Agreement on Implementation of John Martin Reservoir Revised Elevation-Area-Capacity Tables in the H-I Model

August 2015

I. Introduction

In October 2014, Colorado proposed modifying the H-I Model to recognize the resurveys of John Martin Reservoir (JMR) that have occurred prior to the date of this agreement. Kansas reviewed and has agreed to the proposed changes.

II. Background and Context

The Arkansas River and its tributaries transport a significant sediment load, and the process of sedimentation in JMR has been causing a steady decrease in storage capacity over time. The H-I Model uses a progression of area-capacity (AC) relationships to estimate evaporation and limit the maximum Compact conservation storage volume. Before this agreement, the H-I Model (update6eV1_06_GWEff) contained six different AC relationships and eight different maximum storage values which were applied for different date ranges. Up until this agreement, the latest JMR elevation-area-capacity used in the H-I Model was based on the 1994 resurvey.

JMR was resurveyed in 1999 and the resulting elevation-area-capacity table had been used by the Arkansas River Compact Administration from November 1999 through October 2013. As noted above, the 1999 elevation-area-capacity was not recognized by the H-I Model which will be modified with this agreement.

The U.S. Army Corps of Engineers (USACE) dredged JMR around the outlet works in early 2006, completed a bathymetric survey of the reservoir in March 2006, and completed an aerial survey of the “out of water” areas in 2009. USACE completed the sedimentation resurvey report in 2013 which included a new elevation-area-capacity table. This elevation-area-capacity table was implemented in November of 2013.

The USACE provided both the digital elevation-area-capacity table and survey reports from 1999 and 2013. For the tables received from the USACE, the 1999 and 2006/2013 tables were discretized to 0.01 foot elevations. Although the USACE used a Fortran program in the past, GIS was also used in 2013 to develop areas and volumes from mapped contour lines. To apply AC information in the H-I Model, the following exponential function is used to estimate area as a function of volume for two volume ranges for each dataset using two coefficients that are fit using linear regression.

\[
\log(\text{area in acres}) = a \cdot \log(\text{volume in AF}) + b
\]

and

\[
\text{area} = e^{\log(\text{area})} = e^{(a \cdot \log(\text{volume}) + b)}
\]

where \( \log \) = natural (base e) logarithm and \( e \) = Euler’s number

(a and b have been referred to as alpha and beta in the Appendix C.1 section 2.2.5)
III. Scope

For JMR, the months when AC and maximum storage variables change are hardwired in the H-I Model. Currently in the H-I Model, applicable date ranges for AC information are generally the midpoint between survey dates. For example, for the July 1986 and June 1994 surveys, the AC data from 1986 study is applicable until June of 1990 while the 1994 data is used beginning in July of 1990. Of the five AC date changes, three are applied in January and two in July. On the other hand, maximum storage changes have been applied either at the time of the survey or when the area capacity information was presumed to be applied to JMR accounting. The new 1999 survey data is applied starting January 1997 for the AC relationships in the model. JMR was dredged in the first months of 2006 before being resurveyed in March of 2006. As this dredging creates a more discrete change in JMR storage, the new 2006/2009 survey data is applied starting January 2006 for the AC relationships in the model. Tables developed from the 1999 and 2006/2009 resurveys were applied to JMR accounting in November 1999 and November 2013, respectively. Therefore, changes in the maximum storage variable in the H-I Model are applied in November 1999 and November 2013.

IV. H-I Model Code Revisions

The States agree to make the following changes to the H-I Model input file, RESR.DAT, and H-I Model code using the data from Table 1 to account for the 1999 and 2006/2009 elevation-area-capacity curves developed by USACE. The updated H-I Model code has been titled “update6eV1_15.for”

Table 1. John Martin Reservoir Data in the H-I Model

<table>
<thead>
<tr>
<th>Sediment Survey</th>
<th>EAC Table</th>
<th>H-I Model Area Capacity Information for Evaporation</th>
<th>H-I Model Max Cons. Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dates (2)</td>
<td>Months a2 if vol&gt; (2)</td>
<td>a1 (1)</td>
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<tr>
<td>Oct-51</td>
<td>1956</td>
<td>1950-6/59 &lt;115</td>
<td>29216</td>
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<tr>
<td>Aug-57</td>
<td>1958</td>
<td>8/57-2/62 92&lt;147</td>
<td>380858</td>
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<tr>
<td>Mar-62</td>
<td>1962</td>
<td>7/59-12/65 &gt;114&lt;193</td>
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<td>1967</td>
<td>1/71-12/79 &gt;252&lt;361</td>
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<td>1969</td>
<td>1/50-12/70 &gt;192&lt;253</td>
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<td>1/50-12/96 &gt;486&lt;565</td>
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<td>Jul-86</td>
<td>1999</td>
<td>1/50-12/96 &gt;564&lt;673</td>
<td>17808</td>
</tr>
<tr>
<td>Aug-94</td>
<td>2003</td>
<td>1/50-12/96 &gt;672&lt;767</td>
<td>15614</td>
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</table>

Notes: (1) implemented in RESR.DAT, (2) implemented in H-I Model code
A. Revisions to the H-I Model Input File and H-I Model Code

1. Additional Lines Added to RESR.DAT for Proposed JMR Information
   *(added lines shown in red)*

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</table>

-- COEFFICIENTS FOR JOHN MARTIN AREA-STORAGE
2. **Revisions and Additions to H-I Model Code to Incorporate Proposed JRM Information**  
 *(revisions and additions shown in red)*

**Changes to Dimension**

```
DO 370 I=1,16
   READ(92,*)
   201KTJMR
   0202

REAL ALPHA(8,2),BETA(8,2),CFLOW(MAXDVT),DIVTD(MAXDVT),
   0295KTJMR

DO 360 IRANGE=1,2
   DO 355 IPER=1,8
   READ(92,913)ALPHA(IPER,IRANGE),BETA(IPER,IRANGE)
   0679KTJMR

Changes to JMR Area-Capacity Statements

IF (IMONTH.GT.486 .AND. IMONTH.LT.565) THEN
   0926KTJMR

IF (IMONTH.GT.564 .AND. IMONTH.LT.673) THEN
   IPER=7
   IF (VOL.GT.17808.) THEN
      IRANGE=2
   ELSE
      IRANGE=1
   ENDIF
   0933.1KTJMR
   0933.2KTJMR
   0933.3KTJMR
   0933.4KTJMR

ELSE
   IRANGE=1
   0933.5KTJMR
   0933.6KTJMR
   0933.7KTJMR
ENDIF
   0933.8KTJMR

IF (IMONTH.GT.672) THEN
   IPER=8
   IF (VOL.GT.15614.) THEN
      IRANGE=2
   ELSE
      IRANGE=1
   ENDIF
   0933.9KTJMR
   0933.10KTJMR
   0933.11KTJMR
   0933.12KTJMR
ENDIF
   0933.13KTJMR
   0933.14KTJMR
   0933.15KTJMR
   0933.16KTJMR
```

**Changes to JMR Area-Capacity Statements**

```
IF (IMONTH.GE.534 .AND. IMONTH.LT.565) STRMAX(1)=335693.
   1047.1KTJMR

IF (IMONTH.GE.599 .AND. IMONTH.LT.767) STRMAX(1)=333912.
   1047.2KTJMR
```

C--Actual conservation storage capacity as of November 2013

```
IF (IMONTH.GE.767) STRMAX(1)=330703.
   1048
```

1049KTJMR

1050

1051KTJMR

4
IX. General Terms

The States agree to modify the H-I Model code recognizing the JMR elevation-area-capacity data from 1999 resurvey and the 2006/2009 resurvey as described in this agreement. The States agree that the changes will be implemented with the 2014 H-I Model annual update performed in 2015. The results of the ten year Compact compliance for years prior to the 2014 H-I Model annual update will remain unchanged.

This Agreement shall become effective when both States have approved it by the signatures of their Engineers as provided for below or on counterpart copies, and after telecopies or electronic versions of the same have been received by the other State. Two originals of this Agreement will be circulated for signature, one original to be retained by each State.

STATE OF COLORADO

Dick Wolfe
Colorado State Engineer

Date: 8-26-2015

STATE OF KANSAS

David W. Barfield
Kansas Chief Engineer

Date: 8/26/2015