Form 9-1366
(May 2018)

U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations

Customer #: 6000001765
Agreement #: 22NEJFA209
Project #: NE00DUC
TIN #: 12-4904660
City Contract # 456

Fixed Cost Agreement YES[X] NO[ ]

THIS AGREEMENT is entered into as of the October 1, 2021, by the U.S. GEOLOGICAL SURVEY, Central Midwest Water Science Center, UNITED STATES DEPARTMENT OF THE INTERIOR, party of the first part, and the City of Kansas City party of the second part.

1. The parties hereto agree that subject to the availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation, **Value-Added Flood Inundation Mapping Along the Blue River, Indian Creek, and Brush Creek within Kansas City, Missouri** (per attachment), herein called the program. The USGS legal authority is 43 USC 36C; 43 USC 50, and 43 USC 50b.

2. The following amounts shall be contributed to cover all of the cost of the necessary field and analytical work directly related to this program. 2(b) include In-Kind-Services in the amount of $0.00

(a) $141,801 by the party of the first part during the period October 1, 2021 to September 30, 2027

(b) $399,999 by the party of the second part during the period October 1, 2021 to September 30, 2027

(c) Contributions are provided by the party of the first part through other USGS regional or national programs, in the amount of: $0

Description of the USGS regional/national program:

(d) Additional or reduced amounts by each party during the above period or succeeding periods as may be determined by mutual agreement and set forth in an exchange of letters between the parties.

(e) The performance period may be changed by mutual agreement and set forth in an exchange of letters between the parties.

3. The costs of this program may be paid by either party in conformity with the laws and regulations respectively governing each party.

4. The field and analytical work pertaining to this program shall be under the direction of or subject to periodic review by an authorized representative of the party of the first part.

5. The areas to be included in the program shall be determined by mutual agreement between the parties hereto or their authorized representatives. The methods employed in the field and office shall be those adopted by the party of the first part to insure the required standards of accuracy subject to modification by mutual agreement.

6. During the course of this program, all field and analytical work of either party pertaining to this program shall be open to the inspection of the other party, and if the work is not being carried on in a mutually satisfactory manner, either party may terminate this agreement upon 60 days written notice to the other party.

7. The original records resulting from this program will be deposited in the office of origin of those records. Upon request, copies of the original records will be provided to the office of the other party.

8. The maps, records or reports resulting from this program shall be made available to the public as promptly as possible. The maps, records or reports normally will be published by the party of the first part. However, the party of the second part reserves the right to publish the results of this program, and if already published by the party of the first part shall, upon request, be furnished by the party of the first part, at cost, impressions suitable for purposes of reproduction similar to that for which the original copy was prepared. The maps, records or reports published by either party shall contain a statement of the cooperative relations between the parties. The Parties acknowledge that scientific information and data developed as a result of the Scope of Work (SOW) are subject to applicable USGS review, approval, and release requirements, which are available on the USGS Fundamental Science Practices website (https://www.usgs.gov/about/organization/science-support/science-quality-and-integrity/fundamental-science-practices).

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9. Billing for this agreement will be rendered **quarterly**. Invoices not paid within 60 days from the billing date will bear interest, Penalties, and Administrative cost at the annual rate pursuant the Debt Collection Act of 1982, (codified at 31 U.S.C. § 3717) established by the U.S. Treasury.

USGS Technical Point of Contact

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Fax:
Email: james.walton@kcmo.org

U.S. Geological Survey
United States
Department of Interior

Signature

By C. Shane Barks Digitally signed by C.BARKS Date: 2022.02.01 13:41:36 -05'00' Date: 02/01/2022
Acting for: **Name:** Amy Beussink
Title: Director, Central Midwest WSC

City of Kansas City

Signatures

By _____ Date: 4/11/22
Name: Mark P. Jones
Title: Assistant City Attorney

By _____ Date: 4/11/22
Name: Wes Minder
Title: Director, Water Services Department

I hereby certify that there is a balance, otherwise unencumbered, to the credit of the appropriation to which the foregoing expenditure is to be charged, and a cash balance, otherwise unencumbered, in the treasury, to the credit of the fund from which payment is to be made, each sufficient to meet the obligation hereby incurred.

by _____ Date: 5-11-2022
Name: Tammy Queen
Title: Director of Finance

A PROPOSAL SUBMITTED TO:
City of Kansas City

Value-Added Flood Inundation Mapping Along the Blue River, Indian Creek, and Brush Creek within Kansas City, Missouri

U.S. Geological Survey
Central Midwest Water Science Centers

USGS Contacts: Paul Rydlund prydlund@usgs.gov
Date: 07/10/2021

Value-Added Flood Inundation Mapping Along the Blue River, Indian Creek and Brush Creek within Kansas City, Missouri
CENTRAL MIDWEST WATER SCIENCE CENTER

Summary

Digital flood-inundation map libraries were created for a 39.7-mile reach of the Blue River and selected tributaries (Brush Creek and Indian Creek) at Kansas City, Missouri (KCMO), and vicinity by the U.S. Geological Survey (USGS) in cooperation with the City of Kansas City, Missouri (Heimann and others 2014). Map libraries include integration with the National Weather Service (NWS) flood forecasts and real-time stage readings at linked USGS gages. The combined products are accessed through the USGS Flood-Inundation Mapping (FIM) web service at https://fim.wim.usgs.gov/fim/. The FIM tool provides a mechanism by which stakeholders and the general public can address all components of the disaster management cycle involving pre-impact flood preparation, emergency response, recovery and restoration, and reconstruction and mitigation. Addressing these components helps build sustainable and resilient communities, along with preserving continuity of operations during disasters. The USGS Central Midwest Water Science Center (CMWSC) proposes to retrofit existing FIM products throughout the Blue River reach in addition to selected tributaries along Brush and Indian Creek. Proposed retrofits will include updated high-resolution topographic data, infrastructure, and building footprints incorporated among two-dimensional hydraulic modeling upgrades. The scope will add value to the existing FIM products by incorporating interactive velocity, discharge and water-surface elevation data in addition to depth, as well as first-floor elevation differencing and time of travel summaries.

Background/Introduction

Floods are the leading cause of natural-disaster losses in the U.S. More than 75 percent of declared Federal disasters are related to floods, and annual flood losses average almost $8 billion with over 90 fatalities per year (USGS, 2020). Although the amount of fatalities has declined due to improved early warning systems, economic losses continue to rise with increased urbanization in flood-hazard areas (USGS, 2020). To address this issue, Heimann and others, 2014, developed flood profiles among 15 different reaches by means of one- and two-dimensional hydraulic models, using stage-streamflow relations at 10 USGS streamgages throughout the Blue River, Brush Creek, and Indian Creek from 2010 through 2014, with a subsequently revised reach in 2020. These efforts translated into currently displayed USGS FIM products used to reconcile a lack of information needed by emergency management to relate the location of inundation extents and associated water depths.

Early phases of FIM development for the Blue River, Brush Creek, and Indian Creek (Heimann and others, 2014), occurred as far back as 2010. Given the availability of updated high-resolution topographic Light Detection and Ranging (LiDAR) data, anticipated furnished two-dimensional modeling, and the ability to redevelop FIM products without linkages to local KCMO ALERT gages, a retrofit is warranted to leverage updates and provide additional value-added features.

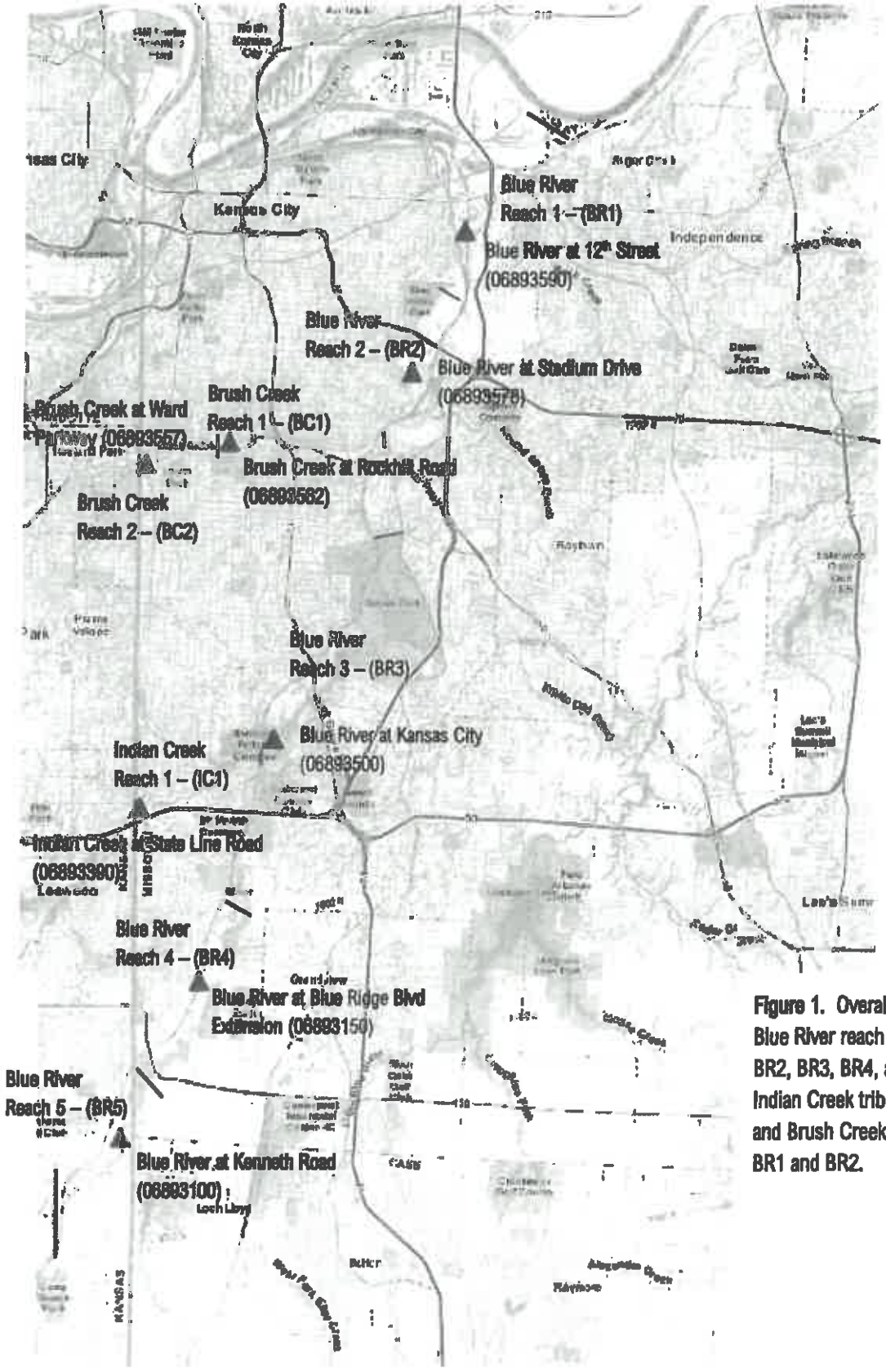

Figure 1. Overall study area of the Blue River reach segments BR1, BR2, BR3, BR4, and BR5, along with Indian Creek tributary segment IC1, and Brush Creek tributary segments BR1 and BR2.

The Blue River retrofit study area (fig 1) that will comprise USGS FIM products begins at the downstream boundary location near the confluence with the Missouri River, downstream of the USGS streamgage 06893590 – Blue River at 12th Street in Kansas City, Missouri (fig 2), moving upstream with specified river reaches through USGS streamgages: 06893578 – Blue River at Stadium Drive in Kansas City, Missouri (fig 3), 06893500 – Blue River at Kansas City, Missouri (fig 4), 06893150 – Blue River at Blue Ridge Blvd Extension in Kansas City, Missouri (fig 5), and 06893100 – Blue River at Kenneth Road in Kansas City, Kansas (fig 6) to the upstream boundary near the confluence with Camp Branch. To simplify a naming convention, each reach is identified from downstream to upstream as BR1, BR2, BR3, BR4, and BR5.

The Indian Creek retrofit study area (fig 1) that will comprise a USGS FIM product begins at the confluence of the Blue River, downstream of the USGS streamgage 06893390 – Indian Creek at State Line Road (fig 4) to the upstream boundary at State Line Road. Similar to the Blue River, a simplified naming convention was identified for the Indian Creek study reach as IC1.

The Brush Creek retrofit study area (fig 1) that will comprise USGS FIM products begins at confluence of the Blue River, downstream of the USGS streamgage 06893562 – Brush Creek at Rockhill Road in Kansas City, Missouri (fig 3), moving upstream through a specified river reach associated with USGS streamgage 06893557 – Brush Creek at Ward Parkway in Kansas City, Missouri (fig 3) to the upstream boundary at State Line Road. Similar to the Blue River, a naming convention for each reach is identified from downstream to upstream as BC1 and BC2. A tabular expression including reach lengths of the Blue River, Indian Creek, and Brush Creek study reaches are summarized in table 1.

With the increased availability of two-dimensional modeling and accompanying raster data sets, more information such as water-surface elevations, velocity, and discharge are available to communicate flood risk. Additionally, time-of-travel estimates and regulatory information such as first-floor elevations provide value to further assess impacts and risk. The U.S. Geological Survey (USGS) FIM Mapper provides inundation extents and accompanying depth data in its current state but has the utility to accommodate additional features through customization within the existing dashboard.

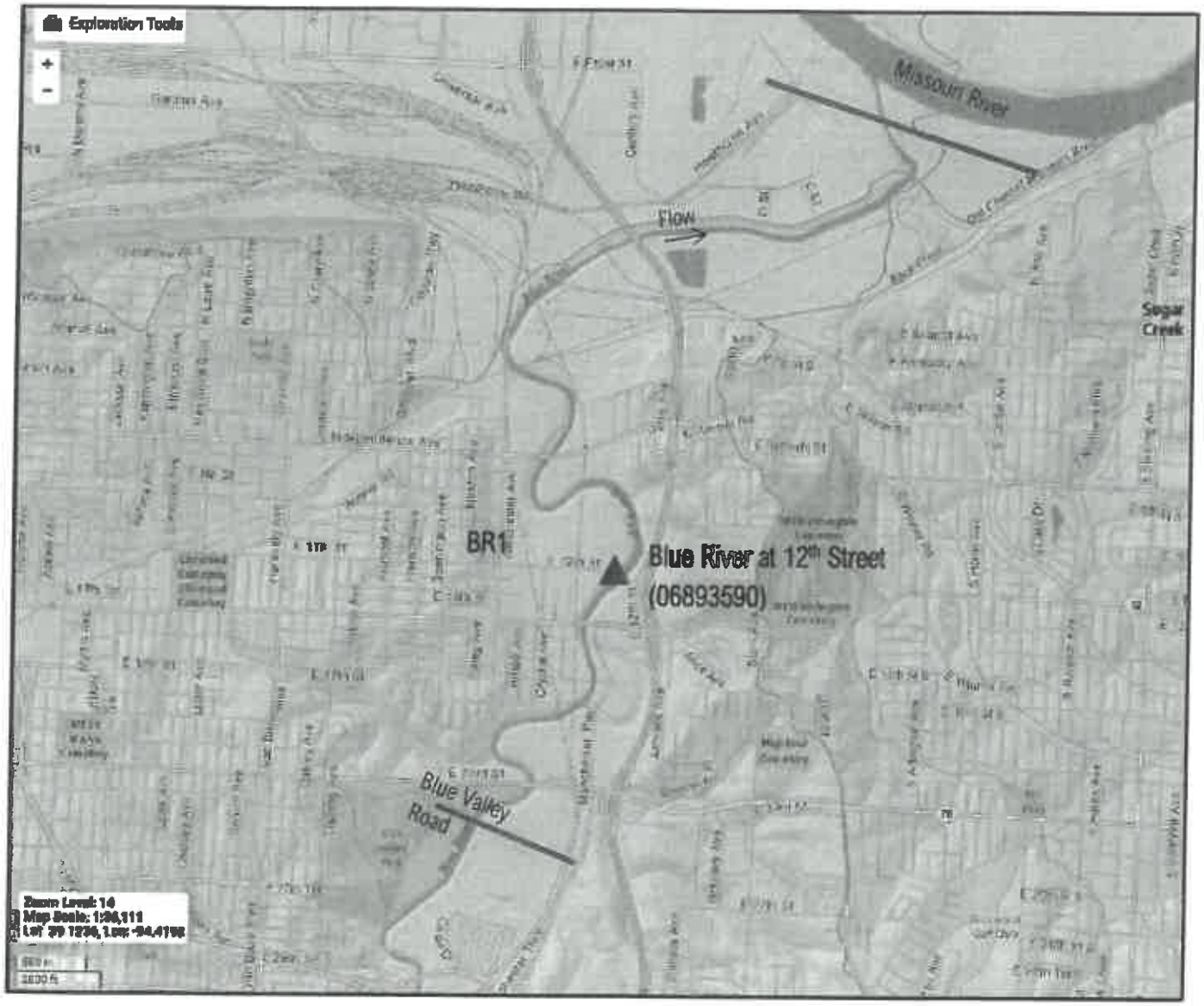

Figure 2. Blue River Reach 1 (**BR1**), extending 5.7 miles downstream from the upstream model boundary near northern Blue Valley Park Road at Blue Valley Park, through the USGS gaging station at 12th Street, downstream to a location near the confluence with the Missouri River.

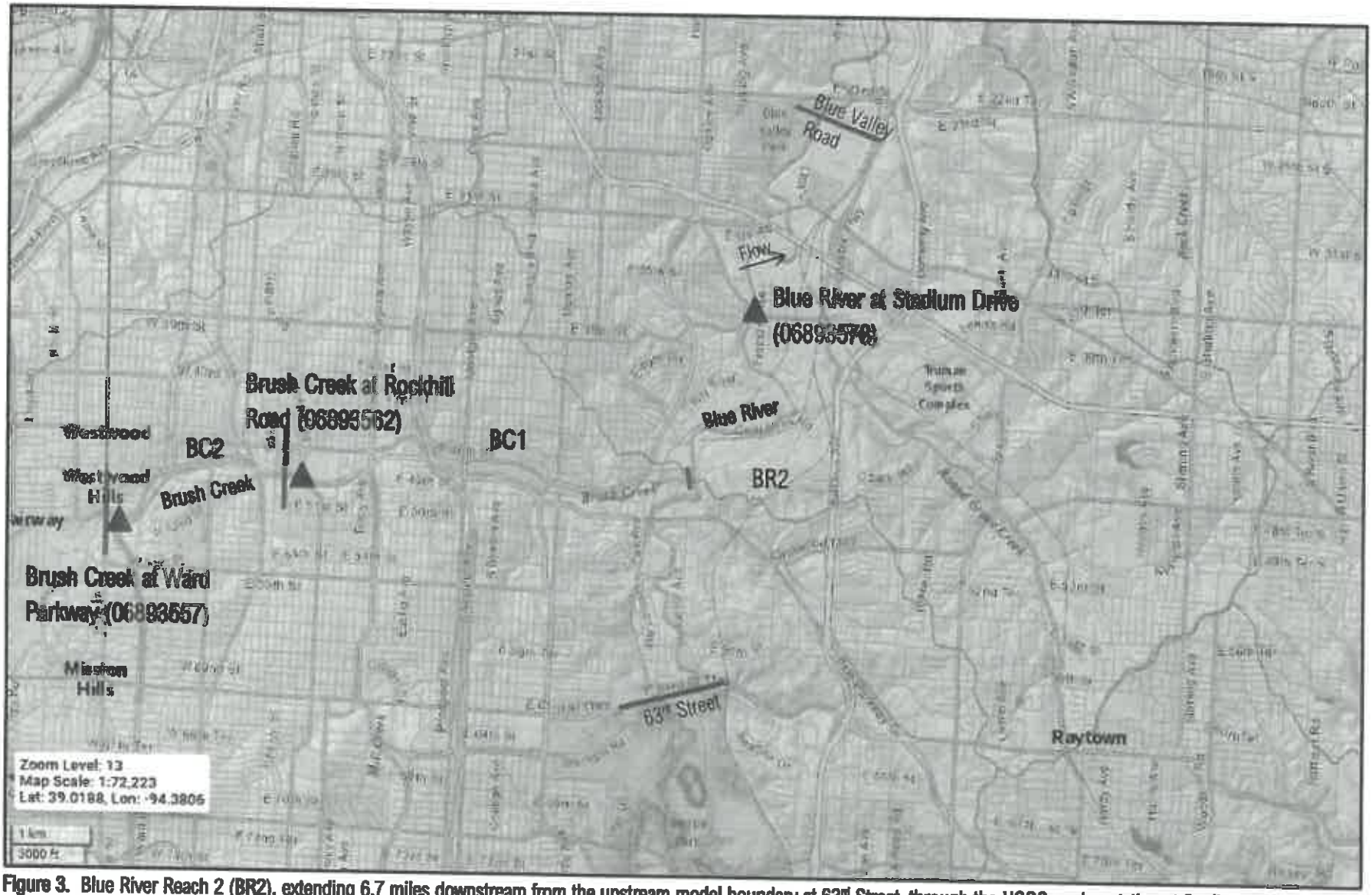

Figure 3. Blue River Reach 2 (BR2), extending 6.7 miles downstream from the upstream model boundary at 63rd Street, through the USGS gaging station at Stadium Drive, downstream to the model boundary near northern Blue Valley Park Road at Blue Valley Park. Brush Creek Reach 1 (BC1), extending 3.5 miles downstream from the upstream model boundary upstream of the Brush Creek at Rockhill Road streamgage, downstream to the confluence with the Blue River. Brush Creek Reach 2 (BC2), extending 1.7 miles downstream from State Line Road, through the USGS gaging station at Ward Parkway, downstream to the model boundary upstream of the Brush Creek at Rockhill Road.

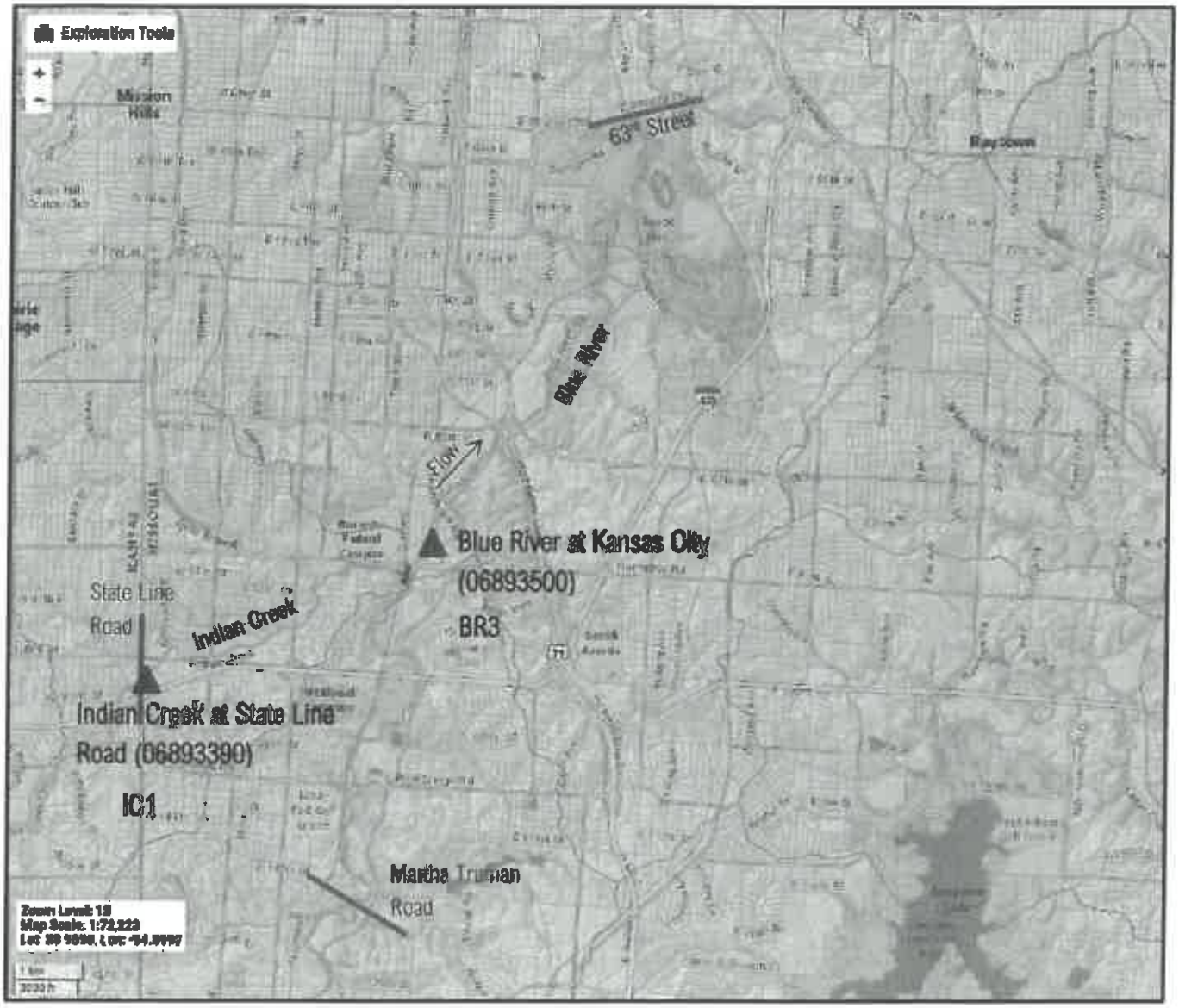

Figure 4. Blue River Reach 3 (**BR3**), extending 11.9 miles downstream from the upstream model boundary near Martha Truman Road at Blue Parkway, through the USGS gaging station at 95th Street, downstream to the northern boundary of Swope Park at 63rd Street. Indian Creek Reach 1 (**IC1**), extending 3.4 miles downstream from State Line Road to the confluence with the Blue River.

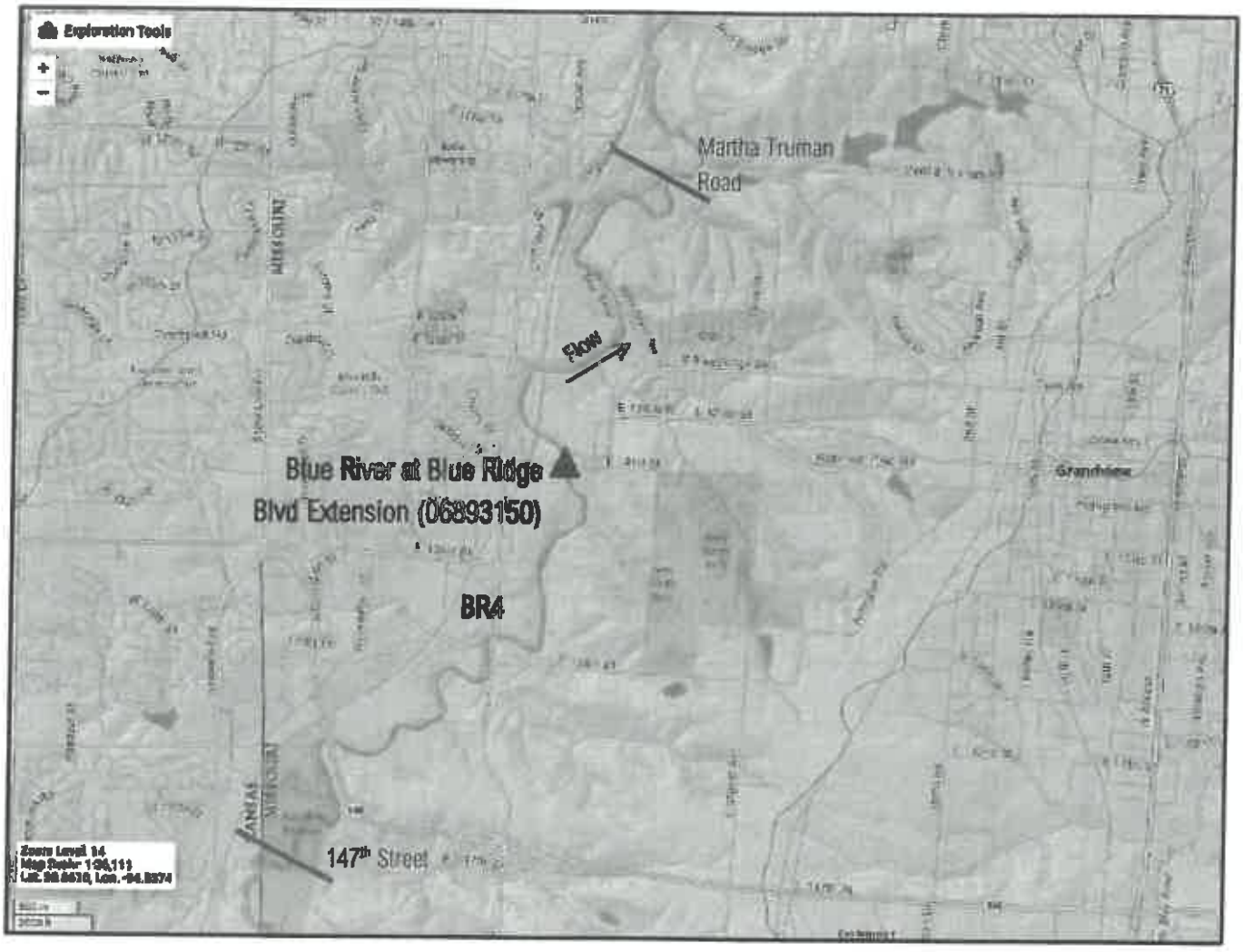

Figure 5. Blue River Reach 4 (**BR4**), extending 6.3 miles downstream from the upstream model boundary near 147th Street at Blue Parkway, through the USGS gaging station at Blue Ridge Boulevard Extension, downstream to the Blue River Parkway near Martha Truman Road.

Figure 6. Blue River Reach 5 (**BR5**), extending 4.4 miles downstream from the upstream model boundary near the confluence of Camp Branch, through the USGS gaging station at Kenneth Road, downstream to the Blue River Parkway near 147th Street.

Blue River							
Reach	Station	Model Boundary	Gage Description/Location (fig. 1-6, and x)	Downstream Referenced River Mile	Model Reach Length (mi)	Estimated number of simulated profiles or maps (1 ft. interval)	Estimated number of simulated backwater profiles or maps (1 ft. interval)
		Downstream	Missouri River Confluence	0			
BR1	6893590		Blue River at 12th Street, MO		5.7	26	
		Upstream/Downstream	Blue Valley Road	5.7			
BR2	6893578		Blue River at Stadium Drive, MO		6.7	27	27
		Upstream/Downstream	63rd Street	12.4			
BR3	6893500		Blue River at Kansas City, MO		11.9	27	
		Upstream/Downstream	Martha Truman Road	24.3			
BR4	6893150		Blue River at Blue Ridge Blvd Extension, MO		6.3	25	
		Upstream/Downstream	147th Street	30.6			
BR5	6893100		Blue River at Kenneth Road, KS		4.4	25	
		Upstream	Camp Branch Confluence	35			

Indian Creek						
Reach	Station	Model Boundary	Gage Description/Location (fig. 1-6)	Downstream Referenced River Mile	Model Reach Length (mi)	Estimated number of simulated profiles or maps (1 ft. interval)
		Downstream	Blue River Confluence	0		
IC1	6893390		Indian Creek at State Line Road, MO		3.4	16
		Upstream/Downstream	State Line Road	3.4		

Brush Creek						
Reach	Station	Model Boundary	Gage Description/Location (fig. 1-6)	Downstream Referenced River Mile	Model Reach Length (mi)	Estimated number of simulated profiles or maps (1 ft. interval)
		Downstream	Blue River Confluence	0		
BR1	6893562		Brush Creek at Rockhill Road, MO		3.5	21
		Upstream/Downstream	Frank Theis Park	3.5		
BR2	6893557		Brush Creek at Ward Parkway, MO		1.7	13
		Upstream/Downstream	State Line Road	5.2		

Table 1. Blue River, Indian Creek, and Brush Creek model reaches in succession referenced from downstream location.

As noted in the previous effort conducted by Heimann and others, 2014, the National Weather Service (NWS) provides observations and forecasting at USGS streamflow gage locations along the Blue River as well as Indian Creek and Brush Creek that can be referred to within the Advanced Hydrologic Prediction Service (AHPS) for the Kansas City area. Forecasting is one of the drivers that translates hydrographs at USGS streamgages to a product that communicates risk and consequence.

Problem

The Blue River flows through the middle of Kansas City and has been a source of flood damage for many years. USGS streamgages along the Blue River, Indian Creek, and Brush Creek provide river level information and/or flow that set the foundation for NWS flood forecasting, along with information used to evaluate water availability, infrastructure design, flood-insurance studies, and environmental impacts. However, more detailed information is needed to address elements of the disaster "life cycle", including before, during, and after flooding. Information, that is provided by USGS FIM products, is needed to address preparedness or "what-if" scenarios, timely response tied to real-time USGS gage and forecast information, recovery by assessing damage, and flood-risk analyses through mitigation and planning. Despite the known hazards of flooding, emergency management personnel typically suffer from a lack of information related to the location and water depth of inundated areas. Although areas of inundation and depth are useful for decision making, additional information such as water-surface elevation, velocity, discharge, time-of-travel, and identification of first-floor elevations within inundated areas are needed to support and regulate development and further communicate risk.

Objectives and Scope

The overall objectives and scope of this study are to use river level and flow information from existing USGS streamgages to retrofit flood-inundation map libraries with reach summaries identified in table 1. Retrofitted inundation maps will continue to be tied to real-time data from the USGS streamgages, flood forecast information, and delivered to the public via the Internet. The maps will be created by the USGS and will depict the approximate area that would be inundated at selected water level increments. Specific objectives from this study may be summarized as:

1. Dissemination of inundation map libraries through the USGS FIM utility (https://fim.wim.usgs.gov/fim/) that disseminate water depth, water-surface elevation, velocity, discharge, time-of-travel information and difference first floor elevations for the following:
    a. Blue River from the mouth at the Missouri River upstream to the confluence at Camp Branch in Kansas.
    b. Brush Creek from the confluence at the Blue River upstream to State Line Road
    c. Indian Creek from the confluence at the Blue River upstream to State Line Road

Relevance and Benefits

The USGS FIM program has (2) main functions:

1. **Partner with local communities to assist with the development and validation of flood inundation map libraries.** A flood inundation map library is a set of maps that shows where flooding may occur over a range of water levels in the community's local stream or river. The USGS works with various stakeholders and communities to identify an appropriate stream section, gather the necessary data to model where flooding will likely occur, and verify that the maps produced are scientifically sound (USGS, 2020).
2. **Provide online access to flood inundation maps along with real-time streamflow data, flood forecasts, and**

potential loss estimates.

Once a community's map library is complete, it is uploaded to the **USGS FIM Mapper**, an online public mapping application. The FIM Mapper allows users to explore the full set of inundation maps that shows where flooding would occur given a selected stream condition. Users also can access historical flood information and potential loss estimates based on the severity of the flood. The FIM Mapper helps communities visualize potential flooding scenarios, identify areas and resources that may be at risk, and enhance their local response effort during a flooding event (USGS, 2020).

The residents, emergency management personnel, or other stakeholders will be able to not only access the flood inundation maps that are tied to NWS flood forecasts during an event (example fig. 8), but use these map libraries for planning, preparedness, mitigation and recovery strategies. Interactive maps will show users at a glance the roads that are inaccessible, the properties that are most at risk, and the areas of the county that are unlikely to be affected.

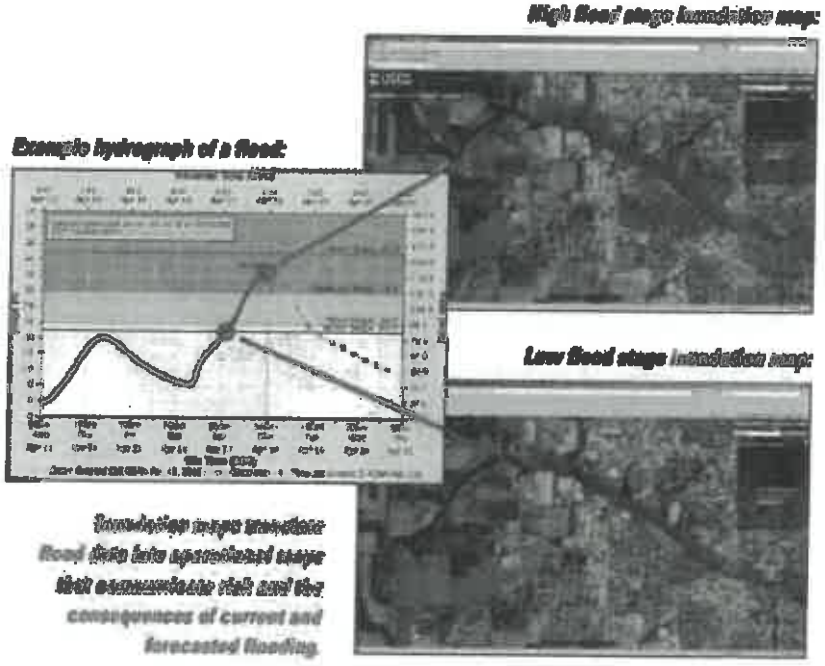

Figure 7. Example of USGS flood-inundation map that incorporates Blue River, Indian Creek, and Brush Creek water-level information from a USGS streamgage, NWS forecast at the gage, and a library of flood-inundation maps that translate those stages to on-the-ground conditions.

During periods of flooding, the availability of timely flood inundation maps could help prevent flood damage, assist recoveries, and possibly save lives. In addition to displaying corresponding flood inundation maps during periods of flooding, users also will have the ability to view the flood inundation map nearest the NWS forecasted flood peak, and selected river levels of interest. This information will help rescue crews, road crews, and property owners plan operations as flood waters rise. The user will be able to choose from a range of stages to analyze many flood scenarios. A flood inundation map near the peak event will be accessible and useful to mitigation teams after the event.

Value is added to the USGS streamgaging program linking real-time river-level information to inundation maps. Other agencies, such as the NWS, benefit from enhanced flood forecast information by the accompanying map product, along

with pre-peak estimates of damaged areas available for FEMA to expedite individual assistance (IA) and public assistance (PA) along with mitigation during disasters. The Missouri Department of Transportation (MoDOT) as well as local street departments can quickly access potential road or bridge impacts and evacuation routes can be assessed for flood access, allowing law enforcement locations to install barricades to block flooded roads. State and local emergency management personnel can better focus flood response and recovery resources. The USGS FIM product is a benefit to local National Flood Insurance Program (NFIP) participating communities that also participate in the Community Rating System (CRS), a program used to reward implementation of local mitigation, floodplain management, and outreach activities that exceed the minimum NFIP requirement (FEMA, 2020). The resulting benefit of the USGS FIM product provides insurance premium discounts through CRS implemented communities. Additional ecological benefits are provided in the management of near-stream resources, including riparian habitat and forest communities.

Value-added features proposed in this study also assist in managing regulatory concerns involving existing and proposed development as well as mitigation strategies for future flooding. This study leverages several agencies resources and aligns with the Water Mission Area (WMA) science strategy goal 4, to anticipate and respond to water-related emergencies (Evenson and others, 2013). Additionally, the proposed study aligns with goal 5 to deliver timely decision-support tools to support water-resource decisions and builds upon prior initiatives to innovate the use of USGS streamgage information (Evenson and others, 2013). As a priority issue of the water-resource mission of the USGS, information from this study will help inform decision makers regarding the minimization of the loss of life and property, in addition to water-resource issues related to watershed management as identified in WMA strategy goal 3, more specifically to a changing climate, population, and land use (Evenson and others, 2013).

Approach

Five tasks will be accomplished to complete the objectives of this study. These tasks are (1) data compilation and collection, (2) hydraulic modeling and time-of-travel analysis, (3) inundation map library development, (4) reporting and flood-inundation map posting (5) public information and outreach. A general timeline for completion of these tasks is provided in the Timeline and Budget section of this proposal.

Task 1: Data Compilation and Collection

- Acquisition of furnished State Emergency Management Agency (SEMA) Flood Insurance Study (FIS) two-dimensional HEC-RAS unsteady flow models available along the Blue River study reach, as well the Indian Creek and Brush Creek study reaches from the confluence with the Blue River upstream to State Line Road (figs.1,3, 4). Models are available as a result of detailed studies used to develop Flood Insurance Rate Maps (FIRMs).

- Time series and geospatial data are required for model development, calibration, and simulations. Some of these data are digital datasets available for download and some are site-specific data that will be obtained from the USGS as part of this study. Time series data associated with the following USGS and Kansas City ALERT streamgages will be used to support existing furnished model retrofits, calibrations, and simulate model reaches:

  Available USGS streamgage information –

  - 06893590 Blue River at 12th Street, Kansas City, MO., stage only, October 1999 to current.
  - 06893578 Blue River at Stadium Drive, Kansas City, MO., stage and discharge, July 2002 to current.
  - 06893562 Brush Creek at Rockhill Road, Kansas City, MO, stage only, October 1998 to current.
  - 06893557 Brush Creek at Ward Parkway, Kansas City, MO, stage and discharge, December 1998 to current
  - 07066510 Blue River at Kansas City, Kansas City, MO., stage and discharge, October 1994 to current.
  - 06893390 Indian Creek at State Line Road, Kansas City, MO, stage and discharge, April 2003 to current.
  - 06893150 Blue River at Blue Ridge Blvd Extension, Kansas City, MO, stage and discharge, October 2005 to current.
  - 06893100 Blue River at Kenneth Road, Kansas City, KS, stage and discharge, October 2003 to current.

  Furnished ALERT streamgage information –

- 06893588 Blue River at 17th Street, Kansas City, MO., stage only.
- 06893553 Blue River at Colorado Avenue, Kansas City, MO., stage only.
- BR16 – Elmwood, stage only.
- BR11 – Main/Brookside, stage only.
- 06893530 Blue River at 63rd Street, Kansas City, MO, stage only.
- 06893510 Blue River at Highway 71, Kansas City, MO, stage only.
- 06893195 Blue River at Red Bridge Road, Kansas City, MO., stage only.

Geospatial data will include (but is not limited to):

- Available lidar as identified by the USGS National Map for the counties of Jackson Missouri and Johnson Kansas.
- Furnished SEMA FIS model geometry (bathymetry cross-sections, hydraulic structures, transportation routes, floodplain storage areas, building footprints, roughness coefficients, and ineffective flow areas)
- Building footprint data available by SEMA.
- Use of GNSS techniques and methods (Rydlund and Densmore, 2012) to capture location and elevation information not defined from available lidar for the Blue River, Indian Creek, and Brush Creek furnished SEMA FIS models as well as first-floor elevations from commercial and residential footprints within estimated inundation extents. Survey information not limited to:
    - Channel bathymetry
    - Infrastructure
        - Floodplain
        - Structure (first floor)
        - Hydraulic
        - Transportation
        - Detention/Retention storage
    - Identification and preservation of high-water marks (Koenig and others, 2016) for moderate and/or high flow events during the first 4 years of this study, as well as capturing documented high-water marks from historic events.

Task 2: Hydraulic Modeling and Time-of-Travel Analysis

Two-dimensional Hydrologic Engineering Center (HEC) – River Analysis System (RAS) - HEC-RAS unsteady flow models furnished by the Missouri State Emergency Management Agency (Darryl Rockfield, SEMA, written commun., 2021) shall be included in 3 project files (one for the Blue River, Indian Creek, and Brush Creek) along with separate GIS shapefiles of all cross-sections (geo-referenced) that were included in the model. These models are available by SEMA as county-wide FIS models used to derive FIRMs. The models will include depictions of hydraulic structures as they appear in the field. All supporting data used to evaluate these models shall be submitted with each model during the quality assurance review. Archival of surface-water model applications will be administered according to the USGS office of surface water technical memorandum TM 2015.01. This technical memorandum assures published model applications are documented in a manner that facilitates reproducibility of the results presented in a published information format, administered through an electronic model archive and vetted as a subsequent data release. Supplemental information required to enhance furnished model geometry and/or calibration will be obtained in task 1.

Hydraulic modeling involving calibration and simulations, using furnished models, will be conducted using two-dimensional HEC-RAS, a model with the capability to perform two-dimensional hydrodynamic routing using the St. Venant or Diffusion-wave equations (Brunner, 2016) with application to simulate channel and floodplain hydraulics in two-dimensions with mixed flow regimes. The Blue River will represent a 35-mile reach composed of adjoining models represented by BR1, BR2, BR3, BR4 and BR5. Indian Creek will represent a 3.4-mile reach composed of one model represented by IC1. Brush Creek will represent a 5.2-mile reach composed of adjoining models represented by BC1 and BC2. All model reaches will use time-series information from USGS stream gages, furnished ALERT gages, and discrete surveyed high-water marks as identified in task 1 for model calibrations.

Manual calibration consists of adjusting process-related parameter values to minimize the differences between simulated output and measured data. Model performance will be evaluated with several criteria by comparisons from observed to simulated conditions with Root Mean Square Error (RMSE). As part of the calibration process, sensitivity analysis will be conducted to determine the association between independent and dependent variables to facilitate more accurate model prediction. Adjusting parameters such as Manning's roughness coefficients as well as normal depth starting assumptions (slope ft/ft) can be applied to evaluate model response and sensitivity that aid in providing uncertainty estimates.

Model simulations will be executed from calibrated models to provide water-surface profiles and map libraries for stages ranging from the NWS defined "Action Stage" near the top of the bank, to the river level corresponding to the estimated annual exceedance probability of 0.2 percent (e.g. 500-year flood). Given backwater from the Missouri River and effects notable in model reaches BR1 and BR2 (figs. 1,2,3), a hybrid model reach will disseminate backwater profiles from the USGS streamgage 06893578 - Blue River at Stadium Drive in Kansas City, MO, downstream to the Missouri River (fig 8). This hybrid model reach will permit the use of Missouri River starting tailwater elevations to appropriately define backwater-influenced profiles upstream to the USGS Stadium Drive gage model boundary. This enhancement will replace existing Missouri River backwater profiles disseminated by Heimann and others, (2014) that utilized a straight-line approach of the Missouri River levels to more accurately account for the compounding effect of Blue River headwater to quantify the effects of a backwater-influenced profiles. The estimated number of hydraulic model profiles or maps per library for the study reaches are summarized in table 1. Generated inundation polygons and depth grids will have an uncertainty of +/- 1 foot. In addition to depth grid data, water-surface, velocity, and discharge data will be generated as raster data sets to be customized by the USGS Web Informatics and Mapping (WiM) group and disseminated in the USGS FIM Mapper.

Given the density and period of record for streamgages identified in task 1 along the Blue River, time of travel analysis will be conducted to develop an interpretive table derived from historic stage and streamflow record that disseminates a range of flood peaks (stage) with associated discharge, and time-of-travel as it interrelates to each streamgage independently and collectively along the Blue River mainstem.

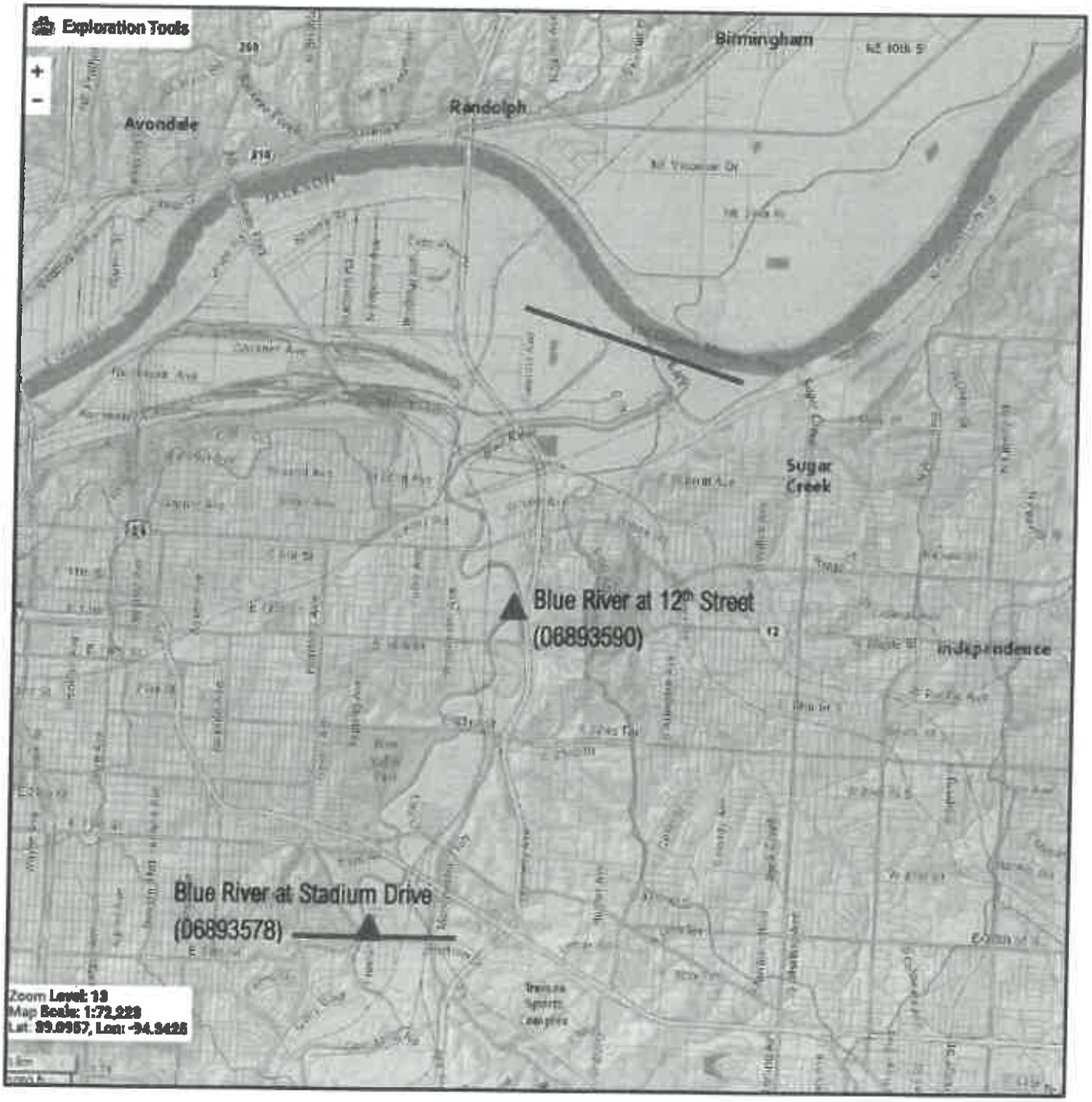

Figure 8. Blue River Backwater Reach, extending 7.7 miles downstream the USGS gaging station at Stadium Drive, through the USGS gaging station at 12th Street, to a location near the confluence with the Missouri River.

Task 3: Inundation Map Library Development

A complete map library referenced to USGS streamgages along the Blue River, Indian Creek, and Brush Creek will include stage-based inundation layers, water-depth grids, and raster data sets that include water-surface elevation, velocity, discharge and any peripheral metadata. The total number of inundation layers is to be determined, but an estimated number of layers is provided for each model reach in table 1. All maps will be produced for each 1-foot increment of stage, beginning at the NWS-defined "Action" stage with a probable maximum to (or slightly beyond) the 0.2 percent Annual Exceedance Probability (AEP). Quality assurance checks and edits will be performed for each inundation layer to resolve isolated inundation extents (ponds) or small discontinuities in the inundation surface (islands) as well as reconciling bridges and pertinent structures that are elevated and not subject to inundation. Special attention to cross-section lengths will be given to assure the mouth of a tributary junction at the valley wall will be inundated where probable.

Task 4: Reporting and Flood Inundation Map Posting

An on-line Scientific Investigations Report (SIR) will be published that summarizes water-surface profiles, furnished hydraulic models, hydraulic model development, calibration, sensitivity analysis, along with documentation of the flood inundation mapping method, library development, and delivery according to USGS FIM standards and technical requirements found in the FIM toolbox. Time-of-travel tables developed in task 3 will also be published and posted to the USGS FIM.

Task 5: Public Information and Outreach

The published on-line SIR and generated inundation polygons, water-depth grids, first-floor elevations, time-of-travel tables, and raster data sets disseminating water-surface elevation, velocity, and discharge will be publicly available through the USGS FIM. To ensure that FIM maps are understood and utilized such that appropriate action are taken during a flood event, the maps will be promoted in a number of ways. Potential methods include media campaigns, web-based education, and informational meetings. All project partners and relevant stakeholders are anticipated to participate in the outreach effort.

Quality Assurance Plan

Quality assurance (QA) measures will be followed to ensure the completeness of the information communicated during the study. The QA objectives for the collection and communication of information will:

- Withstand scientific scrutiny
- Be obtained by methods appropriate for its intended use, and
- Be representative and of known completeness and comparability.

Data management activities in accordance to Survey Manual 502.6, Fundamental Science Practices (Scientific Data Management), will be maintained as a structured document that outlines the project's data management considerations and serves as a record of scientific data management activities throughout the lifecycle of this project, outlining standards and intended actions for acquiring, processing, analyzing, preserving, publishing/sharing, securing, archiving scientific data holdings, and managing data quality. Data used in the modeling process will be derived from reliable host sources, including the USGS National Water Information System for streamflow data, and available Light Detection And Ranging (lidar) derived high-resolution topography.

Hydraulic model outputs will be evaluated using root mean squared error (RMSE) at streamgage locations as well as high-water marks. All digital data and models will be reviewed by USGS personnel to ensure proper documentation and technical standards established by the USGS Office of Surface Water (OSW) guidance for hydraulic modeling studies documented in OSW Technical Notes 2015.37 and 2016.25. The models and modeling results will be archived in accordance with Office of Surface Water Technical Memorandum 2015.01 (Model Archive Memo) and will be disseminated by an accompanying data release as noted in accordance with Survey Manual 502.6, 502.7, 502.8, 502.9.

Data collection standards as provided by USGS Techniques and Methods manuals will be upheld for GNSS surveys (Rydlund and Densmore, 2012), high-water mark collection (Koenig and others, 2016), along with standards and documentation published in the FIM toolbox, more specifically identified below:

- USGS Flood Inundation Map Development and Documentation Standards (https://water.usgs.gov/water-resources/memos/memo.php?id=492).
- National Weather Service Guidelines for the Development of AHPS Flood Inundation Mapping (Version 3) (https://water.weather.gov/ahps/NOAA_AHPS_Guidelines_Final_2011_v3.pdf).

Furnished stage data for use in the current flood-inundation maps referenced to City of Kansas City ALERT gages is subject to USGS Water Mission Area furnished record policy (WMA2008.01).

Policies and procedures for archiving Surface-Water data and project information are also provided in the Central Midwest Water Science Center data management plan specific to this project. The project and project budget will be reviewed by USGS management on a quarterly basis to ensure project timelines are met.

Deliverables

Project deliverables will include an annual accumulation and dissemination of map libraries by way of the USGS FIM Review Mapper for years 2, 3, and 4. The Review Mapper is an interim version of the web-based USGS FIM product that provides access for stakeholder review and use during the course of the study. Each year the USGS FIM Review Mapper will ingest new map libraries for stakeholder use until the last year (year 5) in which a USGS SIR will be published. The USGS FIM Review Mapper will subsequently become the final approved USGS FIM, complete with all map libraries along the Blue River, Indian Creek, and Brush Creek. Annual deliverables will be accompanied by outreach to stakeholders only, until completion of the study where public outreach will be permissible upon final approval of the USGS SIR and USGS FIM product.

The final deliverable will be a published online Scientific Investigations Report (SIR) as identified in the Approach (Task 4). Metadata such as geospatial datasets containing depth grids and raster data sets composed of water-surface, velocity, and discharge data will be available through USGS Science Base as a data release. Additional metadata identifying first-floor elevations and time-of-travel tables will also be available as a data release.

Timeline and Budget

Federal fiscal year timeline and budget below reflect a project start date beginning October 1, 2021 and ending September 30, 2026.

Task	FY 2023				FY 2024				FY 2025				FY 2026				FY 2027			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Data Compilation and Collection																				
Task 2: Hydraulic Modeling and Time of Travel Analysis																				
Task 3: Inundation Map Library Development																				
Task 4: Reporting and Flood Inundation Map Posting																				
Task 5: Public Information and Outreach																				

	FY22	FY23	FY24	FY25	FY26	Total
USGS	$ 15,200.00	$ 23,300.00	$ 28,800.00	$ 37,400.00	$ 33,700.00	$ 138,400.00
KCMO	$ 73,900.00	$ 93,000.00	$ 67,200.00	$ 87,200.00	$ 78,600.00	$ 399,900.00
Total	$ 89,100.00	$ 116,300.00	$ 96,000.00	$ 124,600.00	$ 112,300.00	$ 538,300.00

Personnel

Project staff include GS12 at 100 hours, and (3) project hydrologists: GS12 at 820 hours, GS11 at 3,910 hours, and GS11 at 46 hours. Data collection and compilation support staff are identified as a GS09 at 200 hours, and a GS06 at 200 hours.

References

Brunner, G., 2016, HEC-RAS River Analysis System, 2D Modeling User's Manual, Version 5. https://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%202D%20Modeling%20Users%20Manual.pdf

Evenson, E.J., Orndorff, R.C., Blome, C.D., Böhlke, J.K., Hershberger, P.K., Langenheim, V.E., McCabe, G.J., Morlock, S.E., Reeves, H.W., Verdin, J.P., Weyers, H.S., and Wood, T.M., 2013, U.S. Geological Survey water science strategy—Observing, understanding, predicting, and delivering water science to the Nation: U.S. Geological Survey Circular 1383–G, 49 p.

FEMA, 2020. Federal Insurance and Mitigation Administration, Community Rating System, Fact Sheet. 1p. https://www.fema.gov/media-library-data/1584566648735-b8216fe96907ffae2399034acd4c8e92/NFIP_CRS_Fact_Sheet_2020_508OK.pdf

Heimann, D.C., Wellert, T.E., Kelly, B.P., and Studley, S.E., 2014, Flood-inundation maps and Wetland Restoration Suitability Index for the Blue River and selected tributaries, Kansas City, Missouri, and vicinity, 2012 (ver. 1.1, April 2015): U.S. Geological Survey Scientific Investigations Report 2014–5180, 23 p., *http://dx.doi.org/10.313/ sir20145180.*

Koenig, T.A., Bruce, J.L., O'Connor, J.E., McGee, B.D., Holmes, R.R., Jr., Hollins, Ryan, Forbes, B.T., Kohn, M.S., Schellekens, M.F., Martin, Z.W., and Peppler, M.C., 2016, Identifying and preserving high-water mark data: U.S. Geological Survey Techniques and Methods, book 3, chap. A24, 47 p., http://dx.doi.org/10.3133/tm3A24

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
AMENDMENT OF JOINT FUNDING AGREEMENT
FOR WATER RESOURCES INVESTIGATIONS

Agreement #: 22NEJFA209
Customer #: 6000001765
TIN: 12-4904660
Project: NE00DUC
Fixed Cost Agreement: Yes
Kansas City Contract # 456

This amendment is for the agreement dated October 1, 2021.

1. The parties hereto agree that subject to the availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation, **Value-Added Flood Inundation Mapping Along the Blue River, Indian Creek, and Brush Creek within Kansas City, Missouri**, herein called the program. This amendment adds USGS cooperative matching funds and reimbursable funds, for **USGS modeling**.

2. Paragraph 2a of the agreement is hereby X increased/ __ decreased by **$81,999** to read as follows:

   (a) $**223,800** by the party of the first part during the period **October 1, 2021,** to **June 30, 2026.**

   Paragraph 2b of the agreement is hereby _X_ increased/ ___ decreased by **$161,801** to read as follows:

   (b) **$561,800** by the party of the second part during the period **October 1, 2021,** to **June 30, 2026**.

Billing for this agreement will be rendered **quarterly**. Payments of bills are due within 60 days after billing date. If not paid by the due date, interest will be charged at the current Treasury rate for each 30-day period, or portion thereof, that the payment is delayed beyond the due date. (31 USC 3717; Comptroller General File B-212222, August 23, 1983.) All parties agree that electronic signatures are an acceptable form of approval.

UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

_____
(Signature)

_____
(Name)

_____
(Title)

_____
(Date)

CITY OF KANSAS CITY

By_____ Date:_____
Name: Mark P. Jones
Title: Assistant City Attorney

By_____ Date:_____
Name: Kelly Postlewait
Title: Acting Director, Water Services Department

I hereby certify that there is a balance, otherwise unencumbered, to the credit of the appropriation to which the foregoing expenditure is to be charged, and a cash balance, otherwise unencumbered, in the treasury, to the credit of the fund from which payment is to be made, each sufficient to meet the obligation hereby incurred.

_____ Date:_____
Name: Tammy Queen
Title: Director of Finance