restoration activities, restore stream banks, improve aquatic habitat, address habitat scarcity, and increase biodiversity/bioabundance.

### Goal 6: Develop a comprehensive public education, advocacy, and outreach program to increase public awareness about, understanding of, and involvement in protecting and enhancing our natural and built environment.

Objective 1: Increase awareness and appreciation of natural resource conservation and water quality through public surveys, educational programs, and watershed signage.

Objective 2: Create interactive, educational opportunities for the community that promote good stewardship ethic, connect citizens to the water resource, encourage participation in recreational activities, and develop neighborhood and community pride.

Objective 3: Develop a focused advocacy program to build support for a watershed approach from public officials and the private community.

### GOAL 7: IMPROVE PUBLIC UNDERSTANDING OF FLOOD RISKS WITHIN THE LOWER MERAMEC WATERSHED.

Objective 1: Develop a range of educational tools to inform the general public, elected officials, and interested parties (i.e., realtors, property owners, tenants and developers) of the flood risks, promote floodplain stewardship, connect citizens to the riparian environment, encourage appropriate recreational activities, and develop a sense of watershed ownership along the Lower Meramec River.

Objective 2: Implement an Early Warning System that incorporates multiple media tools that are tied to the NWS.

### GOAL 8: PROACTIVELY MANAGE AND REDUCE FLOOD RISK ALONG THE LOWER MERAMEC RIVER AND ITS TRIBUTARIES TO PROTECT LIFE AND PROPERTY.

Objective 1: Compile known flood risks in the watershed from local stakeholders and characterize the flood risks in terms of public safety (depth, velocity, population-at-risk, warning time, and rate-of-rise).

Objective 2: Evaluate and implement flood warning systems and response plans.

Objective 3: Use a multipurpose stream corridor approach to manage flood risks (flood proofing, building elevation, buyouts, etc.).

Objective 4: Identify and mitigate repetitive loss areas.

Objective 5: Revise floodplain and subdivision policies and regulations.

## 6.2 Goal Screening and Rankings

Following the initial identification of the goals and objectives, the cities and counties ranked their respective government's priorities. Three of the communities gave rankings of 1 to 4 with 1 being the highest priority goal. Three of the communities gave rankings of 1 to 3, also with 1 being the highest priority. Five communities did not submit rankings of the goals and objectives. **Table 19** shows the ranking of the goals by the cities and counties and also the common goals that each share.

*Table 19. Goal Rankings by City and County*

| Community | Goal 1<br>***Develop a collaborative multi-jurisdictional approach towards floodplain management to address the flooding concerns and impacts in the Lower Meramec River Basin.*** | Goal 2<br>***Establish and implement an organizational framework for watershed management.*** | Goal 4<br>***Obtain a balance between development needs and the proper functions of the floodplain within the Lower Meramec River Basin.*** | Goal 5<br>***Protect and preserve the natural riparian corridor environment to enhance habitat connectivity, water quality, erosion and sediment management, bank and channel stabilization, and provide compatible recreational opportunities.*** | Goal 6<br>***Develop a comprehensive public education, advocacy and outreach program to increase public awareness about, understanding of, and involvement in protecting and enhancing our natural and built environment.*** | Goal 7<br>***Improve public understanding of flood risks within the Lower Meramec Watershed.*** | Goal 8<br>***Proactively manage and reduce flood risk along Lower Meramec and its tributaries to protect life and property.*** |
|---|---|---|---|---|---|---|---|
| **City of Arnold** | #1 | #2 | #4 | | | | #3 |
| **City of Eureka** | | | #1 | | | #2 | #3 |
| **City of Fenton** | #2 | | | #3 | | #4 | #1 |
| **City of Sunset Hills** | #3 | | | | | #2 | #1 |
| **Jefferson County** | | | #2 | | #3 | | #1 |
| **St. Louis County** | #4 | | #1 | #2 | | #3 | |
| **Franklin County** | **No Goals/Objectives Received** | | | | | | |
| **City of Valley Park** | **No Goals/Objectives Received** | | | | | | |
| **City of Pacific** | **No Goals/Objectives Received** | | | | | | |
| **City of Union** | **No Goals/Objectives Received** | | | | | | |
| **City of Wildwood** | **No Goals/Objectives Received** | | | | | | |

# 7 Strategies and Tools

Elected officials should work collaboratively with the staff in the community units of government in order to prioritize risk management actions. The FMP helps staff articulate or make the case for these decisions which, in turn, assists elected officials to focus expending limited resources on problem areas that are driving the flood risk.

USACE, in consultation with various partners and stakeholders, considered a long list of strategies and tools and has made recommendations and provided rationale for inclusion or exclusion of each tool. Later, the plan bases prioritized actions on this evaluation. This section serves to describe the reasons for inclusion or rejection of those tools.

The Lower Meramec Multi-Jurisdictional FMP includes tools in four strategy categories:

- Modifying Human Susceptibility to Flood Hazards
- Modifying the Impact of Flooding
- Preserving and Restoring Floodplains' Environmental Quality
- Modifying Floodwaters

The four strategy categories and corresponding tools are the "measures" that the flood risk management professional refers to with very deliberate terminology, because these will lead to the eventual action items in the FMP. That terminology serves to clarify that the measures fall under the category of either

- an "**activity**" or
- a "**feature**"

An "activity" is an effort done by the city, counties, or partnering state and federal agencies to better understand the flood risks, to reduce the risk, and to manage risk in the long-term. Activities involve little to no construction actions. Examples of an activity could be an informational outreach program, an updated study of a flood-prone area, or an emergency action plan.

"Features" are actual construction projects to a property or properties that an individual can undertake, or the city, county or partnering agencies can perform. Features can include major civil works projects such as levees, or smaller "flood risk adaptive measures," such as elevating an existing home or business. USACE typically calls these smaller features "nonstructural measures." This term originates from FEMA policy, but the term can be confusing. For the sake of this FMP, the term "nonstructural" refers to a measure that does not include a large structural project such as a levee, floodwall, floodgate, etc., which is traditionally what the public thinks of when referring to USACE projects. This FMP does consider some structural measures that were proposed by the public during the public workshop, during nonstructural assessment home/business visits, or in the public survey.

**Table 20** presents a list of various structural (physical) and nonstructural (physical and/or non-physical) measures which can be implemented independently or in combination with others to reduce the overall risk to flood damages in the given study area.

*Table 20. List of Potential Structural and Nonstructural Measures*

| Structural Measures | Physical Nonstructural Measures | Nonphysical Nonstructural Measures |
|---|---|---|
| Levees | Elevation | Flood Warning Systems |
| Floodwalls | Relocation | Flood Insurance |
| Berms | Buyout/Acquisition | Floodplain Mapping (FIRM) |
| Flood Gates | Dry Floodproofing | Flood Emergency Preparedness Plans |
| | Wet Floodproofing | Land Use Regulations |
| | | Evacuation Plans |
| | | Risk Communication |

USACE evaluated each of the possible tools and, after involving the stakeholders through public involvement in the decision process, placed each tool into one of the following four categories:

- Not Recommended,
- Further Evaluation Needed,
- Recommended, and
- Effective/Not Effective.

These specific terms will appear with each tool and also in the body text in bold format, because these represent important supporting information to the action items later in the FMP. The expanded meanings are below.

- "**Not Recommended**". The tool was evaluated and determined not to be appropriate for reasons explained.

- "**Further Evaluation Needed**". The tool is likely appropriate, but additional efforts are needed to collect and study the facts of the situation before a decision can be made for the evaluation.

- "**Recommended**". The tool has been evaluated and is a good solution in the community, although the community has yet to begin the effort. This could be a *feature* awaiting construction funding or an *activity* like building codes / inspection or zoning requirements, where guidance is developing with the city or county, for example.

- "**Effective**" (or "Highly Effective"). A tool evaluated with this term is one that the community has already implemented. The measure has proven to manage the flood risks well. As an example, this could be either an activity, like land use regulation or a stream setback ordinance, or even a green space requirement that is proven and will require continuous staff support (including funding) to continue being effective. Another

example would be a constructed feature that has costs for upkeep. Upkeep costs must consider operation and maintenance (for example, costs for mowing grass around the feature), as well as repair (for example, erosion damage from flooding), rehabilitation and replacement (like a failing or old pump that eventually is surpassed by new technology). Without the upkeep, the feature will not have effective performance as originally intended.

## 7.1 Strategy: Modifying Human Susceptibility to Flood Hazards

This strategy and set of tools includes measures directed toward managing the floodplain. Activities under these measures include: land use regulations, public redevelopment policies, flood warning systems, and flood emergency preparedness plans (including emergency action plans and flood fighting plans). Features under these measures include: flood-proofing buildings in the floodplain, berms and floodwalls for buildings, elevation of buildings, basement fill with main floor addition for buildings, acquisition of buildings (for demolition) and relocation of buildings.

### 7.1.1 Tool: Land Use Policies and Regulations

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

Land use regulations include the following potential actions:

- Regulatory NFIP floodplain management ordinance
- Regulatory NFIP flood maps and floodways
- Development permitting
- Zoning Maps
- Building codes
- Critical structure development practices
- Redevelopment processes
- Freeboard or stream setback ordinances
- Comprehensive plans

This tool covers both development policies and land use regulations. Development policies could be found in the various community-wide plans for the city and the county (i.e., comprehensive plans, master plans, economic development strategic plans, etc.). These policies help guide the community decisions of where new development or redevelopment should occur.

Land use regulations can be used to implement a wide variety of site and building requirements, restrictions, and prohibitions to protect new developments as well as existing developments. A minimum standard of floodplain regulations has been established by the NFIP. **Table 21** identifies the specific components of each community's floodplain ordinances. The ordinances can be viewed in full in Appendix B.

*Table 21. Lower Meramec Floodplain Ordinance Review*

| Community Name | Freeboard (Feet) | Repetitive Loss Definition | Non Conforming Use | Mandatory Disclosure | Critical Development Protection | Additional Floodway Requirement | Hazardous Materials | Cumulative Substantial Damage/ Improvement | Lower Substantial Damage Improvement | Setbacks Stream Buffer | Subdivision Standards | Enforcement (min 100.00) | Road/Bridge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eureka | 1 | X | X | | | | | | | | | 500 | |
| Pacific | 2 | X | X | | | X | | X | | | | 100 | |
| Union | 2 | | | | | | | | | | | 1000 | |
| Valley Park | 1 | X | X | | | | | | | | | 500 | |
| Sunset Hills | 1 | X | X | | | | | | | | | 500 | |
| Arnold | 3 | X | X | | | | | | | | | 500 | |
| Franklin County | 2 | X | X | | X | | X | X | | X | | 100 | |
| St. Louis County | 1 | X | | X | | | | | | X | | | |
| Jefferson County | 3 | | X | | X | X | X | | | ? | ? | 1000 | X |
| Wildwood | 2 | X | X | | | | X | | | | | | |
| Fenton | 2 | X | X | | X | | X | | | | | 500 | |

The cities and counties have integrated some of these actions into various policies in the communities' efforts to manage flood risk. Model ordinances are available through the Missouri SEMA, and they include ordinances such as mandating that the community identify a regulatory floodway and prohibit any new development unless it has been demonstrated through a hydraulic analysis that the development would not cause any increase in flood levels during the occurrence of the base flood discharge.

These tools are readily acceptable as an effective measure to protect existing homes and businesses, additions to these existing structures, and new developments from flooding. The tool is **recommended** to be included in the Action Plan of the FMP.

### 7.1.2 Tool: Public Alert Flood Warning System

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

Any flood risk management plan should consider the development and implementation of flood warning systems and emergency preparedness planning. The development of such plans and the installation of pertinent equipment such as data collection devices (rain gages, stream gages) and data processing equipment can become an integral feature of a project. Evacuation planning should consider vertical evacuation as well as lateral evacuation. Reunification sites should be a featured component of any evacuation plan.

Jefferson County participates in and promotes the CodeRED system. It is a reverse 911 system that informs the public of weather conditions and weather watches and warnings via phone call or text. Citizens may sign up at no cost to them by calling 9-1-1 Dispatch. In addition, other medium forums are used such as social media sites Twitter and Facebook. These various mediums can be promoted to reach a broader audience and provide high quality emergency notification.

A flood risk communication tool such as flood warning lights on roadways can also serve to notify traffic to turn around to avoid high water on roadways. This warning system can help prevent motorists from being trapped in moving water, or worse, a drowning. A set of flood warning lights tied to stream gages in the basin is recommended in areas where the most severe flooding occurs in a short amount of time.

### 7.1.3 Tool: Warning Dissemination, Multi-Media

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

As a flood risk communication tool, multi-media approaches have considerably advanced technologically, although other more traditional means are also still very much relevant.

One **recommended** step is to further promote use of social media and website announcements. In addition, during major flooding events similar to 2017, daily status updates could be channeled through newer multi-media outlets used by a demographically diverse group of residents. Pre-identified roles could be established to present daily updates based on reality during the flood to local "traditional" media outlets, as well as through the newer outlets.

Another **recommended** step is to formalize this public media engagement in a new emergency action plan. This may include predefined messages that correspond to action stages identified with NOAA NWS or with USGS development of the FIM for the Lower Meramec Basin, based on the existing or additional river gages in the area. The public can subscribe to the USGS WaterAlert to receive water information texted directly to their cell phones for personal evacuation planning and awareness.

### 7.1.4 Tool: Flood Emergency Preparedness Plans (or Emergency Action Plans)

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

Inter-related to the flood warning system is an emergency preparedness plan for flooding. Generally speaking, emergency preparedness plans include several topics related to identifying the risk:

- Emergency operation plans based on indicators or stages of the magnitude of the risk;
- Emergency communication plans;
- Emergency evacuation plans;
- After action plans.

Each of these is relevant, but all have a unique focus and/or audience.

*Emergency Operation Plan* – An emergency operation plan is the core of the emergency preparedness plan. The flood emergency operation plan is designed to provide needed actions based on existing or forecasted water levels. Using the FIM described above, Emergency Managers for the city and county can define action stages when certain emergency response actions should be initiated. These action stages could be the activation of an Emergency Operation Center, the signaling of emergency sirens, warning lights and multi-media warnings, mobilization of emergency personnel, closing of roads at risk of flooding, and evacuation of impacted areas.

It is **recommended** that the Lower Meramec communities create and adopt an Emergency Operations Plan at the local level.

*Emergency Communication Plan* – As with any emergency situation, communicating to the public is key to describe the event, discuss what risks are associated with the event, and explain what actions should be taken to lessen the impacts of the event. An emergency can be chaotic and at times communicating the risk and other needed information is not always adequately

accomplished. An emergency communication plan can create a framework to establish who will provide the needed communication to the public, what communication media will be used, and generally what the message will be. The added benefits to a detailed emergency communication plan are the effective use of emergency personnel, the timely flow of information about the risk, and the establishment of a dedicated and reliable source of information which will reduce the duplication of messages and/or confusion and rumors.

It is **recommended** that the Lower Meramec communities create and adopt an Emergency Communication Plan at the local level.

*Emergency Evacuation Plan* – By their very nature, emergencies are not predictable and can occur anytime and anywhere. The timing of flood emergencies is generally unpredictable, but the location of a flood event is well known. With modern flood models and mapping software, the location, depth and even velocity of a ravine flood event can be provided to emergency response professionals. Armed with this information and the FIM, it can readily be shown what areas of the community will flood first and how large the impact from the flooding will be. This information is invaluable to determining how many people will be impacted, social characteristics that may create unique circumstances or challenges in evacuating an area (i.e., low car ownership population, English as a second language population), and what routes will be available to get the impacted people out of harm's way. This information can also assist in determining short and long term emergency shelter needs and locations of these shelters.

It is **recommended** that the Lower Meramec communities create and adopt an Emergency Evacuation Plan at the local level.

*After Action Plans* – A later step in the flood emergency preparedness plan is the after action plans. This planning phase covers all of the steps for recovering from the flood event. Items that can be included in this plan can include damage assessment, material disposal, clean-up and recovery communication, and economic recovery. Although this step of the emergency preparedness process is sometimes overlooked, a dedicated plan to help a community recover from a disaster will be extremely beneficial to both the individual and the community as a whole.

This is a **recommended** activity to create a prepared and resilient community in the face of the flood risk. These plans should be periodically practiced and vetted via table top exercises and small scale simulated drills to ensure the variety of plans are up to date and accurate.

### 7.1.5 Tool: Development Policies – Moratorium

ACTIVITY: EFFECTIVE ✓ NOT RECOMMENDED X

A moratorium on development in the floodplain would prohibit any building in the floodplain by law until a specified time when solutions could be created to reduce the flooding impacts from Lower Meramec River and its tributaries. Detailed hydraulic analyses have not been conducted by federal, state, or local agencies or their engineering contractors to justify a moratorium on floodplain development. If implemented by a local jurisdiction the decision could subject the local government to a law suit for "takings". In addition, development moratoriums only affect future development, so the moratoriums would not help mitigate existing development that may have already impacted the floodplain. These factors do not lend to this tool being considered moving forward.

### 7.1.6 Tool: Structure Elevations

FEATURE: EFFECTIVE ✓ RECOMMENDED ✓

As a nonstructural technique, elevating structures involves raising the structure in place to reduce frequency and/or depth of flooding during high-water events. Elevation can be completed on fill, foundation walls, piers, piles, posts, or columns. Selection of proper elevation method depends on flood characteristics such as flood depth or velocity and condition of the structure and site.

### 7.1.7 Tool: Buyouts (Structure and Land Acquisition)

FEATURE: EFFECTIVE ✓ RECOMMENDED ✓

As a nonstructural technique, buyouts remove flood-prone structures and maintain the purchased land as open space. Land acquisition can be in the form of fee title or permanent easement with fee title. Land use after acquisition is open space use via deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is open space based such as trails with interpretive markers, shoreline access, and limited recreation fields. Conversion of previously developed land to open space means there is no longer the need for utilities, streets, or sidewalks which can be removed as part of the project.

### 7.1.8 Tool: Floodproofing (Wet & Dry)

FEATURE: EFFECTIVE ✓ RECOMMENDED ✓

Dry floodproofing involves temporarily or permanently sealing exterior building walls with water proofing compounds, impermeable sheeting, or other water resistant materials to prevent the entry of floodwaters into structures. Temporary dry floodproofing measures, such as installing door barriers, require some early warning for the owner/tenant to be able to install the closure(s) and safely evacuate the premises prior to the arrival of floodwaters. Note: Dry floodproofing cannot be used to bring any structure into compliance with a community's floodplain management ordinance.

Wet floodproofing includes measures that allow floodwater to enter the structure without significant consequence. Vulnerable items such as utilities, appliances, and furnaces are waterproofed or relocated to higher elevations. Basements are abandoned and filled in order to prevent placement of damageable items in the space. By allowing floodwater to enter the structure, hydrostatic forces on the inside and outside of the structure can be equalized, thereby reducing the risk of structural damage. See Section 8.1.2 as well as Appendix E for additional information on nonstructural flood risk measures. Note: Wet floodproofing cannot be used to bring a residential structure into compliance with the community's floodplain management ordinance.

### 7.1.9 Tool: Community Education and Advocacy

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

Community Education and Advocacy is a key component to a healthy and vibrant community. Communication between a unit of government and its constituents, at any and all levels, creates trust and a sense of shared responsibility for the citizens. In terms of reducing flood risk, educating the public on the risks of living in or near a floodplain can and does reduce the risk that lives will be lost or property damaged during a flood event. There must be a balance between community activism and governance, and this balance can be accomplished by sharing the goals and objectives of the unit of government and the citizens whether they are shared individually or as formal or informal groups.

It is **recommended** for the cities and counties in the Lower Meramec Basin to form an official committee or group that has both representatives from the city government, private citizens, and any other county or municipal representatives deemed beneficial to the committee. The mission of this committee will be to openly communicate about the risk of living in or near a floodplain and to host public meetings, both formal and informal, to help citizen and business owners prepare for and respond to all types of natural disasters (including flooding). This will allow the various governmental and nongovernmental groups of city employees and private citizens to pool their efforts and their resources to understand, communicate, and ultimately reduce the risk of flooding in the various communities.

### 7.1.10 Tool: Temporary Flood Risk Adaptive Measures (i.e.: Flood Fighting)

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

The most common temporary measures that are recommended for at-risk structures along the Lower Meramec floodplain are: 1) polyethylene sheeting attached or hung onto the structure exterior (usually to a height of 3 feet above the first floor elevation and continued on the ground surface 4 feet out from the structure exterior), in combination with door and window closures, 2) clear liquid sealant applied to the structure exterior in combination with caulking of large cracks in the exterior and placement of door and window closures, 3) sandbag berms located around all or a portion of the structure, and 4) any of the barriers certified through the National Flood Barrier Testing and Certification Program [see http://nationalfloodbarrier.org/].

See Appendix D (National Nonstructural Committee Assessment with Enclosures) and Appendix E (USACE Analysis of National Nonstructural Committee Assessment) for more information on temporary flood risk adaptive measures.

## 7.2 Strategy: Modifying the Impact of Flooding

This strategy and set of tools involves managing the floodplain with the following specific activities: information and education, flood insurance, tax adjustments, emergency relief, and post-flood recovery processes.

### 7.2.1 Tool: Information and Education

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

City and county officials should, through a variety of methods and media, inform the general public and residents within the floodplain of specific flood hazards, how to prevent and/or prepare for a flood event, and what to do after a flood event.

A number of local, state, and federal agencies, such as the Missouri SEMA, have prepared detailed pamphlets, books, and other informational pieces on how to prevent and prepare for a flood event. Similar information on recovery from a flood event has been created by these agencies and others. City and county officials should continue to collect, review, and maintain a sufficient library of information to assist residents with these topics, with an online database with easy access for residents. In addition to notifying the public about this resource library, the information should be catalogued at public libraries in Lower Meramec communities.

Information on other topics related to flooding, such as water quality and water conservation, should be collected and made public in a similar fashion as the flood hazard and prevention information. This information can be provided at city and county offices and/or the public libraries. A variety of media types can be used to inform residents and other interested parties about these flood related topics. All of the communities maintain informative websites where this information can be displayed. Newsletters, newspaper advertisements, press releases, notices on utility bills, other government notices, social media, and direct mailings should also be used. Both entities should be creative as to how these messages are relayed to the public both broadly and specifically in an effort to have a community well-informed on the hazards of flooding in the area.

In terms of participating in FEMA's CRS, credit points can be earned for a comprehensive approach to informing the general public and residents living and working in the floodplain of the potential hazards of flooding in the community. The cities and counties should set a goal to create a comprehensive public outreach and educational plan that targets a variety of topics and groups of residents to inform as many people as possible and potentially earn greater reductions in flood insurance premiums through the CRS program (if the cities or counties chooses to participate in the program in the future).

### 7.2.2 Tool: Flood Insurance

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

The NFIP contains 3 basic parts: flood insurance, flood mitigation, and floodplain regulation. In terms of reducing flood risk, only flood mitigation and floodplain management regulations are believed to have a direct impact. In regards to the flood insurance component of the NFIP, flood insurance does not reduce flood risk. It simply spreads the flood risk across multiple public and private structures as does any insurance program - it shares flood risk.

Homes and businesses in high-risk flood areas with mortgages from federally regulated or insured lenders are required to have flood insurance. If residents live or own a business in a high-risk flood zone and received federal disaster assistance in the form of grants from FEMA or low-interest disaster loans from the U.S. Small Business Administration (SBA) following a Presidential Disaster Declaration, they must maintain flood insurance in order to be considered

for any future federal disaster aid. Disaster assistance comes in two forms: an SBA loan, which must be paid back with interest, or a FEMA disaster grant, which is about $5,000 per household on average. By comparison, the average flood insurance claim is nearly $30,000 and does not have to be repaid.

Increased Cost of Compliance (ICC) coverage is one of several resources for flood insurance policyholders who need additional help rebuilding after a flood. ICC coverage provides up to $30,000 to help cover the cost of mitigation measures that will reduce flood risk. ICC coverage is a part of most Standard Flood Insurance Policies available under the FEMA's NFIP. When a building insured by a Standard Flood Insurance Policy under the NFIP sustains a flood loss and the community declares the building to be substantially or repetitively damaged, ICC coverage helps pay for the cost to elevate, flood-proof (nonresidential only), demolish, or relocate the building to meet certain building requirements in the community. ICC coverage is available on residential and non-residential buildings (this category includes public or government buildings, such as schools, libraries and municipal buildings) insured under the NFIP's flood insurance policy.

### 7.2.3 Tool: Community Rating System (CRS)

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

The CRS is a national program through FEMA and the NFIP that evaluates a community's floodplain management efforts and rewards those efforts with reductions on National Flood Insurance premiums based on the community's floodplain management performance. None of the communities in the Lower Meramec Basin formally participate in the CRS as of the date of this plan. This FMP is an element that, if adopted, can lead to the community's participation in the CRS, which can increase the premium discounts. Other activities, such as higher floodplain regulations (Section 7.1.1), dedication of open space in the floodplain (Sections 7.1.7 and 7.3.2), and the outreach of information related to flood risk (Section 7.1.9), can also further the community's participation in CRS. Several manuals on this topic are listed in the reference section (Section 9) of this FMP, as well as the Missouri State Floodplain Coordinator's Manual and examples of several applicable activities.

At a very minimum, as part of this FMP, communities should evaluate their administrative capabilities to participate in the CRS program as many smaller units of government may find the administrative duties associated with program entry and maintenance to be burdensome from a manpower aspect.

### 7.2.4 Tool: Local Drainage and Utility Protection

ACTIVITY: EFFECTIVE ✓ FURTHER EVALUATION NEEDED ✓

In addition to back-water flooding of tributaries to the Meramec River, local drainage systems can be inundated with floodwaters during and following large rain events. Depending on the condition of these systems, they can exacerbate the flooding experienced by homes, businesses, and public infrastructure including roads, emergency response organizations, and critical infrastructure. There can also be times where heavy and prolonged rainfall can cause interior flooding when rivers are at or below flood stage.

Local drainage is typically a responsibility of the local unit of government. Each unit of government should seek public input on sources of local drainage concerns and their impacts to properties and **further evaluate** potential solutions. Several of the tools in this FMP are scalable and could address local drainage flooding in addition to larger back-water flooding.

### 7.2.5 Tool: Tax Adjustments

ACTIVITY: EFFECTIVE ✓ FURTHER EVALUATION NEEDED ✓

The use of tax adjustments and tax rebates could be a tool to incentivize the establishment of more open space and/or encourage the construction and renovations of homes and businesses that are better protected from the risk of flooding.

A tax incentive program could provide a reduction of the property tax in exchange for the dedication of the open space area on a parcel through conservation and drainage easements.

Tax rebates could be made available to home and business owners for a portion of the cost of materials and labor to build a new structure to a higher degree of flood protection or renovate an existing structure to mitigate the flood risk. As an example, the tax credits could be used to offset the cost to increase the elevation of a new home above what would typically be required. During the renovations to an existing home, tax credits could be used to cover the cost engineered opening in the foundation, relocation and elevation of utility equipment, or the use of flood resistant materials over traditional materials.

More research is needed to determine if this tool would be a substantial benefit to both the property owners and the community and what mechanisms need to be put into place to make these tax adjustment and tax rebate programs successful.

### 7.2.6 Tool: Post-Flood Recovery Processes

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

The communities in the Lower Meramec Basin, its officials, and citizens in the region have significant training and real-life experience in their roles and responsibilities in post-flood events in their jurisdictions.

It is **recommended** that the entities along the Lower Meramec continue to inspect damaged homes and businesses after flood events to ensure they comply with all regulations. In addition, the local entities should become a repository of post-flood disaster information on flood safety, clean up, and mitigation options for impacted property owners and their tenants. Documenting post-flood lessons learned and developing recovery plans helps to keep all community members aware of the processes and procedures used to recover from varying levels of flood damage.

The officials of the communities along the Lower Meramec and its tributaries should also focus their post-flood recovery efforts on long term needs for a neighborhood or the region. These efforts could include economic recovery and infrastructure recovery plans. A significant portion of the region's commercial and industrial uses are located in the Lower Meramec Basin.

In accordance with FEMA-DR-4250-MO, Interagency Recovery Coordination dated August 19, 2016, offers the following strategies for areas within the state to include the Lower Meramec basin;

- Multi-jurisdictional and multi-discipline coordination in watershed and floodplain management is the best approach to reduce future losses.
- Integrating mitigation actions into recovery plans embeds systematic risk management actions that ensure a community is building resilience to future impacts.
- Engaging all stakeholders with an interest in vulnerability reduction engages the whole community in the process.
- Incorporating hazard mitigation concepts and objectives into existing and future policies, plans, regulations and laws in the State.

## 7.3 Strategy: Preserving and Restoring Environmental Quality

While most people view a river or stream only as the place where there is regularly flowing water, the reality is that the river and floodplain are one integrated system that has evolved over time to convey water and sediment downstream. The floodplain functions to both store water and to slowly release it back into the main channel of the river as the floodwaters recede. This strategy and set of tools involves managing the floodplain with nature based conservation measures for habitat protection and restoration, erosion and sediment control, water quality enhancement, enhancement of recreation and educational opportunities, and preservation of cultural resources.

### 7.3.1 Tool: Wetlands, Stream, and Riparian Protection and Restoration

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

Reducing flood risk through open space preservation and habitat restoration is a large scale proposition based on watershed size, topography, and rainfall intensity. This tool would require the protection and restoration of significant acreage to realize the benefits of flood attenuation. Avoidance of significant future flood damage costs is another benefit of strategic acquisition and conservation of floodplains. A new study finds that in many areas it would be cheaper to buy undeveloped floodplains today than it would be to pay for the flood damage from expected development. Conserving large floodplain areas can have a $5 benefit for every $1 spent.[6] In general, an effectively applied tool requires: (1) identification or mapping of available open space, (2) prioritization of parcels, (3) acquisition of property or educating/informing landowners about available incentivized conservation programs and (4) restoration of habitat types that attenuate or reduce the floodwater velocities. Nature based conservation measures of wetland restoration, riparian restoration or preservation, and floodplain forest restoration have co-benefits of erosion reduction, reduced sediment accretion, and improved water quality. Funding programs and grants for open space preservation and floodplain restoration are outlined in

[6] Johnson, K.A. ET. al., “A benefit-cost analysis of floodplain land acquisition for US flood damage reduction”, Nature Sustainability, December 2019.

Appendix F and at www.wichita.edu/mowatershedfunding. U.S. Department of Agriculture programs and In-Lieu Fee Compensatory Mitigation programs cited in Appendix F offer financial incentives to landowners who are interested in preserving and/or restoring the habitat types identified above.

It is recommended for the communities in the Lower Meramec Basin to partner with nongovernment charitable environmental organizations, such as, The Nature Conservancy (TNC), Great Rivers Greenway, the Open Space Council, and the East West Council of Governments to prioritize potential locations for ecosystem restoration and rehabilitation as a means of reducing flood risks. TNC has created a customized Lower Meramec Floodplain Prioritization Tool (www.fptool.org) that can help the communities identify places where restoration or protection of floodplain areas would have the greatest benefit in reducing flood impacts and improving overall health of the Lower Meramec River. This online tool includes local data and is designed to help decision-makers optimize restoration investments and minimize the impacts of development. Tool users have the ability to interactively select their priorities related to nutrient removal, wildlife habitat, flooding, economic impacts and other goals to identify their priority locations for conservation or restoration.

Designed to support implementation of the FMP, the tool includes the environmental data used by the FMP to assess and rank the environmental considerations as well as the FMP's nonstructural recommendations. Users of the tool can view the FMP "Hubs" and "Structures" from Appendix E of the FMP with their associated recommendations and environmental criteria scoring. This tool will be of extreme value to those jurisdictions that are serious about comprehensive flood risk reduction strategies and entering into the CRS. The CRS provides special credit for community activities that preserve and/or restore natural floodplain functions, even though some of the activities may not directly reduce flood losses to insurable buildings. CRS credits are available for doing the following activities:

- Credits advising people about areas that should be protected because of their natural floodplain functions.
- Credit points are available for a website that provides detailed information about local areas that should be protected for their natural floodplain functions and how they can be protected.
- Adding layers to the community's geographic information system with natural floodplain functions (e.g., wetlands, designated riparian habitat, flood water storage areas) is credited.

### 7.3.2 Tool: Enhancement of Recreation and Education Opportunities

ACTIVITY: EFFECTIVE ✓ RECOMMENDED ✓

Open space along a stream provides for an area that is free and clear of man-made structures to allow storm water runoff and flood waters to flow unobstructed, as nature intended. Buyouts adjacent to natural areas and in priority areas for conservation provide multiple benefits. Floodplain habitat is exceptionally high in value for fish and wildlife and provides a rich resource for food, water, and animal movement. As natural areas increase in size, they typically increase in value for wildlife and host more types of fish and wildlife that are intolerant of smaller habitat

patches. Natural areas also provide recreational benefits including wildlife watching, angling, and hunting. Floodplains with intact natural vegetation slow down and absorb flood and storm waters, acting as natural sponges which results in flood risk reduction. In addition, they reduce sediment and nutrients in the water by filtering nutrients from the storm water and allowing sediment to settle out of flood waters on the floodplain. This in turn improves downstream surface water quality for drinking water.

Since these open public spaces attract residents from within the city and adjoining areas, and since some are parks present within a flood hazard area, this makes them likely candidates for a current project between USACE - Kansas City District and the SEMA. Widespread flooding in 2017 is pushing the state to increase public awareness of flood risks. This project will distribute application forms to get communities to make a sign or signs which capture the flood story. The project creates public historic flooding signs to raise awareness of past severe flood disasters in Missouri. The historic aspects description and a photo will be the two minimum elements on the sign. The signs will also include the Missouri SEMA and the USACE logo as well as a web page URL. The description will describe impacts of past events and emphasize use of:

- any past high water elevations,
- flood damage costs, and
- loss of life data.

All participating communities will be required to document the posting of the sign(s) by providing a photo of the mounted sign(s), which is noted in the application. The communities are responsible for the cost of materials to mount the sign(s) (also on the application).

It is **recommended** for the communities in the Lower Meramec Basin to continue exploring opportunities that enhance educational and recreational benefits along the Meramec River, which can remove structures at risk of flooding from the floodplain.

## 7.4 Strategy: Modifying Floodwaters

This strategy and set of tools focuses on managing the floodwaters with the following specific features: dam, storm water detention basins, levees and floodwalls, landforms, channel alterations, diversions, and pump stations.

### 7.4.1 Tool: Detention/Retention Basins

FEATURE: EFFECTIVE ✓ FURTHER EVALUATION NEEDED ✓

After major floods on the Ohio and Mississippi in the years 1927 and 1937, Congress authorized the building of up to 243 dams on the tributaries of these rivers to alleviate future flooding. Two federal dams were authorized for construction in the Meramec Basin in 1938, with one main reservoir on the Meramec River mainstem (Meramec Park Lake) and a second Union Dam on the Bourbeuse River. In the 1964 Comprehensive Basin Study 5 reservoirs and 19 angler use sites were recommended. House Document 525 authorized 3 major reservoirs and 19 angler sites and confirmed the need for the two previously authorized reservoirs from the Flood Control Act of 1938 at an estimated cost of $236 million. Due to public opposition for the project, the Missouri General Assembly took the project to the people via a referendum that included 12 counties in the Meramec watershed and surrounding region. This referendum was held on August 8, 1978. The final tally showed the area residents opposed to the project by 64%.

Meramec Park Lake was deauthorized by PL99-128 in January 1982 and specified no further consideration for dams on the mainstem Meramec River. In 1988 the Meramec River Basin, Missouri Recon Report carried the Pine Ford and Union Lakes forward in the analysis and identified the reservoir projects were not found to be economically justified. All remaining lakes proposed as part of the federal project were deauthorized on January 1, 1990.

**Further evaluation is needed** before this tool is carried forward for consideration.

### 7.4.2 Tool: Levees and Floodwalls

ACTIVITY: EFFECTIVE ✓ FURTHER EVALUATION NEEDED ✓

In accordance with the Lower Meramec River Flood Damage Reduction Project Plan Formulation Report and General Design Memorandum dated March 1987, “the Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to undertake such structural and nonstructural measures as he determines to be economically and engineeringly feasible to prevent flood damage to communities along the route of the Meramec River in Saint Louis and Jefferson Counties, Missouri. Such structural measures shall not include the construction of any dams or reservoirs.” In this report a full range of structural and nonstructural measures were examined for the study area communities. In the great majority of communities, no solution could be found which met the law's requirement of economic feasibility (plan benefits equaling or exceeding plan costs); the only justified structural project recommended in the report was a levee in Valley Park. While USACE was unable to justify a federal project in most communities, levees and/or floodwalls can be considered by local jurisdictions. However, caution must be taken as levee alignments should avoid any encroachments in the regulatory floodway. Encroachments in the regulatory floodway would not only have violate county and city flood ordinances but also increase the probability of significant increases in flood profile on the opposite bank or upstream.

In general, levees and floodwalls can provide protection both from upstream flooding and from backwater flooding. Although quite effective, levees in urban areas tend to be expensive for many reasons. Levees are earthen structures, typically 10 feet wide at the top with 1 on 3 slopes. Levee height determines the levee bottom width. Levees require regular inspections and have annual operation/maintenance costs. The earthen material needed to construct a levee must come from somewhere. Either it is hauled in from some distance or, if open land is available, it is excavated from "borrow areas" nearby. The former method is usually more costly, but even the latter option can be quite expensive given the high real estate prices in most urban areas. High urban land prices also push up the cost of right-of-way needed for the levee.

Floodwalls, while minimizing the costs associated with real estate, tend to be many times more expensive to construct than earthen levees. Floodwalls are utilized for urban settings and where real estate is limited for flood protection. Floodwalls are typically built of concrete and are typically one width top to bottom. Depending on the height of the floodwall, the width can be 12 inches to 36 inches. Both levees and floodwalls require expensive closure structures at points where roads and railroads must pass through the line of protection. In most cases, however, the most expensive features are those associated with the maintenance of interior drainage. Gravity drains (pipes through the levee embankment) can provide drainage of storm water at times when the Meramec River is not at flood stage. However, when the river reaches higher stages,

these drains must be closed to prevent flood waters from backing through the drains into the protected area behind the levee. In this condition, rain falling on the levee's interior and seep water which percolates through and under the levee must be handled either by pumps or by ponding areas located in vacant areas within the leveed area.

# 8 Action Plan

The Action Plan is the very heart of the FMP. The action plan is a blueprint for implementation of the FMP and is based on the recommendations developed throughout the FMP process, as presented in the earlier sections of the FMP. Possible strategies and tools of the action plan were evaluated for their relationship to the FMP's goals and objectives (Section 6.1) and their feasibility to be completed.

Vital information included in this FMP creates the opportunity to equip city and county floodplain administrators and elected officials with knowledge of the actions necessary to reduce future flood risk and the resources necessary to accomplish the action to achieve the goal.

Based upon the goals and objectives identified by the cities and counties in the Lower Meramec Basin, this FMP recommends the following actions (in no particular order), which are further described in subsequent paragraphs:

1) Adopt the Lower Meramec Multi-Jurisdictional FMP
2) Implement Nonstructural Recommendations in Appendix E
3) Develop/Update a Comprehensive Public Outreach Plan
4) Develop/Update a Flood Emergency Preparedness Plan (and Evacuation Plan)
5) Adopt/Update Higher Regulatory Floodplain Management Standards
6) Maintain and Expand the Existing Flood Warning Systems
7) Join the CRS

## 8.1 Action Items

### 8.1.1 Adoption of the Lower Meramec Floodplain Management Plan

The Lower Meramec Multi-Jurisdictional FMP is the culmination of over a year of participation and work by federal and state agencies, concerned citizens, city and county staff members, and public and private groups. The FMP documents these efforts and creates an action plan to implement strategies and tools to promote mitigation of flooding throughout the Lower Meramec Basin. Adoption of the plan will support future decisions regarding allocation of scarce resources to best reduce the risks of to life and property from flood events in the Lower Meramec watershed. Adoption of the FMP can also count as points toward participation in the CRS, which can ultimately reduce flood insurance premiums.

### 8.1.2 Implement Nonstructural Recommendation in Appendix E

After the USACE's NNC visited the Lower Meramec communities and performed visual assessments of the properties and structures, the Committee wrote a Nonstructural Flood Mitigation Assessment Report with data sheets for each property. That report with data sheets is attached as Appendix D. The findings in that report are preliminary and were further analyzed,

refined, and then expanded to all of the 1% AEP floodplain. The analysis can be found in Appendix E, but the summary is described below.

Of the structures located within the 1% AEP floodplain in the Lower Meramec Basin, 17% (161) are recommended to be elevated, 13% (120) to be acquired, 27% (254) to be relocated, 38% (360) to be flood-proofed, and the rest (5% or 47 structures) had inundation below the first floor and therefore only required either a sewer check valve or relocation of utilities.

### 8.1.3 Develop/Update and Implement a Comprehensive Public Outreach Plan

A comprehensive public outreach plan is crucial to providing the public with information needed to increase flood hazard awareness and to motivate actions to reduce flood damage, encourage flood insurance coverage, and protect the natural functions of floodplains.

Research has shown that awareness of the flood hazard is not enough to motivate people to take action to protect themselves and their property. People need to be told repeatedly, through various means, what specific actions to take before they will change their behavior. Research has also shown that a properly run local information program is more effective in bringing about change than national advertising or publicity campaigns. Based on these research findings, CRS Activity 330 provides credit to communities that engage in thorough critical thinking about their public information needs and what they want the people in their communities to know and do with regard to floodplain resources and flood hazards. The activity provides extra credit for communities that develop locally customized strategies to increase awareness and motivate residents to take action.

Two types of outreach projects are credited:

(1) Outreach projects that are distributed every year; and

(2) Projects that will be distributed when a flood occurs (real time), but are prepared in advance and reviewed and adjusted each year.

The credits for these two types of outreach projects are based on three factors:

(1) What and how many messages are conveyed;

(2) What type of projects they are (e.g., informational projects that people seek out and read, activities that reach out to people, or projects targeted to a specific audience); and

(3) How often they are delivered.

### 8.1.4 Develop/Update a Flood Emergency Preparedness Plan (& Evacuation Plan)

City and county emergency managers and their agencies play a key role in planning and plan maintenance. EWG planning staff also works closely with municipalities throughout the region on development and planning issues. EWG remains current on issues with FEMA and SEMA as well as the local communities. The St. Louis Area Regional Coalition of Community Organizations Active in Disaster (SLARCC) and the network through St. Louis Area Regional Response System (STARRS) both provide for on-going public participation in a wide range of related planning. STARRS serves as a regional grants management organization created to coordinate planning for response to large-scale critical incidents in the bi-state metropolitan region, which includes the project area. STARRS' mission is to help local governments,

businesses, and citizens plan for, prevent, protect against, respond to, and recover from critical incidents in the St. Louis region. In addition, STARRS, through the EWG, provides administration services for homeland security and healthcare disaster preparedness grants. For example, STARRS, along with the SLARCC, and with representatives from the American Red Cross and local social services agencies across the St. Louis region, initiated a comprehensive public awareness campaign called "All Ready?" that was developed to help foster a culture of emergency preparedness in the region. The “All Ready?” campaign used surveys to determine how aware and prepared the public are to face unexpected events, and the program has since ended.

Through the STARRS board, EWG has regular meetings with the relevant emergency response agencies in the region. STARRS provides a valuable structure for making a regional plan effective, since cooperating jurisdictions are already sharing information and resources through STARRS. EWG planning department staff report to the STARRs board annually on the Missouri All Hazard Mitigation plan and invite the county emergency managers to provide regular updates of hazard related activities in their jurisdictions.

The Community Organizations Active in Disaster (COAD) groups are organized in the project area and have a role in information sharing and serving as a resource to local emergency management agencies, local governments, and residents. A COAD is a group of organizations operating within a specific geography and composed of representatives from the public, private, and not-for-profit sectors. Organizations can include businesses, faith-based organizations, community organizations, human service organizations, and community stakeholders with the involvement of government partners. A COAD can help to enhance a community’s ability to mitigate, prepare for, respond to, and recover from disasters, ensuring that human needs inherent in a disaster situation are evaluated and addressed.

The advancement of STARRS and the regional security initiative to form COADs is the single most important advancement in the last ten years. This opportunity is now available to all municipalities and provides a means to address a wide range of issues in community preparedness and education at low cost to governments and school districts while at the same time building the capacity of non-profit and religious organizations to respond to natural disasters.

A flood emergency preparedness plan can build a strong local COAD that can support pre-disaster planning and post-disaster response in the project area.

### 8.1.5 Adopt/Update Higher Regulatory Floodplain Management Standards

The cities and counties should continue to adopt higher floodplain regulations to provide more flood protection to new and existing development, to discourage development in the floodplain, and to reduce the economic and life safety risks associated with flooding. It is **not recommended** to encourage development in the floodplain; however, it is important to adopt higher freeboard standards, for example, to reduce the risk of those currently living or working in the floodplain. It is also recommended to incorporate any current and/or proposed revisions to floodplain regulations into the community education and advocacy piece of the FMP so that residents and business-owners are aware that any new developments in the floodplain can impact their existing development.

The existing floodplain management ordinances identified in Section 7.1.1 have been determined compliant by SEMA in meeting the provisions for participation in the NFIP as outlined in 44 CFR 60.3. It is **recommended** that the cities and counties update their current floodplain management ordinance to reflect the new FIRMs as they are updated. SEMA has provided the jurisdictions with a FEMA model 60.3(d) ordinance, along with standards that meet or exceed minimum NFIP regulations for adoption prior to the June 20, 2019, effective date. The cities and counties are seeking to adopt a stricter floodplain management ordinance, and a cursory review of the model ordinance provided appears to satisfy that recommendation. It is **recommended** to adopt and submit a signed, sealed, and dated copy of its new floodplain management ordinance that includes the new FIRM panels and FIS to the Missouri SEMA.

### 8.1.6 Maintain and Expand the Existing Flood Warning Systems

The Meramec River flows 220 miles from the Ozark highlands northeast through Franklin County and forms much of the border between Jefferson and St. Louis County. The river is large enough to experience gradual rise in flood waters, but many of its tributaries are small enough that they can experience significant flash flooding. On other rivers and streams in the region, the risk of flash flooding as the result of heavy rains is high, and the amount of advance warning time is significantly short.

The USGS and the NWS work together to maintain flood warning systems within the project area. Specifically, the USGS acts as the principal source on surface and groundwater data and operates the six stream gaging stations in the project area. The NWS uses those data and data from other sources to issue river forecasts and flood alerts. Generally speaking, the NWS issues flood alerts either on a county basis or for particular rivers and streams. These alerts are distributed in Specific Area Message Encoding through the Emergency Alert System and the NOAA Weather Radio network.

Franklin County is able to receive NWS warnings and equipment is radio-activated. More than 70 percent of the county's population could be alerted within 30 minutes and responders and key executive officials within 5 minutes. The county could benefit from the development of a reliable warning system for dam failures for those living downstream of dams.

Jefferson County is able to receive NWS warnings; equipment is radio-activated. During waking hours, using all available communications, less than 50 percent of the county's population could be alerted within 30 minutes; responders and key executive officials could be alerted within 5 minutes. Beyond that, Jefferson County 911 Dispatch has a CodeRed Warning System. This is an automated system tied to the NWS that automatically calls everyone in the affected area if they have signed up with Code Red. In most cases, calls will be generated within 5 minutes of the emergency notification. In addition, Code Red can be used for other than NWS-originated emergencies. Communication and warning systems are tested on a regular basis.

St. Louis County is able to receive NWS warnings and warning equipment is radio-activated, with over 200 sirens located throughout the county. More than 85 percent of the county's population could be alerted within 30 minutes, and responders and key executive officials within 15 minutes.

The NWS acknowledges that, even in areas where they provide flood warning coverage, a real-time, community-oriented flood warning system can reduce risks involved with flooding.

From a flood-warning perspective, the use of USGS WaterAlert service (which utilizes gage parameters/information) can provide a text or email message straight to a subscriber's smartphone. Users can define river level thresholds and be alerted when those thresholds are exceeded. See the following link for website access. https://water.usgs.gov/wateralert/subscribe2/index.html?site_no=07019500&type_cd=sw.

To further enhance flood-warning, the USGS in cooperation with USACE, Metropolitan St. Louis Sewer District, Missouri Department of Transportation, Missouri American Water, and FEMA Region 7 created digital flood-inundation maps. The availability of these maps, along with internet information regarding current stage from the USGS stream gages and forecasted high-flow stages from the NWS, enables users to visualize the potential extent of flooding and may motivate residents to take precautions and heed warnings that they previously might have disregarded.

### 8.1.7 Join the Community Rating System

The NFIP's CRS is a voluntary incentive program that recognizes communities for implementing floodplain management practices that exceed the federal minimum requirements of the NFIP. Any community in full compliance with the minimum NFIP floodplain management requirements may apply to join the CRS. CRS uses a Class rating system that is similar to fire insurance ratings to determine flood insurance premium reductions for residents. CRS Classes are rated from 9 (lowest rating) to 1 (highest rating). Each CRS Class improvement produces a 5 percent greater discount on flood insurance premiums for properties in the Special Flood Hazard Areas (SFHAs).

Most communities enter the program at a CRS Class 9 rating, which entitles residents in SFHAs to a 5 percent discount on their flood insurance premiums. As a community engages in additional mitigation activities, its residents become eligible for increased NFIP policy premium discounts. Class 1 is the highest level of CRS and provides the largest flood insurance premium reduction (45 percent); The CRS Classes are based on completion of 19 creditable activities organized into 4 categories:

1. Public Information
2. Mapping and Regulations
3. Flood Damage Reduction
4. Warning and Response

In exchange for a community's proactive efforts to reduce flood risk, policyholders can receive reduced flood insurance premiums for buildings in the community. These reduced premiums reflect the reduced flood risk resulting from community efforts toward achieving the three (3) CRS goals:

1. Reduce flood damage to insurable property.
2. Strengthen and support the insurance aspects of the NFIP.
3. Encourage a comprehensive approach to floodplain management.

At a very minimum, as part of this FMP, communities should evaluate their administrative capabilities to participate in the CRS program as many smaller units of government may find the administrative duties associated with program entry and maintenance to be burdensome from a manpower aspect.

FEMA has performed a courtesy review of a draft version of this FMP and its appendices and has completed the CRS Checklist with points awarded per CRS step. This checklist contains the Section and Page number where the CRS step can be found within the FMP or one of its appendices as well as how many points would be awarded per CRS step. Additional points could be awarded during an official review if each community updates the checklist and includes missing or partial documentation before submitting the package to FEMA. For example, 15 points can be assigned due to the three completed public meetings to share the FMP draft with the public (CRS Checklist Item 2C).

FEMA's CRS checklist and preliminary review and scoring can be found in Appendix H.

## 8.2 Potential Funding Sources

There are several programs available to assist the cities and counties with financial resources to implement action items and recommendations of the floodplain management plan. Advancing mitigation action is not easy and requires significant, varying resources. These resources may include grants, loans, technical assistance and in-kind services, among others. Recognizing the many funding programs that currently exist across various federal departments and agencies, the state and non-governmental organizations compiled a list of programs to make it accessible to those who want to advance mitigation action in their communities. The purpose of this section is to provide local officials with a spectrum of potential mitigation funding sources. This guide will assist officials in determining the best source(s) of funding and technical assistance for potential mitigation projects.

The full list and the requirements for each source can be found in Appendix F - Healthy Watershed Funding Options for the Lower Meramec Watershed Communications Plan

As part of the public release of the Lower Meramec Multi-Jurisdictional FMP, the USACE - St. Louis District, along with the interagency partnership, are developing a communication plan. The communication plan will be used at a public workshop that will be held to communicate the FMP to the public and any stakeholders who did not participate in the partner and agency review of the FMP. Once the final version is transmitted to the cities and counties, it will be posted to the USACE - St. Louis District website. It is also **recommended** for the cities and counties to post the FMP to their respective websites to allow for more community-based involvement before any implementation of the plan by each community's officials or governing boards.

## 8.3 Monitor, Evaluation, and Changes to the Floodplain Management Plan

The cities and counties, in partnership with other local, state and federal agencies and nonfederal organizations, will initiate an annual review of the Lower Meramec Multi-Jurisdictional FMP with technical staff members who will monitor and evaluate activities related to the aforementioned Action Plan.

The annual review will discuss effectiveness of the following items and provide any recommendations or changes:

- Adopted policies and regulations
- Public outreach projects conducted and what products were produced
- Infrastructure improvements completed.

An annual report outlining discussion and identifying issues by technical staff members will be made to the respective Boards and, if necessary, to the municipal boards.

Substantial changes to the Action Plan or other parts of the FMP will be made through a formal public hearing or similar public outreach process.

Every five (5) years following the initial adoption of the Lower Meramec Multi-Jurisdictional FMP, a formal review and update will be conducted to include changes in the watershed, risk assessment, and needed updates to the strategies, tools, and Action Plan.

# 9 References

American Rivers.org. 2019. https://www.americanrivers.org/rivers/discover-your-river/why-do-rivers-flood/. Accessed 30 October 2019.

Bringing the Plan to Life: Implementing the Hazard Mitigation Plan (FEMA-386-4) covers planning Phase IV and CRS planning Steps 9-10.

Developing the Mitigation Plan: Identifying Mitigation Actions and Implementation Strategies (FEMA-386-3) covers planning Phase III and CRS planning Steps 6-8.

FEMA has a series of "how-to guides" on planning, to help communities meet the multi- hazard mitigation planning criteria. They can be found at www.fema.gov/hazard- mitigation-planning-resources#1.

*Getting Started: Building Support for Mitigation Planning* (FEMA-386-1) covers planning Phase I and CRS planning Steps 1-3.

Integrating Manmade Hazards into Mitigation Planning, FEMA-386-7.

"Mitigation Benefit Cost (BCA) Toolkit Compact Disc." This CD includes all the FEMA BCA software, technical manuals, BCA training course documentation, and other supporting material and BCA guidance. Copies can be obtained by calling FEMA's toll- free BC Hotline at 1-866-222-3580

MDC. (1998). *Missouri Watershed Inventory and Assessment: Meramec River*. Retrieved 14 November, 2019, from http://mdc.mo.gov/your-property/greener-communities/missouri-watershed-inventory-and-assessment/meramec-river

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*Planning for a Sustainable Future: The Link Between Hazard Mitigation and Livability*, 43 pages, FEMA-364, 2000. Also available for downloading at http://www.fema.gov/media-library/assets/documents/2110?id=1541.

*Reducing Damage from Localized Flooding: A Guide for Communities*, FEMA-511 (2005). Also available at www.fema.gov/library/viewRecord.do?id=1448.

*Reducing Losses in High Risk Flood Hazard Areas-A Guidebook for Local Officials*, FEMA-116, 1987. Also available for downloading at www.fema.gov/library/viewRecord.do?id=1508.

*St. Louis Regional Hazard Mitigation Plan Update for 2015-20*, East-West Gateway Council of Governments, 295 pages. dated June 23, 2015.

Understanding Your Risks: Identifying Hazards and Estimating Losses (FEMA-386-2) covers planning Phase II and CRS planning Steps 4-5.

Whittier Narrows Dam Safety Modification Study, Retrieved on 15 November 2019 from https://www.spl.usace.army.mil/Missions/Civil-Works/Projects-Studies/Whittier-Narrows-Dam-Safety-Modification-Study/