

RESOLUTION 2018-105  
OF THE COUNCIL OF THE CITY OF FORT COLLINS  
AUTHORIZING THE CITY MANAGER TO EXECUTE AN AGREEMENT WITH THE  
CITY OF GREELEY AND THE WATER SUPPLY AND STORAGE COMPANY  
REGARDING A DAM BREACH FLOOD INUNDATION MAPPING STUDY

WHEREAS, the City owns two water storage reservoirs in the upper Cache la Poudre River basin: Joe Wright Reservoir and Halligan Reservoir (“City’s Reservoirs”); and

WHEREAS, both of the City’s Reservoirs are subject to the rules and regulations of the State of Colorado’s Office of Dam Safety in the Division of Water Resources, including the *Rules and Regulations for Dam Safety and Construction*, set out in at 2 Colorado Code of Regulations 402-1, which require, among other things, that all high hazard dams have an approved dam breach inundation map showing the limits of the flooding associated with a failure of the dam under certain conditions; and

WHEREAS, the City’s Reservoirs are considered to be “high hazard dams” under said regulations because they have dams “for which loss of human life is expected to result from failure of the dam,” which is not meant to imply that the dams are actually anticipated to fail at this time; and

WHEREAS, the City of Greeley (“Greeley”) owns six water storage reservoirs with “high hazard dams” in the upper Cache la Poudre River basin (Milton Seaman Reservoir, Barnes Meadow Reservoir, Peterson Lake Reservoir, Comanche Reservoir, Hourglass Reservoir, and Twin Lakes Reservoir) (“Greeley’s Reservoirs”); and

WHEREAS, the Water Supply and Storage Company (“WSSC”) owns two water storage reservoirs with “high hazard dams” in the upper Cache la Poudre River basin (Long Draw Reservoir and Chambers Lake) (“WSSC’s Reservoirs”); and

WHEREAS, the dam breach inundation mapping for the City’s Reservoirs, Greeley’s Reservoirs, and WSSC’s Reservoirs is in need of updating; and

WHEREAS, the City can save money by collaborating with Greeley and WSSC on the project to update the dam breach inundation mapping by reducing unnecessary duplication and triplication of efforts; and

WHEREAS, the State of Colorado has grant funds that may be applicable to the project; and

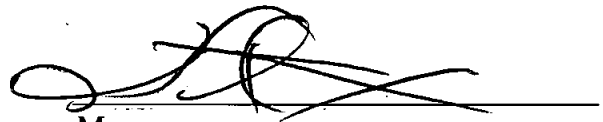
WHEREAS, staff from the City, Greeley, and WSSC have negotiated an agreement to jointly update the dam breach inundation mapping, as set for the in draft Agreement attached hereto as Exhibit “A”.

NOW, THEREFORE, BE IT RESOLVED BY THE COUNCIL OF THE CITY OF FORT COLLINS as follows:

Section 1. That the City Council hereby makes and adopts the determinations and findings contained in the recitals set forth above.

Section 2. That the City Manager is hereby authorized to execute an agreement substantially in the form of Exhibit "A", with such modifications and additional terms and conditions not inconsistent with this Resolution as the City Manager, in consultation with the City Attorney, determines to be necessary and appropriate to protect the interests of the City or effectuate the purposes of this Resolution.

Passed and adopted at a regular meeting of the Council of the City of Fort Collins this 6th day of November, A.D. 2018.

  
\_\_\_\_\_  
Mayor

ATTEST:

  
\_\_\_\_\_  
City Clerk

**AGREEMENT BETWEEN THE CITY OF GREELEY, THE CITY OF FORT COLLINS,  
AND THE WATER SUPPLY AND STORAGE COMPANY  
REGARDING A DAM BREACH FLOOD INUNDATION MAPPING STUDY**

This Agreement is entered into by and between the following Parties: the City of Greeley, Colorado, a home rule municipality ("Greeley"); the City of Fort Collins, Colorado, a home rule municipality ("Fort Collins"); and the Water Supply and Storage Company, a Colorado mutual ditch and reservoir company ("WSSC"). Greeley, Fort Collins and WSSC are sometimes hereinafter referred to as the "Parties" or individually as "Party".

**RECITALS**

A. The Parties each own and operate certain reservoirs located in the Cache la Poudre River Basin above the canyon mouth, as listed below:

- Greeley: Milton Seaman Reservoir, Barnes Meadow Reservoir, Peterson Lake Reservoir, Comanche Reservoir, Hourglass Reservoir, and Twin Lakes Reservoir.
- Fort Collins: Joe Wright Reservoir and Halligan Reservoir.
- WSSC: Long Draw Reservoir and Chambers Lake.

B. The Parties each intend to perform certain dam breach modeling, flood routing modeling, generation of breach flood inundation GIS mapping, and related tasks and analyses for their reservoirs ("Study") as requested by the Dam Safety Office of the Colorado Division of Water Resources ("CDWR").

C. By performing the Study jointly ("Joint Study"), the Parties have each determined that they would save time and money, be eligible for State grant funds, and benefit their respective ratepayers, constituents, and shareholders.

D. Greeley has requested and received several proposals from consultants to perform the analyses and other tasks associated with the Joint Study identified in the request for proposals. The Parties have evaluated and selected a mutually agreeable proposal prepared by Anderson Consulting Engineers, Inc. ("Consultant").

E. Greeley has agreed to retain the Consultant to perform the scope of work, attached hereto as Exhibit A ("Scope of Work"), and to submit an application to CDWR for up to fifty percent matching funds ("CDWR Grant") on behalf of the Parties. Fort Collins and WSSC have agreed to reimburse Greeley for each respective Party's cost incurred on their behalf as described in Exhibit B ("Budget"), and subject to the terms and conditions of this Agreement.

F. Greeley and Fort Collins are authorized to cooperate or contract with one another to provide any function, service, or facility lawfully authorized to each of them pursuant to Article II, Section 16 of the Charter of the City of Fort Collins and Article I, Section 1-3 of the Charter of the City of Greeley and Title 2, Section 2.07.040 of the Municipal Code of the City of Greeley, and C.R.S. §29-1-203(1).

NOW THEREFORE, in consideration of the above-recited premises and the promises set forth below, the Parties agree as follows.

## AGREEMENT

### 1. DUTIES AND OBLIGATION OF THE PARTIES.

- 1.1. Greeley agrees to contract with the Consultant to perform the Scope of Work. Upon completion of the Scope of Work and issuance of final payment, Greeley will also submit an application for a CDWR Grant on behalf of the Parties. Fort Collins and WSSC agree to provide Greeley with information and documentation necessary for the CDWR Grant and Joint Study.
- 1.2. Fort Collins agrees to reimburse Greeley for the total cost of Task A as described in the Budget and WSSC agrees to reimburse Greeley for the total cost of Task B as described in the Budget. The total costs for Task A and Task B shall include any additional costs incurred through authorized change orders. Payment shall be made within 35 days of receipt of the invoice from Greeley.
- 1.3. The CDWR Grant is a cost-share program that reimburses a dam owner up to 50% of the dam owner's cost of the Study, subject to certain terms and conditions ("Qualifying Dam"). If a CDWR Grant is awarded, Greeley will apply the funds as a credit to each Task identified in the Budget, prior to invoicing Fort Collins and WSSC. Greeley will allocate the CDWR Grant credit to each Task in an amount equal to the Task's pro-rata share of the total cost. For example, the total cost is anticipated to be \$118,270, and the CDWR Grant is anticipated to be \$59,135. Task C's pro-rata-cost is currently estimated to be 52.78% ( $\$62,430 / \$118,270 = 0.5278$ ) of the total cost. Therefore, Task C would receive a credit of \$31,211.50 ( $\$59,135.00 * 0.5278 = \$31,211.50$ ). For purposes of determining the credit only, a Party's pro-rata cost will be based on the cost of a Party's Qualifying Dam(s) and the total cost will be determined based on the total cost of all Qualifying Dams. If a dam identified in the Budget does not meet the terms and conditions of the CDWR Grant and the CDWR Grant is reduced accordingly, then no CDWR Grant funding will be applied to the cost of that dam. For example, if Barnes Meadow Reservoir is not a Qualifying Dam (solely for the purpose of this hypothetical example) and the CDWR Grant is reduced from \$59,135 to \$53,805 ( $\$59,135 - (\$10,660 * 0.5) = \$53,805$ ) accordingly, then the cost of Barnes Meadow would be subtracted from the total cost of \$118,270 to \$107,610 ( $\$118,270 - \$10,660 = \$107,610$ ) to determine Task C's pro-rata-cost and portion of the grant. Thus, Task C's pro-rata-cost for Qualifying Dams would be 48.10% ( $(\$62,430 - \$10,660) / \$107,610 = 0.4810$ ) of the total cost, and receive a credit of \$25,880.20 ( $\$53,805 * 0.4810 = \$25,880.20$ ).

2. **FORT COLLINS AND WSSC COOPERATION WITH THE STUDY.** Fort Collins and WSSC agree to cooperate in good faith with Greeley and/or the Consultant to complete the Scope of Work and to secure the CDWR Grant including, but not limited to, providing a current Emergency Action Plan and information and documentation necessary to complete the Scope of

Work and/or secure the CDWR Grant. If a Party does not provide the required information and documentation necessary to secure its pro-rata share of the CDWR Grant, then that Party may forfeit their pro-rata share of the anticipated CDWR Grant as determined by CDWR.

3. **DELIVERABLES.** Greeley shall provide Fort Collins and WSSC with copies of the deliverables, identified in Sub-Task 3 of the Scope of Work (“Deliverables”) for their respective dams within 30 days of Greeley’s receipt of the same, subject to the terms and conditions of this Agreement, such as Paragraph 6.

4. **NO ENDORSEMENT OF OTHER PARTY’S PROJECTS OR RIGHTS.** A Party’s cooperation in this Agreement and Study is not an endorsement of the other Party’s various projects or rights (including, but not limited to, water rights) and shall not limit the rights of a Party to fully participate in any proceedings regarding the other Party’s various projects or rights.

5. **RIGHT TO TERMINATE.** Any Party may terminate this Agreement, with or without cause, upon written notice to the other Party pursuant to Paragraph 11. If this Agreement is terminated, Fort Collins and WSSC shall be responsible for all reimbursement payments due to Greeley as of the date of termination, and shall only be entitled to a copy of the Deliverables for their respective dams if it has made all payments due to Greeley under this Agreement, provided that Fort Collins or WSSC shall not be required to return any Deliverable it has possession of as of the date of termination.

6. **FISCAL CONTINGENCY.** Notwithstanding any other provision of this Agreement to the contrary, the obligations of Greeley and Fort Collins (“Public Entity” in this paragraph) in fiscal years after the fiscal year of this Agreement shall be subject to appropriation of funds sufficient and intended therefor, with the Public Entity having the sole discretion to determine whether the subject funds are sufficient and intended for use under this Agreement, and the failure of the Public Entity to appropriate such funds shall be grounds for the Public Entity to terminate this Agreement with written notice pursuant to Paragraph 11.

7. **REMEDIES.** If any Party fails to comply with the provisions of this Agreement, the other Party, after providing written notification to the noncomplying Party, and upon the failure of the noncomplying Party to achieve compliance within 35 days, may seek all such remedies available under Colorado law.

8. **NO THIRD-PARTY BENEFICIARIES.** This Agreement is entered into between the Parties for the purposes set forth herein. It is the intent of the Parties that they are the only beneficiaries of this Agreement and the Parties are only benefitted to the extent provided under the express terms and conditions of this Agreement.

9. **GOVERNING LAW AND ENFORCEABILITY.** This Agreement shall be construed in accordance with the laws of the State of Colorado. The Parties recognize that the constitutions, statutes, and rules and regulations of the State of Colorado and of the United States, as well as the Parties’ respective bylaws, city charters and codes, and rules and regulations, impose certain legal constraints on each Party and that the Parties intend to carry out the terms and conditions of this

Agreement subject to those constraints. Whenever possible, each provision of this Agreement shall be interpreted in such a manner so as to be effective and valid under applicable law.

10. **WAIVER.** A waiver of a breach of any of the provisions of this Agreement shall not constitute a waiver of any subsequent breach of the same or another provision of this Agreement. Nothing in this Agreement shall be construed as any waiver of governmental immunity of the Parties who are governments or any other governmental provisions of State law. Specifically, by entering into this Agreement, neither Party waives the monetary limitations on liability or any other rights, immunities, or protections provided by the Colorado Government Immunity Act, C.R.S. § 24-10-101, *et seq.*, or any successor or similar statutes of the State of Colorado.

11. **NOTICES.** All notices or other communications hereunder shall be sufficiently given and shall be deemed given when personally delivered, or after the lapse of five business days following mailing by certified mail-return receipt requested, postage prepaid, addressed as follows:

To Greeley: Greeley Water and Sewer Department  
Attn: Deputy Director of Water Resources  
1001 11th Avenue, 2nd Floor  
Greeley, Colorado 80631

With a copy to: Greeley City Attorney's Office  
Attn: Environmental and Water Resources  
1100 10<sup>th</sup> Street, Suite 401  
Greeley, Colorado 80631

To Fort Collins: City Manager  
City Hall West  
300 LaPorte Avenue; P.O. Box 580  
Fort Collins, Colorado 80522-0580

With copy to: Fort Collins City Attorney  
300 LaPorte Avenue; P.O. Box 580  
Fort Collins, Colorado 80522-0580  
epotyondy@fcgov.com

and: Fort Collins Utilities  
Attn: Director of Plant Operations  
4316 LaPorte Avenue  
Fort Collins, Colorado 80521  
mkempton@fcgov.com

To WSSC: The Water Supply and Storage Company  
2319 Mulberry Street  
Fort Collins, Colorado 80522

With a copy to: Fischer, Brown, Bartlett & Gunn, P.C.

1319 East Prospect Rd.  
Fort Collins, CO 80525

12. **CONSTRUCTION.** This Agreement shall be construed according to its fair meaning as it was prepared by the Parties. Headings in this Agreement are for convenience and reference only and shall in no way define, limit, or prescribe the scope or intent of any provision of this Agreement.

13. **ENTIRE AGREEMENT.** This Agreement constitutes the entire agreement of the Parties regarding the matters addressed herein. This Agreement binds and benefits the Parties and their respective successors. Covenants or representations not contained in this Agreement regarding the matters addressed herein shall not bind the Parties.

14. **REPRESENTATIONS.** Each Party represents to the other parties that it has the power and authority to enter into this Agreement and the individual signing below on behalf of that Party has the authority to execute this Agreement on its behalf and legally bind that Party.

15. **ASSIGNMENT.** No Party may assign any rights or delegate any duties under this Agreement without the written consent of all other Parties.

16. **COUNTERPARTS.** This Agreement may be executed in any number of counterparts each of which, when taken together, shall constitute one agreement. This Agreement shall only be effective when counterparts are signed by the all the Parties. The Agreement may be executed and delivered by electronic signature by any Party and all Parties consent to the use of electronic signatures.

**[Remainder of Page Left Blank Intentionally]**

**CITY OF GREELEY, COLORADO, a home rule municipality**

By: \_\_\_\_\_  
John Gates, Mayor

Date: \_\_\_\_\_

**ATTEST:**

By: \_\_\_\_\_  
Betsy Holder, City Clerk

**AS TO SUBSTANCE:**

By: \_\_\_\_\_  
Roy Otto, City Manager

**AS TO LEGAL FORM:**

By: \_\_\_\_\_  
Doug Marek, City Attorney

**AS TO AVAILABILITY OF FUNDS:**

By: \_\_\_\_\_  
Victoria Runkle, Director of Finance



**CITY OF FORT COLLINS, COLORADO, a Colorado home rule city**

By: \_\_\_\_\_  
Darin A. Atteberry, City Manager

Date: \_\_\_\_\_

ATTEST:

By: \_\_\_\_\_  
City Clerk

APPROVED AS TO LEGAL FORM:

By: \_\_\_\_\_  
Eric Potyondy, Assistant City Attorney  
City Attorney's Office

**WATER SUPPLY AND STORAGE COMPANY, a Colorado mutual ditch and reservoir company**

By: \_\_\_\_\_  
Keith Amen, President

Date: \_\_\_\_\_

ATTEST:

By: \_\_\_\_\_

**EXHIBIT A**

**to**

**AGREEMENT BETWEEN THE CITY OF GREELEY, THE CITY OF FORT COLLINS,  
AND THE WATER SUPPLY AND STORAGE COMPANY  
REGARDING A DAM BREACH FLOOD INUNDATION MAPPING STUDY**

**(Scope of Work)**

EXHIBIT A

SCOPE OF WORK  
 DAM BREACH FLOOD INUNDATION MAPPING  
 CITY OF GREELEY, CITY OF FORT COLLINS, AND WATER SUPPLY & STORAGE CO.  
 OCTOBER 12, 2018

This scope of work includes tasks needed to provide dam breach flood inundation mapping for ten dams located within Poudre Canyon. Dams included in this study are listed below.

**City of Fort Collins Dams**

- Joe Wright Reservoir
- Halligan Reservoir

**City of Greeley Dams**

- Barns Meadow Reservoir
- Comanche Reservoir
- Seaman Reservoir
- Hourglass Reservoir
- Peterson Lake Reservoir
- Twin Lakes Reservoir

**Water Supply and Storage Company Dams**

- Long Draw Reservoir
- Chambers Lake Reservoir

The study area includes approximately 116 miles of the Cache la Poudre River (Poudre River) upstream of its confluence with the South Platte River, 6.7 miles of Joe Wright Creek, 2.1 miles of La Poudre Pass Creek, 6 miles of Beaver Creek, 16 miles of the South Fork of the Cache la Poudre River (South Fork), and 24 miles of the North Fork of the Cache la Poudre River (North Fork). Figure 1 illustrates the location of all ten reservoirs relative to the river network that drains them.

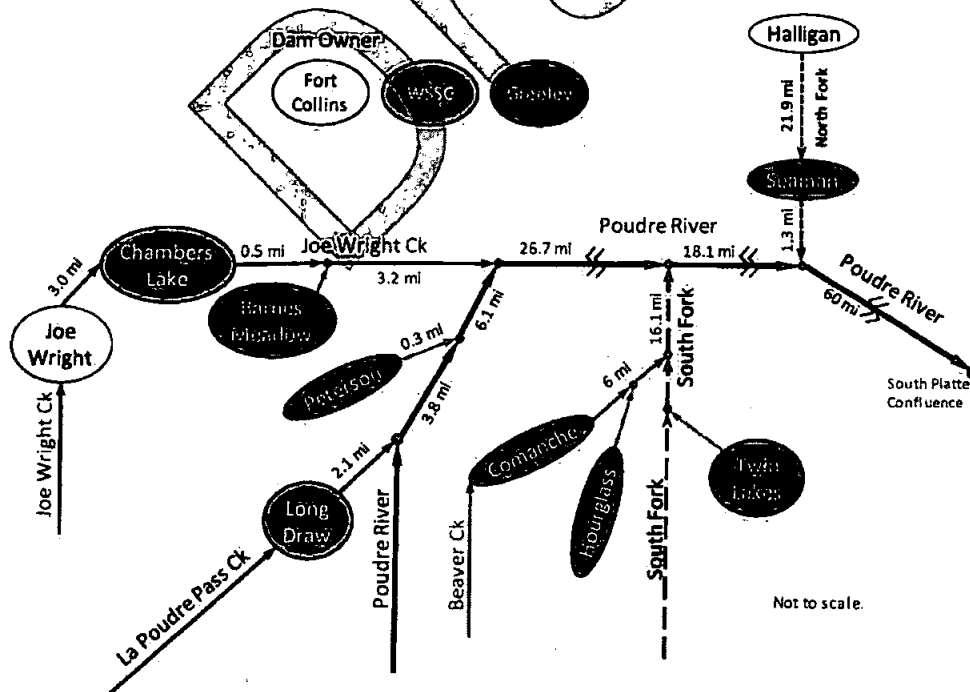


Figure 1 Dam Location and River Network of Study Area

## TASKS A, B, AND C

This scope of work is divided into three major tasks (Tasks A, B, and C) which are grouped by dam ownership. Task A applies to City of Fort Collins Dams, Task B applies to Water Supply and Storage Company Dams, and Task C applies to City of Greeley Dams. Tasks A, B, and C are comprised of three sub-tasks including: Sub-Task 1 Breach Modeling, Sub-Task 2 Flood Routing and Inundation Mapping, and Sub-Task 3 Development of Deliverables.

## SCOPE OF SUB-TASKS

The three subtasks described below will be conducted to produce inundation mapping for each of the 10 dams described and included in Tasks A, B, and C. All work shall be performed in accord with: 1) "Rules and Regulations for Dam Safety and Dam Construction" (DWR 2007) and 2) "Guidelines for Dam Breach Analysis" published by the Colorado Office of the State Engineer (DWR 2010).

### SUB-TASK 1 BREACH MODELING

This task includes items required to conduct breach modeling for an individual dam.

#### SUB-TASK 1.1 BREACH MODELING DATA COLLECTION

The following information and data will be obtained and reviewed to inform development of breach parameters and breach modeling. Information and data include, but is not limited to:

- State Engineer records including dam as-built plans and stage-storage curves
- Additional dam information from the dam owners
- Best available topography

#### SUB-TASK 1.2 DEVELOPMENT OF DAM BREACH PARAMETERS

Dam breach parameters including geometry and time to failure will be developed using empirical equations recommended by the Colorado State Engineers Office Dam Safety Branch and described in "Guidelines for Dam Breach Analysis" (DWR 2010). Methodologies for dam breach parameter estimations will include MacDonald & Langridge-Monopolis (1984), State of Washington Method (2007), and Froehlich (2008). Evaluation of Halligan Dam will assume a structural failure of the concrete structure.

#### SUB-TASK 1.3 BREACH MODELING

Breach modeling will be conducted using the USACE's HEC-RAS Version 5.0.5. Dam embankment geometry, breach parameters, stage vs storage curves, and downstream channel geometry will be input into HEC-RAS to produce an outflow hydrograph. Multiple breach scenarios may be run for individual dams depending upon configuration of the dam's embankment and outlet works. The resulting outflow hydrograph with the largest peak discharge will be used as input to the 2D HEC-RAS models for flood routing and inundation mapping.

The "Guidelines for Hazard Classification" (DWR 2010) states that: "if failure of the subject dam can cause the failure of another dam or series of dams located downstream the cumulative dam break flood wave must be considered...." A cumulative dam break analysis will be evaluated for Task A dams including Joe Wright and Halligan Reservoirs. Joe Wright Reservoir is located on Joe Wright Creek approximately three

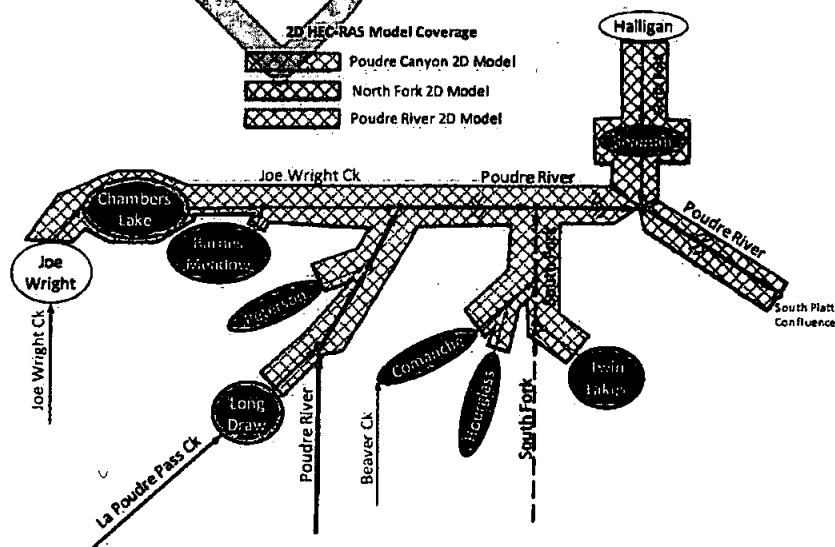
miles upstream of Chambers Lake Reservoir. Similarly, Halligan Reservoir is located on the North Fork approximately 22 miles upstream of Seaman Reservoir. The attenuated breach hydrograph from the subject dam (either Joe Wright or Halligan) entering a downstream reservoir (either Chambers Lake or Seaman) will be compared with the capacity of the emergency spillway of the downstream reservoir. If the peak discharge of the attenuated breach hydrograph is larger than the emergency spillway capacity a cumulative dam break evaluation may be necessary. The final approach to breach modeling of Joe Wright and Halligan Reservoir will be guided by review and input from the Dam Safety Branch and the owners of the dams.

**SUB-TASK 1.4 BREACH MODELING REVIEW/MEETING WITH DAM SAFETY BRANCH AND DAM OWNERS**

Dam breach parameters and results of initial breach modeling will be provided to the Dam Safety Branch and Dam Owners for discussion and review. Commencement of flood routing and inundation mapping (Sub-Task 2) will begin upon final approval of breach modeling.

**SUB-TASK 2 FLOOD ROUTING AND INUNDATION MAPPING**

Three two-dimensional hydraulic models will be developed to conduct flood routing and inundation mapping. Hydraulic modeling will be conducted using the USACE's HEC-RAS 2D Model Version 5.0.5. Model extents were chosen based upon location of dams, major confluences, and potential cumulative failure analyses. Figure 2 shows a schematic and extent of each HEC-RAS 2D model. The 'Poudre Canyon 2D Model' will include the Joe Wright Creek, La Poudre Pass Creek, Beaver Creek, the South Fork, and the Poudre River upstream of the North Fork Confluence and will be utilized to analyze eight of the ten dams. The 'North Fork 2D Model' will cover the North Fork below Halligan Reservoir and will be applied to evaluations of Halligan and Seaman Reservoirs. The 'Poudre River 2D Model' covers the lower 60 miles of the river between the North Fork and its confluence with the South Platte River. The 'Poudre River 2D Model' will be utilized for all ten dams.



**Figure 2 Schematic of HEC-RAS 2D Model Extents**

## **SUB-TASK 2.1 DATA COLLECTION**

This task includes collection of data required for development of the HEC-RAS 2D models and production of inundation mapping. Data to be collected includes, but is not limited to:

- 2013 Post Flood LiDAR (USGS/Photo Sciences, Inc.)
- 2009 LiDAR on North Fork Poudre (Halligan Supply Project, Fugro Horizons, Inc)
- USGS 10 Meter Digital Elevation Models (10-meter DEM)
- Best available color NAIP aerial photography from the USDA (2011 or newer)
- Effective FEMA 100-year floodplain mapping along the Poudre River
- Available GIS data including but not limited to identification of critical facilities, critical sections roads, and jurisdictional boundaries from municipalities and counties (Larimer County, Weld County, City of Fort Collins, Town of Timnath, Town of Windsor, and City of Greeley)
- National Land Cover Dataset (USGS)

## **SUB-TASK 2.2 GIS DATA PREPARATION AND TERRAIN DEVELOPMENT**

This task includes preparation of all GIS data needed for input to the HEC-RAS 2D modeling. Cost for this task is pro-rated by estimated length of inundation mapping for each dam.

A digital terrain model for each model will be developed by ACE's GIS specialists. Multiple topographic sources will be stitched together to produce a single terrain needed as input to HEC-RAS. The following topographic sources will be used to develop terrain for the corresponding HEC-RAS 2D model indicated below.

- Poudre Canyon 2D Model Terrain
  - 2013 Post Flood LiDAR: 1) Poudre River between the South Fork and North Fork; 2) South Fork
  - USGS 10 Meter DEM: 1) Poudre River between La Poudre Pass Creek to the South Fork; 2) Joe Wright Creek, La Poudre Pass Creek, Beaver Creek
- North Fork 2D Model Terrain: 2009 LiDAR – full coverage
- Poudre River 2D Model Terrain: 2013 Post Flood LiDAR – full coverage

The digital terrain models will be clipped to the river corridor to reduce file size and model run times.

Digital land coverage from the National Land Cover Dataset (USGS) collected as part of Sub-Task 2.1 will be used to create a manning's n shape file that will be applied to the model grid to compute surface roughness. Manning's n coverages will be developed at a course scale. A shape file including break lines delineating major roads, embankments, or land features will also be developed using available GIS data (transportation lines, levee lines, etc.) and engineering judgement. Break line development will be conducted at a course scale. Critical section identified by municipalities will be included in the model where detailed output (peak flow, arrival time, flood depth, and flood velocity) is needed.

**SUB-TASK 2.3 HEC-RAS 2D MODEL DEVELOPMENT**

This task includes development of each of the three HEC-RAS 2D models. Data developed in Sub-Task 2.2 including the digital terrain, Manning's *n* shape file, break line shape file, location of critical facilities, location of critical sections will be used to build the HEC-RAS 2D models.

Cost of model development is be pro-rated by the estimated distance of inundation mapping for dams utilized by each model. Table 1 summarizes the estimated length of inundation mapping that will be produced by each model for individual dams. The estimated mileage was used to pro-rate costs.

**Table 1 Flood Routing and Inundation Mapping Model Usage**

Poudre Canyon 2D Model		North Fork 2D Model		Poudre River 2D Model	
Dam	Est. Usage	Dam	Est. Usage	Dam	Est. Usage
Joe Wright Reservoir	52 mi	Halligan Reservoir	22 mi	Joe Wright Reservoir	60 mi
Long Draw Reservoir	57 mi	Seaman Reservoir	2 mi	Halligan Reservoir	60 mi
Chambers Lake	49 mi			Long Draw Reservoir	60 mi
Comanche Reservoir	40 mi			Chambers Lake	60 mi
Barns Meadow Reservoir	48 mi			Seaman Reservoir	60 mi
Hourglass Reservoir	39 mi			Comanche Reservoir	60 mi
Peterson Lake Reservoir	51 mi			Barns Meadow Reservoir	22 mi
Twin Lakes Reservoir	36 mi			Hourglass Reservoir	22 mi
				Peterson Lake Reservoir	4 mi
				Twin Lakes Reservoir	4 mi

**SUB-TASK 2.4 PREPARATION OF INUNDATION BASE MAPPING**

This task includes preparation of base mapping that will consolidate and streamline inundation mapping production. Project wide base mapping and layout of mapping sheets will be developed in GIS to create a mapping template. Mapping sheets will be 11x17 in size and at a scale of approximately 1:1,000. All printed map sheets will include the following information:

- Dam name and DAM ID
- North arrow and graphic scale
- Dam break inundation boundaries
- Effective FEMA 100-year floodplain
- Critical facilities and critical sections
- Jurisdictional boundaries
- Color aerial photography (2011 and newer)
- Annotation of roads, highways, and landmarks
- A table providing initial flood wave arrival time, peak flood arrival time, peak discharge, peak flood wave depth, and peak flood wave velocity for critical facilities/sections

This task also includes set up of attribute tables for critical facilities and critical section GIS shape files that identify the initial flood wave arrival time, peak flood arrival time, peak discharge, peak flood wave depth, and peak flood wave velocity.

Cost of this task is pro-rated by the estimated length of inundation mapping for each dam.



## **SUB-TASK 2.5 FLOOD ROUTING AND INUNDATION MAPPING**

This sub-task includes items needed to run the HEC-RAS 2D models, produce inundation mapping, and production of GIS deliverables. Cost for this task is specific to each dam.

Modifications to the HEC-RAS 2D models to allow for flood routing and inundation mapping for a specific dam will be conducted. Modification will include input of appropriate inflowing hydrographs (developed in Sub-Task 2.3), setup of downstream boundary conditions, and reduction of the 2D model area if necessary. Multiple model runs may be necessary to map multiple flow paths when the dam breach location differs from the spillway. Initial inundation boundaries and detailed hydraulic output will be extracted for post-processing.

Post processing of model output will be conducted by ACE's GIS specialist. The downstream limit of inundation mapping will be identified where it falls below the level of the effective FEMA 100-year floodplain on the Poudre River. The downstream limit of inundation mapping will be tied into the 100-year floodplain delineation on the maps. Inundation mapping near the dam may include multiple flow paths through the embankment or spillway. If the spillway flow path and dam breach flow path are not coincident, then mapping of the peak spillway discharge will be included and tied into the dam breach flow path inundation boundaries. The final inundation boundaries will be prepared in ESRI shape file format that references UTM coordinates (NAD 83, Zone 13-meters). The attribute tables for the critical facility and critical section GIS shape files will be populated with the HEC-RAS 2D detailed hydraulic output (initial flood wave arrival time, peak flood arrival time, peak discharge, peak flood wave depth, and peak flood wave velocity). A set of inundation maps will be produced for each dam using the template developed in Sub-Task 2.4.

## **SUB-TASK 3 DELIVERABLES**

Deliverables will be produced individually for each dam and will include the Inundation Mapping Report (including color inundation maps), a CD containing digital inundation boundaries and critical facilities shape files, PDFs of the report and inundation maps, supporting spreadsheets, and all HEC-RAS models.

A single Inundation Mapping Report template will be developed to produce an individual report for each dam. Use of a template promotes efficiency and consistency in the production of reporting to keep costs down. Cost to develop the template is split evenly between the ten project dams.

### **SUB-TASK 3.1 PRELIMINARY REPORTING**

For each dam the data collection effort, base mapping, calculated dam breach parameters, hydraulic analyses' assumptions/methodologies/results, and dam break inundation mapping will be summarized in a draft Inundation Mapping Report that will be submitted to the Dam Safety Branch for review. The report will be prepared in both Microsoft WORD and Adobe Acrobat PDF formats and shall include:

- A narrative that describes the background of the project, the data collected as part of the project, including the base mapping, the estimation of the dam breach parameters, and the hydraulic analyses and inundation mapping methodologies for the project;

- Tables summarizing the initial flood wave arrival time, peak flood arrival time, peak discharge, peak flood wave depth, and peak flood wave velocity at all critical facilities and critical sections; and
- Dam failure inundation maps in Adobe Acrobat and ESRI's ArcGIS format.

Upon receipt of review comments from the Dam Safety Branch, ACE will revise the preliminary report to produce the Final Inundation Mapping Report in both hard copy and digital formats as specified in the RFP.

#### **SUB-TASK 3.2 FINAL REPORTING**

Two hard copies of final Inundation Mapping Report for each dam, including the inundation maps, will be stamped by the ACE Project Manager, who is a registered Professional Engineer in the State of Colorado. The final reports (total of 10) and all deliverables will be submitted to the Dam Safety Branch. Each Project Partner will receive one hardcopy report for their own dams.

Draft

**EXHIBIT B**

to

**AGREEMENT BETWEEN THE CITY OF GREELEY, THE CITY OF FORT COLLINS,  
AND THE WATER SUPPLY AND STORAGE COMPANY  
REGARDING A DAM BREACH FLOOD INUNDATION MAPPING STUDY**

**(Budget)**

**EXHIBIT B**  
**BUDGET**  
**DAM BREACH FLOOD INUNDATION MAPPING**  
**CITY OF GREELEY, CITY OF FORT COLLINS, AND WATER SUPPLY & STORAGE CO.**  
**OCTOBER 12, 2018**

**Table 1 Project Budget**

	<b>Sub-Task 1 Breach Modeling</b>	<b>Sub-Task 2 Flood Routing &amp; Inundation Mapping</b>	<b>Sub-Task 3 Deliverables</b>	<b>ODC'S</b>	<b>Total</b>
<b>Task A City of Fort Collins Dams</b>					<b>\$32,360</b>
Joe Wright Reservoir	\$3,600	\$6,600	\$3,300	\$90	\$13,590
Halligan Reservoir	\$3,600	\$11,800	\$3,300	\$70	\$18,770
<b>Task B Water Supply and Storage Company Dams</b>					<b>\$23,480</b>
Long Draw Reservoir	\$2,200	\$6,300	\$3,300	\$90	\$11,890
Chambers Lake	\$2,200	\$6,000	\$3,300	\$90	\$11,590
<b>Task C City of Greeley Dams</b>					<b>\$62,430</b>
Barns Meadow Reservoir	\$2,200	\$5,100	\$3,300	\$60	\$10,660
Comanche Reservoir	\$2,200	\$5,800	\$3,300	\$80	\$11,380
Seaman Reservoir	\$2,200	\$4,600	\$3,300	\$50	\$10,150
Hourglass Reservoir	\$2,200	\$4,800	\$3,300	\$50	\$10,350
Peterson Lake Reservoir	\$2,200	\$4,600	\$3,300	\$50	\$10,150
Twin Lakes Reservoir	\$2,200	\$4,200	\$3,300	\$40	\$9,740
				<b>Total Project Cost</b>	<b>\$118,270</b>