DRAFT

Model Management, Distribution, and Update Guide

Carson River Regional Hydraulic Model

Alpine County, CA, Douglas County, NV, Carson City, NV and Lyon County, NV

March 2017

Prepared for
Carson Water Subconservancy District

HDR Project Number: 10019907

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Acronyms and Abbreviations

0.2-percent	0.2 percent annual chance flood
1-percent	1 percent annual chance flood
1D	one-dimensional
2D	two-dimensional
CWSD	Carson Water Subconservancy District
FEMA	Federal Emergency Management Agency
GB	gigabyte
HDR	HDR Engineering, Inc.
HEC-RAS	Hydrologic Engineering Center's River Analysis System
model	Carson River Regional Hydraulic Model
PMR	physical map revision
TB	terabyte
US-95	U.S. Highway 95
USGS	U.S. Geological Survey

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1 Introduction

As part of continuing efforts to provide sound floodplain management in the Carson River Watershed, the Carson Water Subconservancy District (CWSD) is developing detailed hydrology, hydraulic models, and floodplain mapping for the East Fork, West Fork, and main stem of the Carson River in Carson City, Lyon County and Douglas County in Nevada, and a small portion of Alpine County in California.

1.1 Modeling and Mapping Goals and Objectives

CWSD contracted with HDR Engineering, Inc. (HDR) to develop a detailed hydraulic model for the Carson River Corridor, the goal of which is to provide revised, updated flood hazard mapping for the West Fork, East Fork and main stem of the Carson River from the lower sections of Alpine County, CA to Lyon County, NV. This modeling and mapping is being submitted to the Federal Emergency Management Agency (FEMA) for a physical map revision (PMR) to major portions of Lyon County, Carson City, and Douglas County panels.

A secondary goal of the modeling is to provide a complete and consistent tool to assess cumulative impacts of regional and local changes to the floodplain corridor. These may include encroachments, stormwater improvement projects, or land use changes within the floodplain. Using the model to assess the timing, volume, and peak flow impacts of proposed projects ensures the evaluation and possible mitigation of flood hazards to downstream communities, loss of riparian habitat and floodplain function, and degradation of water quality.

When completed, the model will represent a single tool to help water resource practitioners in the public and private sectors comply with National Flood Insurance Program (NFIP) guidelines and regulations as well as meeting local floodplain management objectives for the multiple communities that are impacted by flooding events on the Carson River.

1.2 Project Area

The downstream terminus of the Carson River Regional Hydraulic Model (Regional Model) is approximately 4 miles upstream of the U.S. Highway 95 (US-95) bridge crossing in Lyon County, Nevada. The approximate upstream extent for the West Fork of the Carson River is the U.S. Geological Survey (USGS) stream gage at Woodfords, California (ID #10310000), in Alpine County, California. The approximate upstream extent for the East Fork of the Carson River is the USGS stream gage near Gardnerville, Nevada (ID #10309000), in Douglas County, Nevada (**Figure 1**).
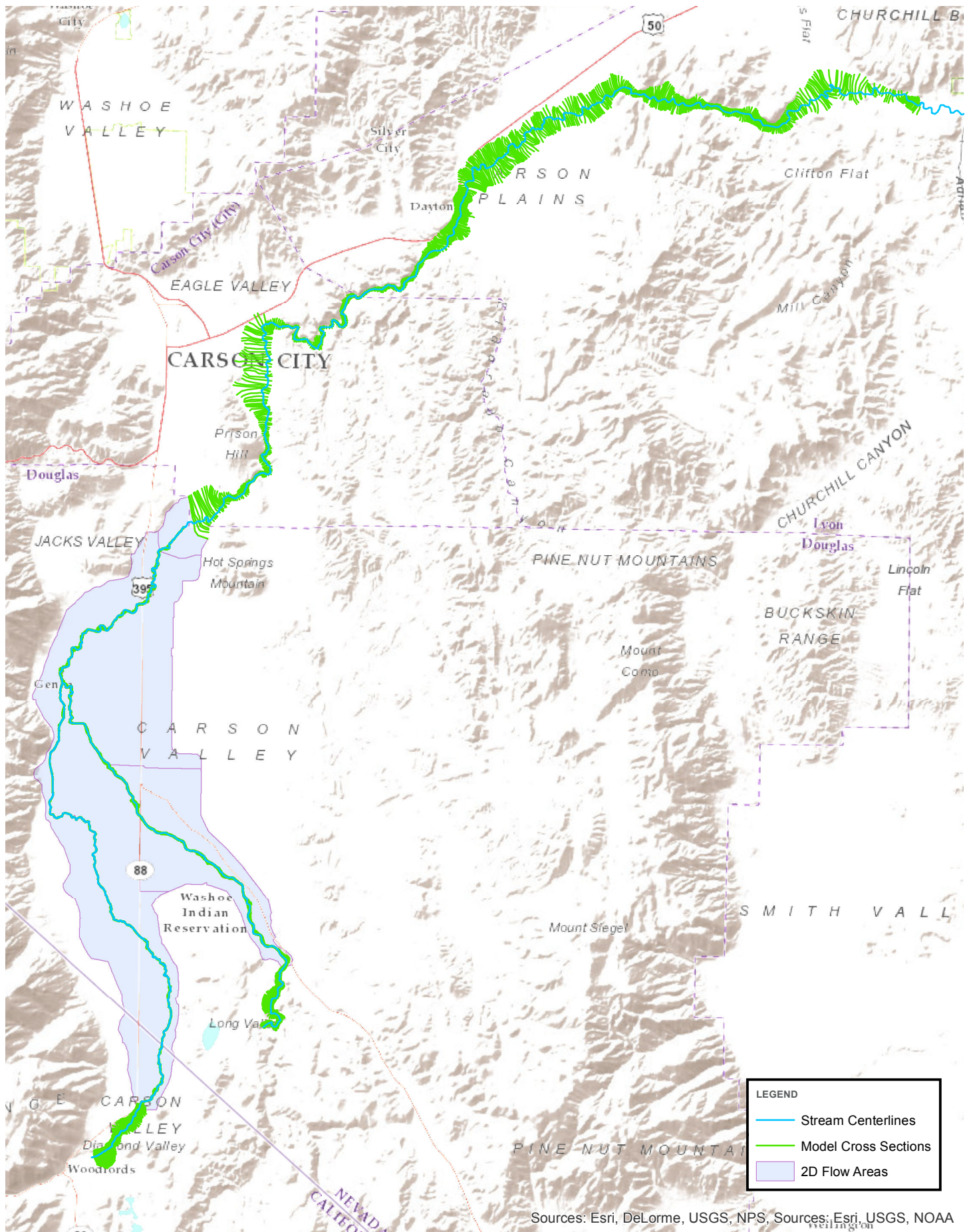
1.3 Model Development

HDR developed the overall model in three phases with each piece approximately covering the Lyon County, Carson City, and Douglas County areas (**Figure 1**). Phase 1 covers the reach of the Carson River from approximately Dayton, NV down to 4 miles above US-95. Phase 2 includes the reach of the Carson River from the USGS Carson City stream gage down to

Dayton, NV. Phase 3 extends from the USGS stream gages on the East and West forks of the Carson River downstream to the USGS stream gage at Carson City.

After completion of each of the three phases, the models were submitted to FEMA for a Physical Map Revision.

1.4 Purpose of this Guide

This document provides guidance regarding the management, distribution, modification, submission, and review of the model. It describes procedures associated with requesting a copy of the model; requirements for modifying, running, and submitting the model; and describes the review process that occurs after submission of a revised model version.

CARSON RIVER PHYSICAL MAP REVISION

FULL MODEL EXTENTS

FIGURE 1

LEGEND

Stream Centerlines

Model Cross Sections

2D Flow Areas

Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA

HDR

0   Miles   4.5

2 Model Components

2.1 Model Version

HDR completed the model using the U.S. Army Corps of Engineers' (Corps) HEC-RAS, Version 5.0.3, which was released in September 2016. This or later versions of the software should be used for any modifications.

2.2 Model Completion Dates

Originally developed in three phases, HDR will ultimately combine each phase of the model into a single HEC-RAS model after FEMA's approval of each phase. HDR completed the modeling of Phase 1 in May 2012, Phase 2 in April 2014, and Phase 3 in December 2016.

2.3 Model Type and Setup

Phases 1 and 2 of the model extend from the Carson City USGS stream gage downstream to Lahontan Reservoir. The modeling tool selected for use on the portion of the Carson River MAS 1 and 2 areas shown on Figure 2 was HEC-RAS 4.1.0. Both of these phases use only one-dimensional (1D) model components for a number of reasons. The Carson River in this area generally consists of a well defined main channel with relatively small floodplain areas. This lends itself to the use of a 1D model. Phase 3 includes the main stem of Carson River upstream of the USGS Carson City stream gage, as well as the East and West forks of the Carson River upstream to the Gardnerville and Woodfords USGS gages, respectively. This portion of the Carson River has very complex floodplain conditions with highly bifurcated flow patterns that are very challenging to model with a one dimensional modeling tool due to the number of independent and commingling split flow patterns that arise during larger events. When the original FEMA model was developed in the early 1980s for Douglas County, these complex flow patterns required the original study contractor (Soil Conservation Service) to make many simplifying assumptions and split flow analyses to attempt to capture these complex dynamics using the one-dimensional modeling tool (WSP-2) that was available to them at the time. In the current state of the art, we now have the ability to model these types of flow complexities using a two-dimensional model combined with far superior topographic data than was available to the SCS. This provides the ability to capture these complex flow dynamics with a much higher degree of confidence in the results.

The modeling tool selected for use on the portion of the Carson River MAS 3 area shown on Figure 2 is HEC-RAS 5.0.3. The model developed with this tool uses a one-dimensional domain to represent the primary channel and associated bridges with two-dimensional (2D) domains to represent the overbank portions of the floodplain. Overbank flows in the Carson Valley are generally shallow, bifurcated flows with relatively low velocity and unpredictable flow patterns. The presence of many agricultural berms that often wash-out during flooding events are what cause many of the unpredictable flow patterns.

The current model has three plans included in the overall project. The following plans will be available for public use:

- The 1 percent annual chance (1-percent) Zone AE floodplain plan;
- The 0.2 percent annual chance (0.2-percent) Zone X floodplain plan; and
- The 1 percent annual chance floodway plan.

2.4 Summary of Files Stored

The model consists of a set of several types of files, all of which are required to successfully run the model and review results. These files include the following:

- *.prj – Project file, contains current plan files, project units, and project description

- *.g01 – Geometry file, contains all model components that represent physical features, such as cross-sectional data, hydraulic structures, 2D flow areas, etc.

- *.u01 – Unsteady flow file, contains inflow hydrographs, initial conditions, and boundary condition information

- *.dss – Time series data file, can contain inflow information for a model run, or can also contain output results

- *.p01 – Plan file, directs which geometry and flow files will be used during a model run, also controls simulation time frame, computational time step, and other model parameters

- *.O01 – Output file, contains computed results for the associated plan

- *.hdf –Binary data storage file, can be a 2D output file, which contains time series results data for 2D and some 1D model components. Is also used to store data about terrain datasets.

- *.tif – Graphics file, contains spatial data associated with a terrain dataset.

- *.vrt – Visualization file that specifies the layers used in a terrain dataset or a results map
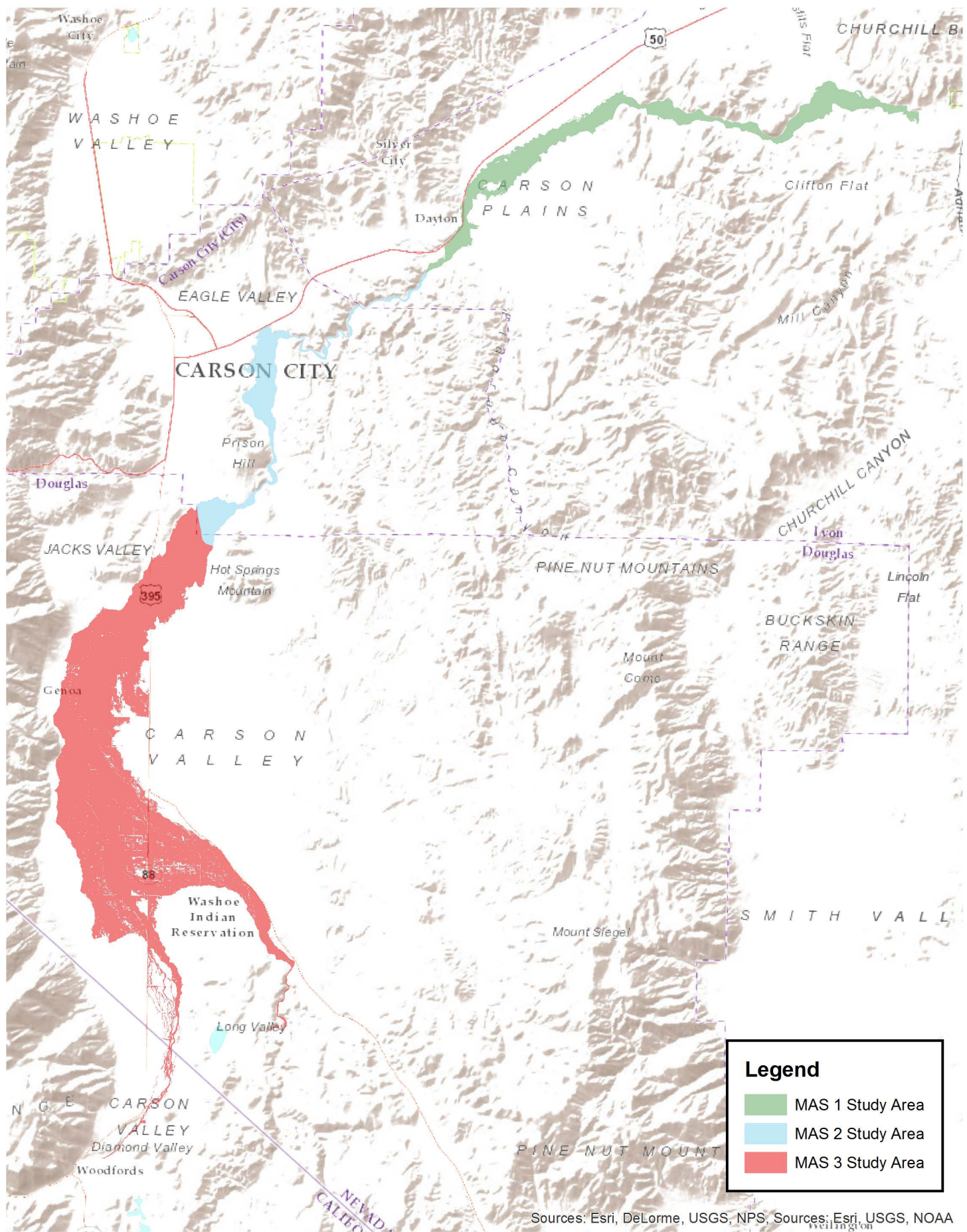
CARSON RIVER REGIONAL MODEL

MAS 1, 2 AND 3 STUDY AREAS

FIGURE 2

Legend

MAS 1 Study Area

MAS 2 Study Area

MAS 3 Study Area

Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA

3 Model Storage

3.1 Location of the Model Files

The most up-to-date model files will be stored on CWSD premises, or in an online storage facility of their choosing. The model may also be stored on external hard drives at CWSD for distribution.

3.2 Data Storage Requirement

Due to the 1D/2D nature of the model and the regional extents of the model, it is anticipated that model file sizes will be relatively large for model input and particularly output files. Each plan and associated output can easily be 10s of gigabytes (GB) worth of data. Therefore, CWSD will house the base model geometry and any subsequent updates on a minimum 1 terabyte (TB) server drive. Model users will need to have access to computer storage in the range of 20 gigabytes to accept and run the model successfully.

4 Model Distribution

A primary selection criterion for the modeling platform was that the tool had to be a well supported, free, public domain software package in order to ensure that there were no financial or access limitations to stakeholders or practitioners using the model. HEC-RAS is public domain software that is free to download and use, with well supported documentation and widespread use in the industry. Therefore, the model is available to practitioners for the purposes of evaluating proposed projects in the floodplain corridor.

It is the vision of the CWSD however, that final modifications, updates and quality checks of any proposed conditions within the model area will be conducted by a qualified consultant under contract with the CWSD. This is to ensure consistent, correct updates to the model.

4.1 Model Distribution Fee

In order to pay for updates and maintenance of the Regional Model, the CWSD will charge a modeling use fee to be determined in future ordinance updates by affected communities.

4.2 Projects Requiring Modeling

One of the main modeling objectives as defined by the CWSD and cooperating municipalities is to track the hydraulic and hydrologic impacts of land use changes, civil drainage projects, or development throughout the entire Carson River Corridor. Future ordinance revisions will require the use of this model to incorporate changes and assess hydraulic impact for all areas within the newly established Flood Hazard Areas. This includes all Zones A, AE, AH, AO, and Floodway.

Upon FEMA approval of these revised flood zones and model, FEMA regulatory requirements will be in effect for all areas shown on the current FEMA effective Flood Insurance Rate Maps.

Figure 3 is a map showing the model proposed areas that will require a flood impact analysis. These boundaries have not yet been approved by FEMA and may therefore change as a result of the technical review and acceptance process. Therefore, this model would be considered preliminary by FEMA but also be treated as "best available information" with regard to compliance with 44 CFR 60.3.   A project proponent would likely be required by FEMA to evaluate the impacts of their proposed project with both the existing effective model and the preliminary model. Subsequent sections in the guide describe the process for obtaining, modifying, and submitting the model for review.

Legend

Areas Requiring Impact Analysis
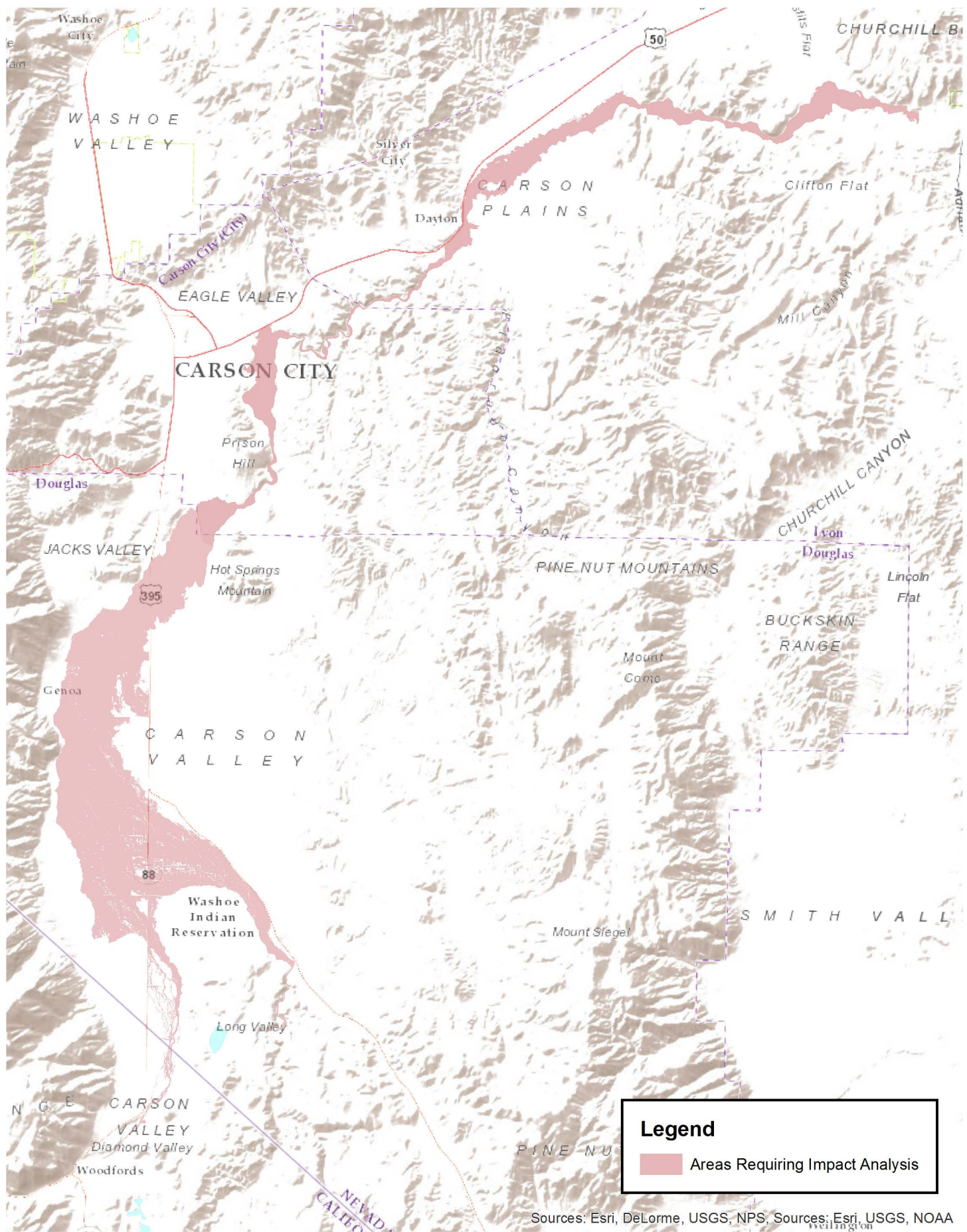
CARSON RIVER REGIONAL MODEL

AREAS REQUIRING MODEL IMPACT ANALYSIS

FIGURE 3

4.3 Model Request

Although final modifications for proposed projects will be made by a consultant contracted under CWSD, the model may be distributed for project proponents to do alternative analyses or conduct their own impact assessment.

In order to obtain the model, a formal model request shall be made to the CWSD for each project requiring analyses. The requesting party shall obtain an electronic request form from the CWSD website. This request form shall be filled out and submitted electronically, by mail, or in person to the CWSD. The Model Request Form is attached in Appendix A. CWSD staff shall review the model request and distribute the model accordingly. This model will constitute the "Base Model Plan" which will be the basis of comparison for water surface impacts.

4.4 Files to be Transferred

Due to their large file size, no output files will be distributed with the model unless a special exemption is approved. Therefore, it is the model consultant's responsibility to run the "Base Model Plan" once obtained to generate hydraulic output files for comparison purposes. The following files will be transferred to the model requestor:

- *.prj – The overall project file
- *.g01 – The 1-percent floodplain geometry file
- *.g02 – The 0.2-percent floodplain geometry file
- *.g03 – The 1-percent floodway geometry file
- *.p01 – The 1-percent floodplain plan file
- *.p02 – The 0.2-percent floodplain plan file
- *.p03 – The 1-percent floodway plan file
- *.u01 – The 1-percent floodplain flow file
- *.u02 – The 0.2-percent floodplain flow file
- *.u03 – The 1-percent floodway flow file
- *.hdf, *.vrt, and associated *.tif - The most current existing conditions terrain files
- *.hdf and associated *.tif – the most current Manning's n land use file

These files constitute the necessary files to open and run the model for all three flood hazard areas. Depending on the project type and area, all three plans may not be necessary but all will be provided. The file date and time stamp will be noted in the delivery log and should not be altered by the model recipient.

The model shall be left in the original file folder upon transport to a local server and simply opened and run in HEC-RAS with no alteration to the files to retain original time stamps. Modifications to the model for any proposed conditions will be made on copies of the "Base Model" files within this original folder. This will ensure preservation of the original "Base Model Run."

The model folder shall be named with the project name, date, and FEMA panel number of the proposed project. This folder shall not be modified and shall be submitted back to CWSD in this format. **Figure 4** is an example of the folder and file structure.
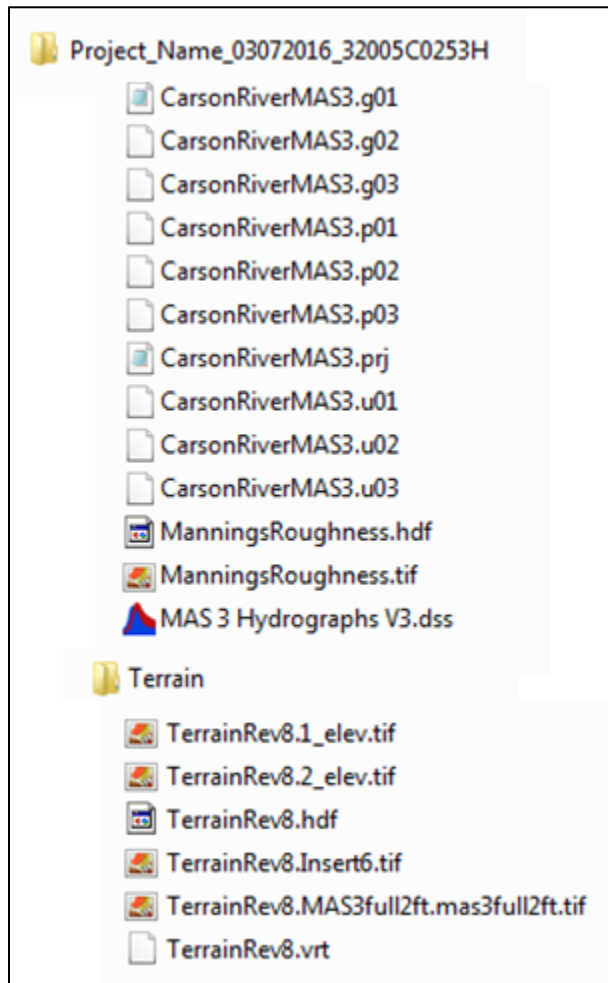

Figure 4: Model delivery folder naming convention

4.5 Format of Transfer

Due to large file sizes, the model will be transferred via USB external hard drive. The capacity of the drive should be at least 20 GB. The party requesting the model will provide the drive to CWSD for model transfer.

5 Model Modifications

The Modeling Fee described in section 4.1 will be used to contract with a qualified consultant to make final revisions to the model to reflect the proposed project modification to the floodplain based on input from the project proponents. The modeling consultant will follow sound engineering guidelines, up-to-date specifications, regulatory requirements, and modeling best practices in accordance with the latest version of the model and industry standards. The model consultant must ensure the model meets appropriate standards set forth by the review agencies. FEMA's review through the Conditional Letter of Map Revision (CLOMR) process is governed by 44 CFR 60.3 and 65.12.

Since there are three separate models that describe the Carson River within the overall study area, there may be instances where a project's impacts include not only localized impacts but could also result in increases in downstream peak discharges.   Also, the hydraulic impacts of a project that is located near the upstream or downstream end of one of the model reaches shown on Figure 2 could result in changes to the water surface elevation or discharge that is the basis of the adjoining model. Should that occur, the proponent may be required to make appropriate modifications to all impacted models for the Carson River or its associated tributaries as represented on the current FIRMs.

5.1 Proposed Project Information

The proponent of the proposed project occurring within the Special Flood Hazard Area outlined in Figure 3 shall provide the CWSD with enough information about the proposed project to accurately update the Regional Model. The project proponent may submit this information in a number of forms including:

- A set of engineering plans for the proposed project
- A proposed conditions HEC-RAS model based on the Regional Model
- A drainage report summarizing proposed changes

If insufficient information is submitted to update the model CWSD will make a request to the project proponent for more information.

5.2 Model Modifications

Model modifications shall be made to a copy, within HEC-RAS, of the original "Base Model" plan. As stated in Section 4.4, the model shall be left in the original file folder and simply opened and run in HEC-RAS with no alteration to the files to retain original time stamps. Modifications to the model for any proposed conditions will be made on <u>copies</u> of the "Base Model" files within this original folder. This will preserve the original "Base Model Run".

The consultant shall use the *File > Save As* option to make appropriate copies of the "Base Model" plan, geometry, and flow files. This process shall be followed for all proposed plans used for impact analyses. The new file plan names shall include the date of copy in the name as an eight digit string in the following format: MONTH DAY YEAR (example: 03042016).

Modifications to the model geometries shall be made in accordance with CWSD's *Hydraulic Modeling and Floodplain Mapping Guidelines* (2011) (*Modeling Guide*), which is included in the model delivery package.

For 2D elements not covered in the *Modeling Guide*, modeling changes shall be made to the "Base Model" existing terrain as terrain layers or overlays and/or to the 2D modeling domain as described in the following documents:

- February 2016 *HEC-RAS River Analysis System User's Manual*, Version 5.0 (http://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%20Users%20Manual.pdf)

  and

- February 2016 *HEC-RAS River Analysis System 2D Modeling User's Guide*, Version 5. (http://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%202D%20Modeling%20Users%20Manual.pdf) or later versions.

Consultants shall also follow best practices outlined in the February 2016 *HEC-RAS River Analysis System Hydraulic Reference Manual*, Version 5.0 (http://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%20Reference%20Manual.pdf) or later versions.

6 Model Run

As described in Section 5, the CWSD contracted consultant shall run the "Base Model" and any "Proposed" model plans in the originally provided modeling folder with no alteration to the "Base Model" plans. Consultants shall run the model in unsteady-state mode with a subcritical or mixed-flow regime (if necessary for model stability). Modeling time steps shall be chosen to satisfy the Courant Condition in the specific plan or smaller to stabilize the model run. Consultants shall use default "Calculation Options and Tolerances" unless modification is necessary for model stability or as a best practice described in the *Modeling Guide*.

6.1 Operation System Requirements

At the time of this guide's publication, HEC-RAS, Version 5.0.3 runs on the following operating systems: Windows XP, Vista, 7, 8, 8.1, and 10. Both 32-bit and 64-bit versions are supported. HEC-RAS can be run on a desktop PC. Following are minimum hardware requirements with recommended parameters shown in parentheses.

- Intel-based PC or compatible machine with Pentium processor or higher (Intel I3 or higher with multiple cores is recommended)

- Hard drive with at least 5-10 GB of free space

- Minimum of 2 GB of RAM (4 GB or more recommended)

- Mouse, touch pad or touch screen

- Color Video Display (Recommend running in Super VGA (1024x768) or higher, and as large a monitor as possible)

6.2 Run Times

It is anticipated that with the combined 1D/2D model, run times for the Douglas County, Nevada portions of the model may be in the 10 to 20 hour range or longer depending on model iteration and level of model instability. For final plans submitted to CWSD, modelers shall run the entire hydrograph event for the same time period as the "Base Model" run. Modelers should allow enough time to anticipate up to a 24-hour run time depending on the chosen time step and changes to the model that may cause instabilities.

7 Model Submission

CWSD's long-term goal for this modeling effort is to be the clearinghouse for distributing and updating this Regional Model. CWSD will collect and store the most current versions oif the model after completion of each proposed project has been integrated into the model by the CWSD contracted consultant.

CWSD is <u>not</u> responsible for submitting this model to any regulatory agencies or municipalities on behalf of the project proponent. CWSD will provide a final updated version to the project proponent in the format described in section 4.4 of this document for their use in regulatory requirements.

7.1 Items to be Submitted to CWSD by the Consultant

7.1.1 Modeling Memorandum
The model consultant shall submit a <u>brief</u> memorandum describing the proposed conditions model changes and a summary of impacts to water surface elevations, flow magnitudes, and flow patterns as appropriate.

7.1.2 Modeling Files
Upon completion of the proposed conditions model and finalized runs for both the existing and proposed condition models, model consultants shall submit the final modeling folder. This folder shall be identical to the one described in Section 0 with the addition of the following for proposed conditions modeling and output files as appropriate:

- New plan(s) (*.p0*)
- New geometry(s) (*.g0*)
- New flow(s) (*.u0*)
- Revised project (*.prj)
- Output files (*O0*),
- DSS files (*.dss)
- HDF files associated with each plan (*.p0*.hdf)
- Proposed terrain Files (*.hdf, *.tif, and *.vrt)
- Proposed Manning's n files (*.hdf and *.tif)
- RASMapper files (*.rasmap)
- Output folders generated by HEC-RAS

7.1.3 Internal Quality Check of Modeling
Model consultants shall submit evidence that a model internal quality check (QC) was completed.

7.1.4 Submission Forms
Model consultant shall fill out and submit the Modeling Submission Form contained in Appendix B.

7.2 Submission Format

Model consultants shall deliver submissions to CWSD on an external hard drive, thumb drive or DVD.

8 Model Finalization
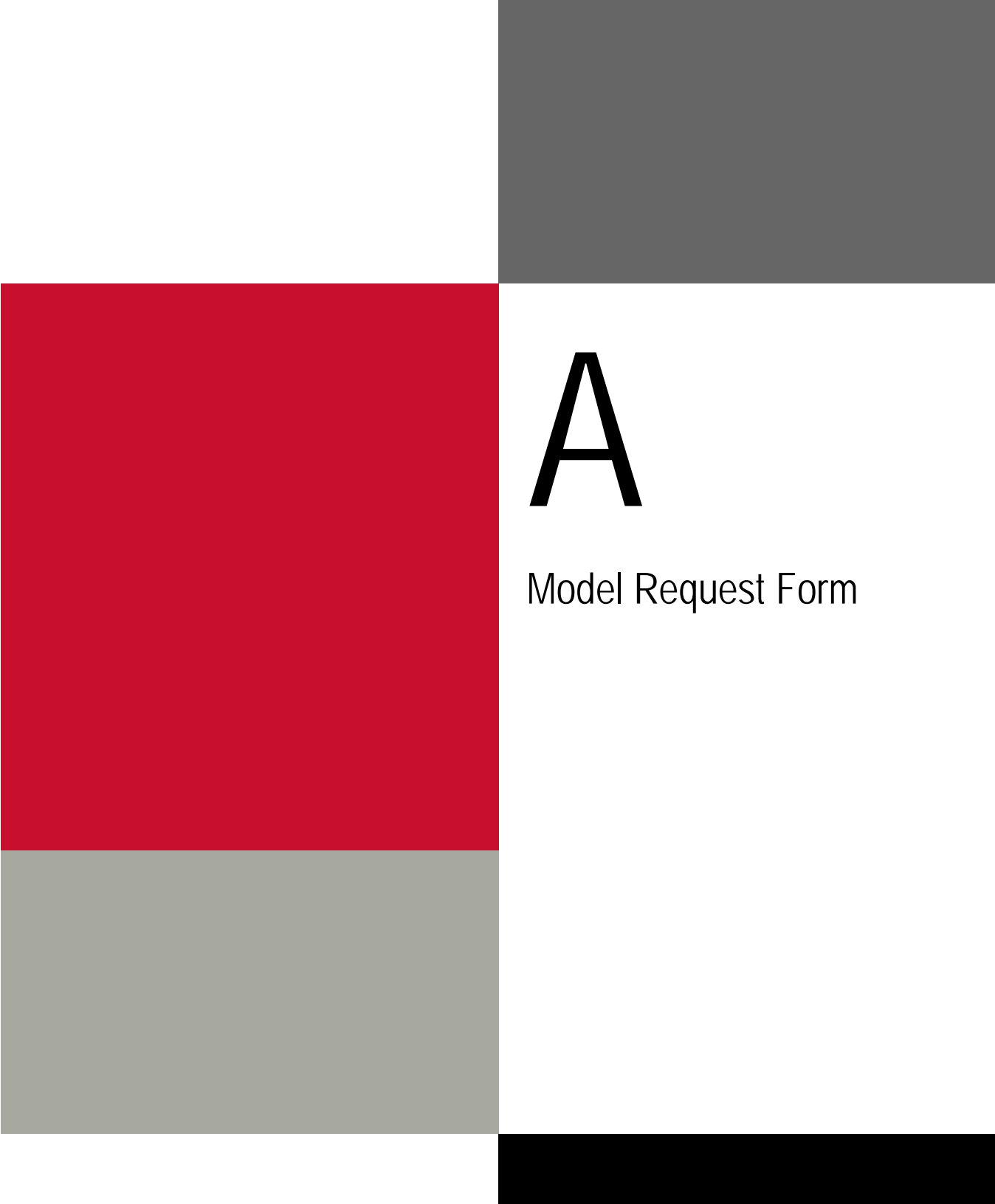
8.1 CWSD Review and Sign Off

After submission of the final proposed conditions model and technical memorandum, the CWSD will review the documentation to ensure completeness of the submission package, consistency of the technical memorandum, and compliance with the intent of this guide. The CWSD will not comment on any technical modeling aspects but will review the impacts to hydrology and hydraulics as stated in the technical memo.

The CWSD will make comments on the technical memorandum as appropriate and submit to the consultant and project proponent. The consultant will then respond to any CWSD comments and makes the necessary revisions to the technical memo. CWSD will ensure that the memo revisions provide an acceptable resolution of the comments. Once all comments and revisions have been accepted, the CWSD reviewer will close out the QC review, sign and date the form, and store it electronically with the model version.

Floodplain regulatory compliance review responsibility lies with each of the NFIP communities impacted by the proponent's project. The project proponent should be prepared to address the requirements from multiple jurisdictions if the impacts of a proposed project have systemic impacts to the Carson River rather than just localized impacts. The responsibility for obtaining such approvals from each impacted jurisdiction lies with the project proponent.

8.2 Model Packaging and Archiving

After all QC comments and responses are closed out, the model, technical memo, QC comment sheets, and all associated digital files will be zipped into a compressed folder and archived at CWSD. The zipped folder will have the same name and format as described in **Figure 4** with the addition of the files described in Section 7.1.2.

A

Model Request Form

Carson River
Regional Model

Project Name		Date	

Requester Information

Name	
Agency/Firm	
Position	
Address	
Phone	
Email	
FIRM Panel Number	

Township		Range		Section	

Project Description

Signature		Date	

B

Modeling Submission Form

Carson River Regional Model

Model Submittal Form

Project Name		Date	

Requester Information

Name	
Agency/Firm	
Position	
Address	
Phone	
Email	
FIRM Panel Number	

Township		Range		Section	

Model Revision(s) Description

Submittal Format

Disk	☐	Thumb Drive	☐	External Drive	☐

Signature		Date	

C

Quality Control Review Form

Carson River Regional Model

Quality Control Review Form

Project Name		Date	

Submitter Information

Name	
Agency/Firm	
Position	
Address	
FIRM Panel Number	

QC Information

QC Reviewer	
Review Date	Select date...
Technical Memo Name	

Project Description

Township		Range		Section	

Quality Control Review

Comment	Response