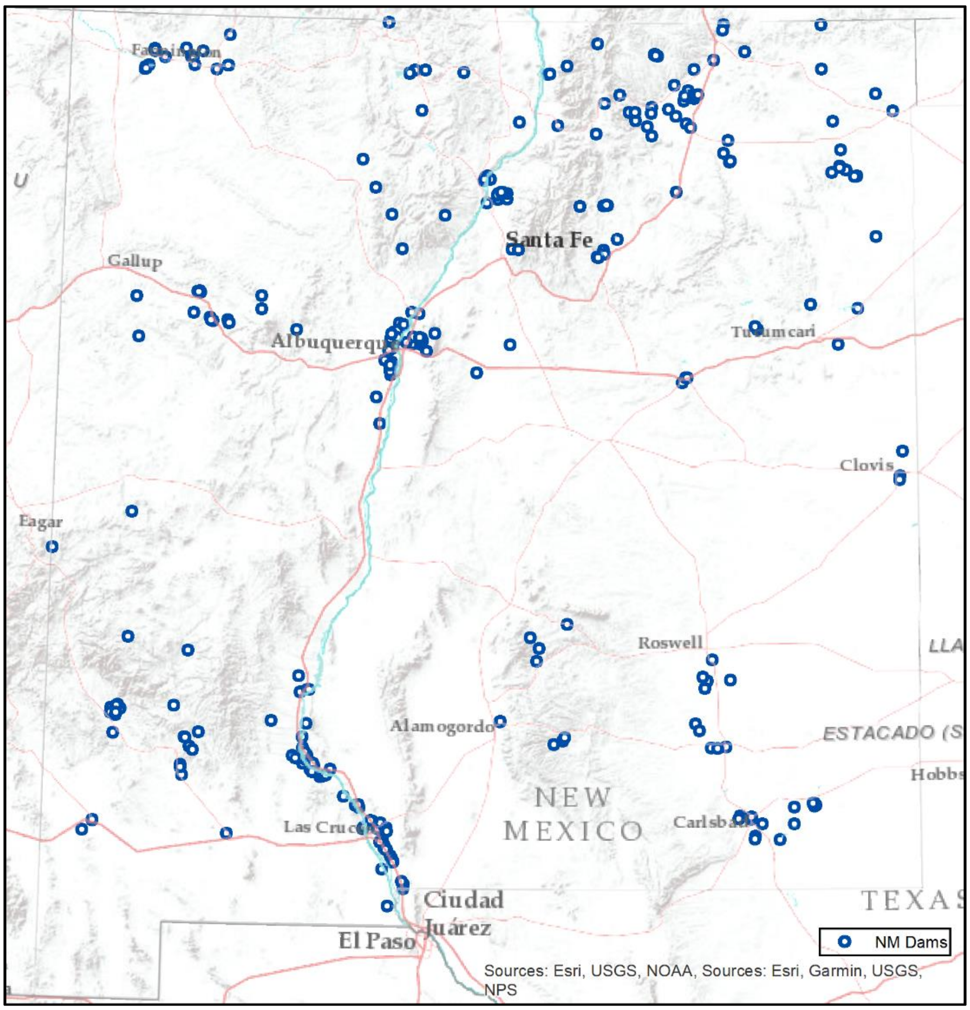
# New Mexico Dam Safety Bureau

## *Evaluation of and Updates to Hydrologic Modeling Practice and Guidance*

Workshop No. 3 Summary

January 15, 2021

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Office of the State Engineer
Interstate Stream Commission

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# Table of Contents

## List of Figures



## List of Tables

# 1.0 Introduction and Agenda

On January 15, 2021, Gannett Fleming and the New Mexico Office of the State Engineer (OSE) Dam Safety Bureau (Dam Safety Bureau) met virtually to discuss the data collection effort, stakeholder questionnaire responses, and the scope of work for Task 2 for the *Evaluation of and Updates to Hydrologic Modeling Practice and Guidance Project* for the Dam Safety Bureau's jurisdictional dams. Those who were present are listed in Table 1.1. Juan Solis, a graduate student at New Mexico State University, attended and will be integrated into the project team. After introductions and a safety moment, Workshop No. 3's agenda was presented, and a summary of Workshop No. 2 was given.

*Table 1.1: Workshop No. 3 Attendees*

| Dam Safety Bureau | Gannett Fleming | Guests |
|---|---|---|
| Bud Brock | Amanda Hess | Juan Solis (NM State University) |
| Sushil Chaudhary | Gregory Richards | |
| David Heber | Paul Schweiger | |
| James Head | Seth Thompson | |
| Chuck Thompson | Yan Wang | |

## 1.1 Workshop No. 3 Agenda

Workshop No. 3's agenda is as follows:

1. Progress Update
2. Questionnaire Results
3. Workshop No. 2 Follow-up
    a. Antecedent Conditions
    b. Jarrett's Method
4. IDF Determination
    a. State Guidelines
        i. Colorado
        ii. Washington
5. Hydrologic Methods and Data Availability
    a. Hydrologic Loss Methods
    b. Hydrologic Transform Methods
    c. Temporal Distributions
    d. Validation Data
        i. Regional Peak Flow Envelope Curves
6. Scope and Schedule of Task 2

### 1.2 Progress Update

Gannett Fleming discussed the progress that has been made on the project thus far, which includes the following accomplishments:

- From the questionnaire, learned that stakeholders are open to risk-informed methods for decision making.
- From the state dam safety program data collection effort, gained a broader understanding of the current state of the practice for inflow design flood (IDF) determination and hydrologic modeling in the western U.S.
- From discussions with the project team in Workshop No. 2, agreed that Colorado and Washington guidelines have elements that may be able to be applied in New Mexico.

## 2.0 Stakeholder Questionnaire Results

As of January 15, 2021, the stakeholder questionnaire received 14 responses: five from dam owners, and nine from consulting engineers. The new responses (since Workshop No. 2 on December 17, 2020) to each question were summarized. Results are available in the *"Stakeholder Questionnaire.xlsx"* saved on Gannett Fleming's SharePoint service. A general summary of the responses discussed is given herein as well.

**Question 5:** What concerns do you have with the existing NM hydrologic guidelines and Dam Safety Bureau submittal process? What would you like to see changed?

- One consultant requested official incorporation of the new CO-NM Regional Extreme Precipitation Study (CO-NM REPS) data. Another requested that spillway size based on an incremental damage assessment (IDA) should be allowed (this currently is allowed by the Dam Safety Bureau but is not common practice). Two other consultants asked for clarification on acceptable hydrologic methods and inputs and clarification on how the Dam Safety Bureau would like information to be presented.

**Question 6:** What do you like about the existing NM hydrologic guidelines and Dam Safety Review Process?

- Consultants like the organization of the current guidelines and like that the Dam Safety Bureau does not require a specific hydrologic method.

**Question 7:** What are your preferred hydrologic analysis methods for estimating rainfall losses in New Mexico? Why are these methods preferred?

- Three mentioned the Initial and Constant Loss method
- Three mentioned the Natural Resources Conservation Service (NRCS) Curve Number (CN)
- Two mentioned the Green and Ampt method

**Question 8:** What are your preferred hydrologic analysis methods for transforming rainfall to runoff in New Mexico? Why are these methods preferred?

- Four mentioned the Clark Unit Hydrograph (UH).
- Three mentioned the NRCS UH.
- Three mentioned the Snyder UH.
- Two mentioned the USBR UHs.

**Question 9:** What is your comfort level with the following hydrologic modeling parameters and methodologies?

- As depicted in Figure 2.1, this poll showed that most engineers were comfortable with the CO-NM REPS, and each hydrologic loss and transform method mentioned with the exception of the S-graph hydrologic transform method. In Figure 2.1, the orange coloration represents comfort, and the blue represents discomfort with each statement.

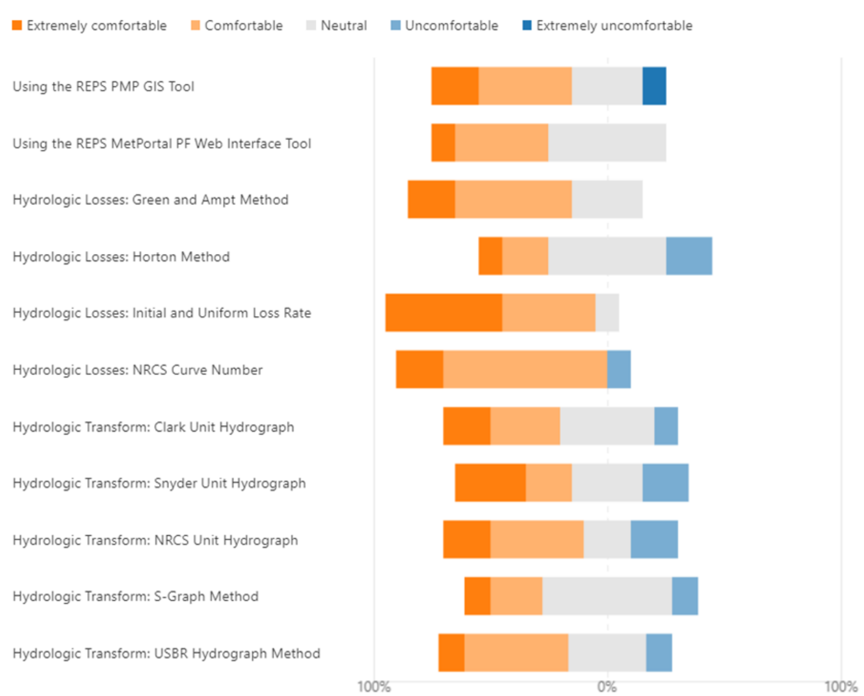


*Figure 2.1: Results to Question 9 as of January 15, 2021 in the Stakeholder Questionnaire.*

**Question 10:** Would you feel comfortable applying a risk-based approach to determine the spillway design flood (SDF) for a dam (e.g., based on incremental consequences or estimates of loss of life potential)? Would clear guidance from the NM Dam Safety Bureau on applying risk-based methods increase your level of comfort? Please explain.

Because these responses give good insight they are quoted below.

- *I think risk (e.g., QRA, SQRA, FMEA) and incremental damages assessments are valuable tools and should be used to guide designs and communicate with stakeholders and regulators. I also think that risk-based approaches are more ethical than designing for PMP/PMF or some percentage of the PMP/PMF because the latter may provide a false sense of dam safety by appearing more deterministic. I think risk-inform design/regulatory criteria would also allow for more responsible stewardship of public money.*
- *Yes and yes. A general fundamental charge of professional civil engineers is to apply a standard of care to provide public safety (acceptable risk). I believe that the standard of care a prudent professional civil engineer should apply to spillway design is risk-based. Without a risk-based approach, it can be unclear, or at least less clear, how probability and consequence factor into the determination of acceptable risk.*
- *Yes, I would feel comfortable and clear guidance would increase my level of comfort. USACE and FEMA provide clear guidance for applying risk-based methods towards designing and accrediting levees (ECB 2019-11). Guidance like this for spillway design with specific software endorsements (HEC-FDA) would increase my level of comfort. A risk-based approach provides dam owners and stakeholders a better sense of failure probabilities, consequences, and remediation priorities than designing for the Probable Maximum Flood (PMF). I worry that designing for the PMF provides a false sense of safety by meeting a deterministic standard. At the same time, I do not think that designing for the PMF is always unreasonably conservative. I believe it is a nuanced and site-specific issue, but in general, I support risk-based designs over the PMF.*
- *We are comfortable with this approach as long as clear guidance on how to interpret incremental depths and loss of life are clear and future downstream creep issues are accounted for.*
- *We would support such if data, especially for the watershed, is brought up to date and reviewed every 5 years. Our dam spillway was over-designed so we are very comfortable with it, at least for now.*
- *Yes, a risk-based approach can be more applicable in certain situations. Clear guidance from DSB as to what would be acceptable consequences (i.e. flow depth increases) would be helpful in order to evaluate different risk scenarios.*

**Question 11:** Indicate to what extent you agree or disagree with the following statements regarding risk-based decision making.

- The results of this poll varied and are presented in Figure 2.2. The orange coloration represents agreement, and the blue represents disagreement with each statement.

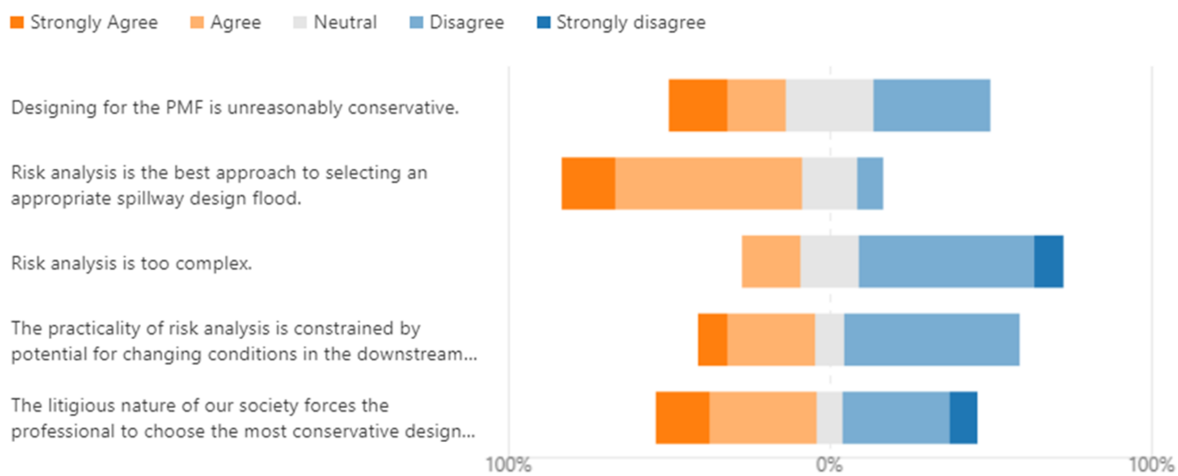


*Figure 2.2: Results to Question 11 as of January 15, 2021 in the Stakeholder Questionnaire.*

**Question 12:** Are you interested in reviewing and having an opportunity to provide comment on draft updates to dam safety guidelines from the Dam Safety Bureau?

**Question 13:** If you have interest, what is the best way to contact and share information with you?

- Twelve of the fourteen respondents indicated their interest in reviewing and providing feedback on the draft updates and indicated that email is the best method of contact.

The Workshop attendees discussed that questionnaire responses will still be considered through the end of Task 2. The Dam Safety Bureau will send out a second email to stakeholders to solicit more responses.

## 3.0 Workshop No. 2 Follow-up

As described more fully in the written summary of Workshop No. 2, the second workshop was held on December 17, 2020 and focused on state and federal dam safety program guidelines regarding IDF determination and hydrologic modeling criteria. As part of Workshop No. 2's discussion, the Dam Safety Bureau requested that Gannett Fleming perform additional research into the use of Jarrett's Method (specifically by Arizona Dam Safety) and the range of antecedent watershed conditions recommended by the various state dam safety agencies.

### 3.1 Jarrett's Method

Jarrett's Method refers to a 1985 United States Geological Survey (USGS) Water-Resources Investigation Report (WRIR) publication titled: *Determination of Roughness Coefficients for Streams in Colorado (WRIR 85-4004)*. The report gives a regional, empirical equation for determining Manning's "n" for steep channels in Colorado. Gannett Fleming did not find reference to Jarrett's Method in their initial Arizona hydrologic guidelines data collection effort. After Workshop No. 2, Gannett Fleming reached back out to Arizona who stated that they have seen Jarrett's Method applied in hydraulic routings and being used for the channelized section of the segmental velocity approach to calculating time of concentration.

### 3.2 Antecedent Conditions

Gannett Fleming researched states' published guidelines and reached out to the states initially interviewed to understand what states were assuming for antecedent watershed conditions. The following was found:

- OK, TX, UT – Specify NRCS antecedent runoff condition (ARC) III (saturated conditions).
- ND – Recommends ARC II (normal conditions) or ARC III.
- CA, CO, WA – Require antecedent conditions to be based on region and season taking into consideration the effects of elevation, snowmelt, storm seasonality, etc.
- AZ, MT, NV – Do not require a specific antecedent condition.

## 4.0 Inflow Design Flood Determination

During Workshop No. 2, the project team discussed that both Washington's and Colorado's guidelines have elements that may be able to be applied to New Mexico. For a list of the advantages and disadvantages, as discussed in Workshop No. 2, see Tables 3.11 and 3.12 in the *Workshop No. 2 Summary*. This conversation was continued in Workshop No. 3.

The Dam Safety Bureau indicated that if New Mexico includes risk-informed standards, they will likely still need a prescriptive approach consistent with the federal guidelines (Federal Emergency Management Agency [FEMA] Publication No. P-94) for those stakeholders who are not comfortable applying a risk-informed approach to IDF determination or do not want to spend extra money and effort on complex analyses. This approach of including both prescriptive and risk-informed standards is consistent with FEMA P-94 recommendations.

The Dam Safety Bureau has received complaints from dam owners that the current level of required analysis is too complex. Gannett Fleming indicated that tools developed within the current project may lessen the burden of complex analysis.

The workshop attendees further mentioned that they want to couple the Washington IDF determination guidelines with those of Colorado. The project team likes that Washington's guidelines were developed using risk-informed benchmarks, but the actual use of their guidelines is prescriptive; this simplifies analysis and review and facilitates repeatability. The project team was generally concerned with the repeatability of Colorado's required analysis and their sole basis on and guidance for determining loss of life (LOL); further, Colorado's guidance requires a potential failure modes analysis (PFMA), which the New Mexico Dam Safety Bureau does not have the resources to perform. See Section 8.0: References for Colorado's and Washington's guidance documents.

The group discussed that a potential option for IDF determination could be to adopt FEMA P-94 prescriptive IDF standards (see Table 4.1) but allow for risk-informed methods, similar to Washington's, to be applied to the Significant and High Hazard categories to potentially reduce the IDF.

*Table 4.1: FEMA P-94 Prescriptive IDF guidelines*

| Hazard Classification | Inflow Design Flood |
|---|---|
| High Hazard | probable maximum flood (PMF) event |
| Significant Hazard | 0.1% annual exceedance probability (AEP) event |
| Low Hazard | 1% AEP event |

A discussion followed stating that Washington's approach was originally calibrated to an f-N chart that Washington created based on the guidance available (Johnson). Since, the United States Army Corps of Engineers (USACE) and the United States Bureau of Reclamation (USBR) have published their own standard f-N charts (summarized in FEMA P-1025) that are specific to dam safety and could be used in adapting Washington's IDF approach to New Mexico. The Dam Safety Bureau mentioned that it may be helpful to consult with Mel G. Schaefer, the consultant who originally developed Washington's risk-informed standards.

The workshop attendees further conversed on how to determine population at risk (PAR). Guidance from other state and federal entities such as the USBR ACER-11 guidance or general rules regarding depth-velocity relationships may be considered. The Australia National Committee on Large Dams (ANCOLD) may have publications that are also worth consideration.

## 5.0 Hydrologic Methods

Gannett Fleming presented the soil and terrain data available for use in hydrologic modeling as well as hydrologic loss and transform (UH) methods with their potential advantages, disadvantages and required input parameters. Ultimately, the following methods were decided to be carried forward into the next phase of investigation and/or validation:

**Loss Methods**

- Initial and Constant Loss
- Green and Ampt*
- NRCS CN

  **The Green and Ampt method will not be validated through the modeling efforts in Task 2; however, its advantages, disadvantages, and potential limitations will be documented in Task 2.*

**Transform Methods**

- Clark Unit Hydrograph
- USBR Unit Hydrographs and S-graphs
- NRCS Unit Hydrograph

These methods and the ensuing discussion for each will be summarized in Sections 5.2.1 and 5.3.15.3. Other methods presented, but not recommended for further consideration will also be discussed (Sections 5.2.2 and 5.3.2).

### 5.1 Data Availability

Gannett Fleming presented the USGS soil data available in New Mexico (see Figure 5.1). Data from the State Soil Geographic Database (STATSGO) is available statewide and provides hydrologic modelers with the hydrologic soil group (HSG) of a particular soil map unit. The more detailed, Soil Survey Geographic Database (SSURGO) is available within a majority of the state (see green areas in Figure 5.1); this data would be required to use infiltration models requiring detailed soil information, such as the Green and Ampt Method.

Terrain data availability was also presented (see Figure 5.2). One-third arc-second resolution data are available statewide at a coarse resolution of 10 meters. LiDAR data of 1 meter resolution (or finer) are available in portions of the state (see the dark blue in Figure 5.2), and LiDAR data are expected to be available statewide in the near future. Originally, these data were planned for a 2020 release date but have likely been delayed due to the effects of the COVID-19 pandemic.

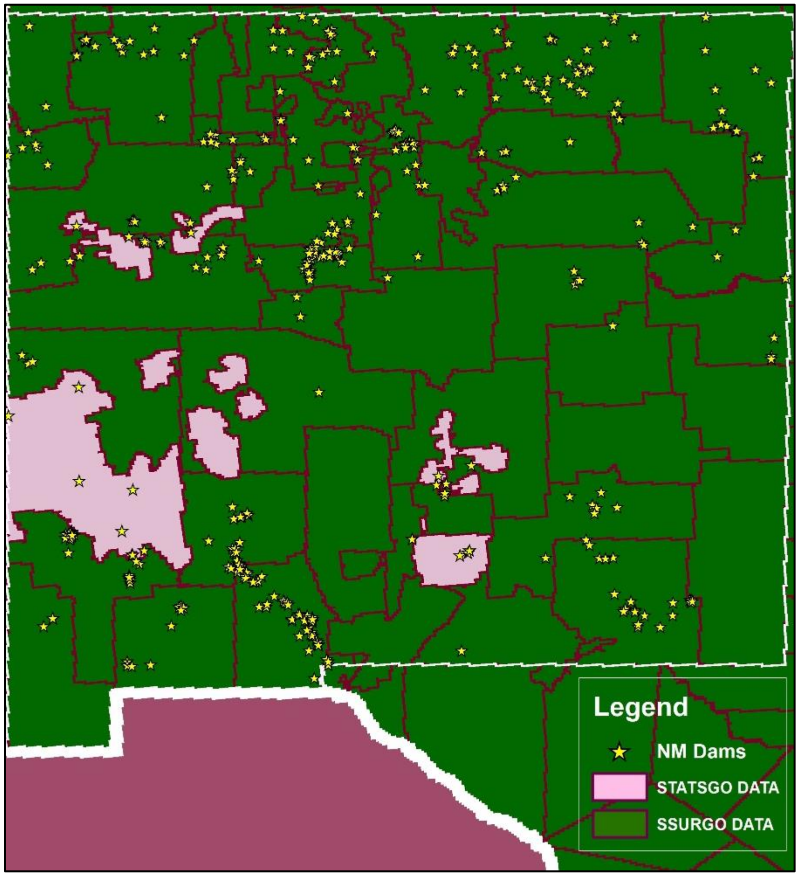


*Figure 5.1: New Mexico USGS Soil Data Availability*

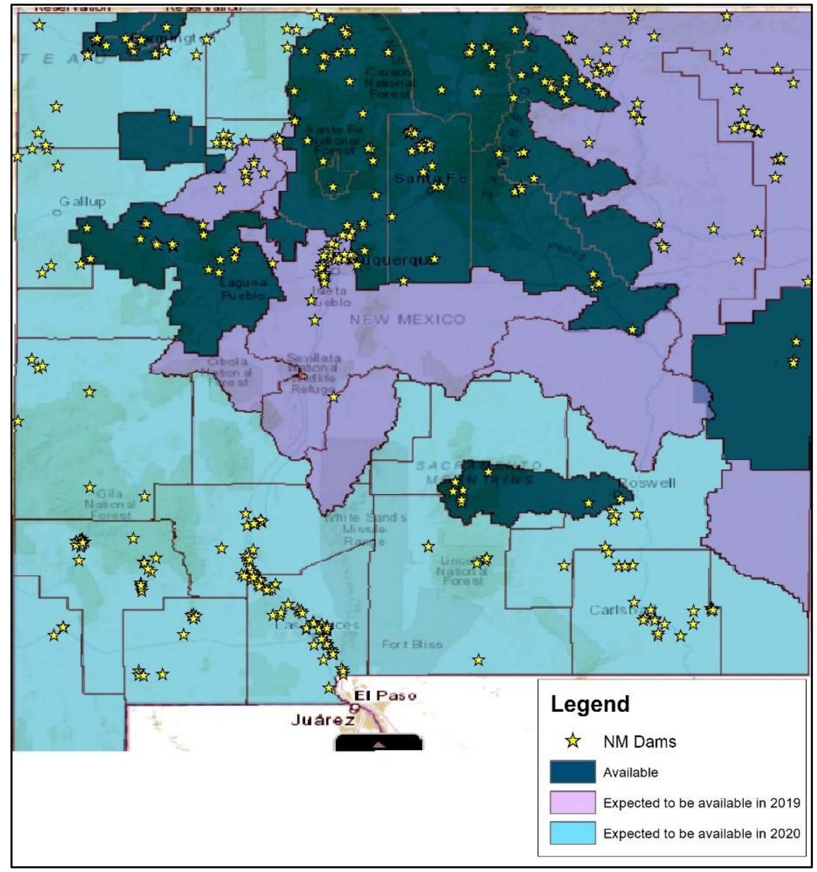


*Figure 5.2: New Mexico LiDAR Data Availability*

## 5.2 Hydrologic Loss Methods

### *5.2.1 Methods to Consider in Task 2*

#### 5.2.1.1 Initial and Constant Loss

**Advantages**

- Physically based
- Simple to use and calibrate (where calibration data is available)
- Applicable to all storm durations

**Disadvantages**

- Infinite sink model
- Not time-based

**Parameters**

- *Initial Loss*: Surface Retention/Initial Abstraction (IA) and Initial Infiltration (II)
- *Constant Loss*: Ultimate infiltration capacity (i.e. saturated hydraulic conductivity)

**Parameter Estimation**

- *Initial Loss*
  - The USACE recommends using 10 to 20 percent of total rainfall for forested areas and 0.1 to 0.2 inches for urban areas (EM1110-2-1417).
  - The Arizona Department of Water Resources (DWR) presents a table based on various land uses and/or land covers (AZ DWR 2007).
  - The Colorado DWR provides a table that bases IA on average basin slope and percent vegetation cover; they also provide a table for II that is based on the constant loss rate and initial soil conditions (dry, normal, saturated) (Tierra Grande 2008).
  - Other methods might include a regional regression equation based on HSG.
- *Constant Loss*
  - This parameter is often related to the NRCS HSGs and minimum, saturated infiltration rates developed by G. W Musgrave (1955) as presented in the United States Department of Agriculture (USDA) *Yearbook of Agriculture 1955*. These values are presented in Table 5.1. These data are referenced in guidelines by FERC (2001), USBR (1987), USACE Hydrologic Engineering Center (HEC), Texas Dam Safety (2007), and Arizona DWR (2007) indicating general use among the industry.

After discussing the data presented in Table 5.1, the Dam Safety Bureau asked if it is appropriate to assume saturated conditions for short duration, high intensity rainfall events, such as a 2-hour probable maximum precipitation (PMP) event. Gannett Fleming responded by stating that during high intensity storms, such as a 2-hour PMP event, infiltration rates can often be insignificant compared to the rate of rainfall and that modelers should err on the side of conservatism to account for the uncertainty that comes with these low frequency storm events.

The group also discussed the need for sensitivity analyses. Such analyses allow modelers to understand which parameters have the greatest effect on the peak inflow and flood volume; greater attention can then be given to the parameters the model is more sensitive towards.

*Table 5.1: Minimum Infiltration Rates for Hydrologic Soil Groups (Musgrave 1955)*

| Hydrologic Soil Group | Minimum Infiltration Rates (inches/hour) | Soil Description |
|---|---|---|
| A | 0.30 to 0.45 | Deep sand, deep loess, aggregated silts |
| B | 0.15 to 0.30 | Shallow loess, sandy loam |
| C | 0.05 to 0.15 | Clay loams, shallow loam, soils low in organic content, soils usually high in clay |
| D | 0 to 0.05 | Soils that swell significantly when wet, heavy plastic clays, certain saline soils |

The Dam Safety Bureau also expressed concerns about the Musgrave (1955) rates deviating from the rates presented in the USGS web soil survey database. The group agreed that further study is warranted and that the work of Task 2 and the regional peak flow envelop curve will help determine which rates are applicable.

#### 5.2.1.2 Green and Ampt

**Advantages**

- Physically based model
- Parameters can be obtained through the USGS SSURGO database
- Time based model

**Disadvantages**

- Infinite sink model
- Complexity
- Data intensive requiring detailed soil characteristics
- Data may not be available statewide

**Parameters**

- *Initial Water Content or Initial Deficit*
- *Soil Porosity* (saturated water content)
- *Wetting Front Suction Head*
- *Hydraulic Conductivity* (θ or $K_{sat}$)
- Each of the above-mentioned parameters can be estimated from Table 5.2 originally developed by Rawls, et al. (1982). Soil texture class can be obtained from the USGS SSURGO Database.

The Dam Safety Bureau has concerns regarding the complexity of the Green and Ampt Method; such complexity makes it difficult to correctly apply and adequately review. Concerns were specifically expressed regarding layered soils. Layered soils can greatly increase the level of complexity and introduce room for error.

*Table 5.2: Texture class soil parameter estimates (Rawls, et al., 1982)*

| Texture Class | Porosity, $\phi$ ($cm^3$/cm) | Hydraulic conductivity, $\theta$, saturated (cm/hr) | Wetting front suction (cm) |
|---|---|---|---|
| Sand | 0.437 | 21.00 | 10.6 |
| Loamy sand | 0.437 | 6.11 | 14.2 |
| Sandy loam | 0.453 | 2.59 | 22.2 |
| Loam | 0.463 | 1.32 | 31.5 |
| Silt loam | 0.501 | 0.68 | 40.4 |
| Sandy clay loam | 0.398 | 0.43 | 44.9 |
| Clay loam | 0.464 | 0.23 | 44.6 |
| Silty clay loam | 0.471 | 0.15 | 58.1 |
| Sandy clay | 0.430 | 0.12 | 63.6 |
| Silty clay | 0.479 | 0.09 | 64.7 |
| Clay | 0.475 | 0.06 | 71.4 |

It was also discussed that Colorado's 2008 hydrologic guidelines (Tierra Grande 2008) only recommend the Green and Ampt Method for storms more frequent (less severe) than the 1% AEP event. The Initial and Constant Loss Method is recommended for less frequent events. This is likely because during more extreme events, watersheds are often saturated, and the initial moisture deficit approaches zero and becomes insignificant. Therefore, losses are directly related to the constant loss rate (saturated hydraulic conductivity), which the simpler, Initial and Constant Loss Method approximates well.

Ultimately the Dam Safety Bureau would like to better understand and document the limitations of the Green and Ampt Method. This documentation will occur in Task 2.

5.2.1.3 NRCS Curve Number

**Advantages**

- Ease of use and repeatability
- Widespread use in dam safety industry
- Generally conservative

**Disadvantages**

- Not time based (time independent)
- Not physically based

**Parameters**

- *Initial abstraction*
- *HSG*
- *Landcover*
- *ARC*

The Project team agreed that while there may be misgivings with the CN method, due to its simplicity and widespread use it will be studied in Task 2. This method's limitations will also be documented.

### *5.2.2 Methods not Considered for Task 2*

#### 5.2.2.1 <u>Soil Moisture Accounting (SMA)</u>

**Advantages**

- Allows for long-term continuous simulation
- Can estimate evapotranspiration (ET), surface runoff, and groundwater flow

**Disadvantages**

- Many parameters that typically require calibration
- Not recommended for event simulation by USACE HEC

**Parameters**

- Eleven parameters to estimate canopy interception, surface depression, evapotranspiration, infiltration rate, soil profile storage, percolation rate, groundwater flow, etc.

Currently Colorado Dam Safety jointly with Colorado State University is studying the SMA method and plans to implement it in future dam safety hydrologic guidelines. The project team agreed that this is likely not feasible for New Mexico. However, Colorado's developments will be closely followed for potential consideration in the future.

#### 5.2.2.2 <u>Horton</u>

**Advantages**

- Relatively easy parameter estimation process
- Physically based (reflects Darcy's Law)

**Disadvantages**

- Considers only surface conditions
- Assumes that hydraulic conductivity is independent of soil moisture content
- Not included in HEC-HMS

**Parameters**

- *Ultimate infiltration rate*
- *Initial rate of infiltration capacity*
- *Decay factor*

5.2.2.3 Holtan

**Advantages**

- Accounts for antecedent moisture conditions
- Uses a conceptual soil storage element

**Disadvantages**

- Many parameters required
- Moisture depletion occurs at a constant rate
- Not time based
- Not included in HEC-HMS

**Parameters**

- *Potential infiltration rate*
- *Growth index:* represents relative maturity of the ground
- *Factor A:* an index related to the cover crop and the soil texture
- *Soil storage capacity*
- *Empirical exponent*

5.2.2.4 Exponential

**Advantages**

- Allows for calibration to observed data

**Disadvantages**

- Requires parameter calibration, not very applicable to ungaged watersheds
- Not widely used or studied

**Parameters**

- *Initial Range*
- *Initial Coefficient*
- *Coefficient Ratio*
- *Exponent*

## 5.3 Hydrologic Transform Methods

### *5.3.1 Methods to Consider in Task 2*

5.3.1.1 Clark

**Advantages**

- Simple to use and calibrate to gaged watersheds
- Considers the effects of basin shape, slope, and roughness on travel time.
- Accounts for watershed storage and attenuation

**Disadvantages**

- Not physically based.
- Storage Coefficient, *R,* typically requires regional regression to estimate.

**Parameters**

- Time of Concentration, $T_c$
- Storage Coefficient, $R$
  - Several regression-based, empirical equations used to estimate $T_c$ and $R$ in other states were presented. Both the hydrologic guidelines form Arizona DWR (2007) and Colorado DWR (Tierra Grande 2008) recommend the same regression equations, which will be investigated in Task 2.
- Time-Area Relationship
  - Similar to $T_c$ and $R$, AZ (2007) and CO DWR (Tierra Grande 2008) recommend three time-area relationships: Urban, HEC-1/HMS Default, Mountains/Plains.
  - This relationship can also be estimated using GIS and Manning's Equation.

An example of regression analysis for Clark UH parameter estimation is presented in USGS WSP-2420. The USGS performed a hydrologic analysis on 26 gaged storm events in Montana to determine regression equations for the parameters for both the Clark UH and Snyder UH methods. Nine of the 26 events had a return interval of the 50-year flood or less; the remaining 17 events were equal to or exceeded the 100-year flood (USGS WSP-2420). The Montana Dam Safety Program prefers hydrologic modelers to use the Clark UH with the regression equations for $T_c$ and $R$ developed in WSP-2420 (DOWL 2019).

Similar to Montana and other states, New Mexico may consider developing regression equations for the Clark UH method as part of a future study. The work in Task 2 may help determine whether this is possible with the gage data available in New Mexico.

The Clark UH method has not generally been used in New Mexico dam hydrologic models in the past; however, it will be considered further. If it is incorporated into the updated guidelines detailed instructions for parameter estimation will also be included.

#### 5.3.1.2 USBR Flood Hydrology Manual

**Advantages**

- Based on Snyder's Standard Lag.
- Accounts for watershed hydraulic characteristics.
- Predefined unit hydrographs based on region and watershed characteristics.
- Developed for the western United States.

**Disadvantages**

- Not included in HEC-HMS.
- $K_n$ can be difficult to estimate.

**Parameters**

- Lag Time, $L_g$, based on the following equation: $L_g=26\ K_n(L\ L_{ca}/S^{0.5})^{0.33}$ (Cudworth 1989)
  - Where $K_n$ is the average Manning's $n$ value representing the resistance of a basin's drainage network.

The Dam Safety Bureau stated that engineers typically use standard values for $K_n$ based on the charts contained in the USBR Flood Hydrology Manual (Cudworth 1989). It is not typical to see engineers make physical comparisons between the study watershed and the watersheds used in the original UH development. It was also discussed that $K_n$ can vary with storm intensity. During Task 2, this method will be considered and guidance for $K_n$ estimates will be further investigated.

#### 5.3.1.3 NRCS

**Advantages**

- Ease of use
- Widespread use in dam safety industry
- Generally conservative

**Disadvantages**

- May be overly conservative.
- Typically used as a one-parameter method that may be tend to difficult calibration for gaged watersheds.

**Parameters**

- Time of Concentration, $T_c$.
  - Typically estimated using the NRCS standard lag equation or the segmental velocity approach as outlined in the NRCS *National Engineering Handbook* (NEH).
- Peak Rate Factor (typically estimated as 484).
  - The peak rate factor may be varied to calibrate the UH to observed or regional data. Potential adjustments to the peak rate factor that may be applicable to New Mexico will be investigated in Task 2.

### *5.3.2 Methods not Considered for Task 2*

#### 5.3.2.1 Snyder

**Advantages**

- Simple and easy to calibrate to gaged watersheds.

**Disadvantages**

- The Peaking Coefficient, $C_p$, can be difficult to estimate for ungaged watersheds. No regression equations were found in Gannett Fleming's data collection effort.
- Not physically based.

**Parameters**

- Standard Lag, $t_p$
- Peaking Coefficient, $C_p$

## 5.4 Temporal Distributions

CO-NM REPS presents 12 synthetic temporal distributions for the precipitation frequency (PF) storms and eight for the PMP. These distributions are physically based and represent statistically averaged values. The Dam Safety Bureau expressed concerns about the level of confidence they have in using the CO-NM REPS distributions; they have also seen two- and three-fold differences between critically stacked distributions and the CO-NM REPS distributions. One potential method could be to recommend a critically stacked distribution unless further justification of the CO-NM REPS average values can be provided.

Gannett Fleming indicated that the PA Dam Safety Program also struggled with this decision after performing their statewide PMP study and decided to use the distribution of the controlling historical storm. Gannett Fleming will reach out to the PA Dam Safety Program to further understand the process involved in making this decision.

## 5.5 Validation Data

### *5.5.1 Regional Peak Flow Envelope Curve*

Gannett Fleming presented historical studies undertaken to develop regional peak flow envelopes. The historical events occurring in New Mexico will be included in the envelope curves that will be developed for the Dam Safety Bureau; the applicable empirical equations developed will also be included. Gannett Fleming has also started compiling and organizing peak flow stream gage data in New Mexico. The gage data will be coupled with the historical data and USGS peak flow regression equations to develop peak flow envelope curves like those used by the Colorado Dam Safety Branch.

The Dam Safety Bureau mentioned historical USGS, USBR, and USACE curves in their possession that could be included in this effort; these will be scanned and provided to Gannett Fleming. Further, Gannett Fleming will contact John England at the USACE to discuss paleohydrology and potential data he may have that could be included in the envelope curves.

### *5.5.2 Hydrologic Method Validation*

The gage data collected to develop the regional peak flow envelope curves will also be used to validate hydrologic models. Peak flow gage data will be collected and analyzed and, in conjunction with Applied Weather Associates, historical gaged storms that are relatively infrequent (i.e. 2% to 0.2% AEP, depending on data availability) will be modeled using the methods outlined in Section 5.0.

# 6.0 Scope of Work for Task 2 and 3

The remaining project schedule was presented, which included the schedule for Tasks 2 and 3. A draft of the scope of work for Task 2 was also presented and will be updated based on the discussion had during the workshop. The updated scope of work will be provided in a separate, official document.

The Dam Safety Bureau indicated that there may be benefit in removing the formal separation of Task 2 and Task 3 and merging them into one final task. The group agreed this would be the most efficient path forward but that an interim deliverable should still be made to document the study and decision-making process for the updated guidelines.

While discussing the proposed scope for determining and validating hydrologic methods, the Dam Safety Bureau asked if it would be possible to assess more than the initial, proposed five gaged historical storm events. Gannett Fleming will consider staff availability and whether more budget could allow for more analysis in the same timeframe. The Dam Safety Bureau also asked Gannett Fleming to provide the required level of effort to update New Mexico's hazard classification guidance.

The Dam Safety Bureau agreed that updates to their IDF determination regulations will be based on the Washington Dam Safety Bureau's framework. Gannett Fleming will also attempt to incorporate the prescriptive FEMA federal guidelines (FEMA P-94), allowing for the risk-informed approach (based on Washington's framework) to be optional.

Gannett Fleming will also provide a progress update to stakeholders in April, prior to the New Mexico Dam Owners Coalition Conference in May. However, stakeholder review and commenting will likely occur after the June 30th project deadline. A training webinar will be included as a deliverable and may be prerecorded. Areas for potential future study will also be identified.

## 7.0 Schedule

In the coming weeks, Gannett Fleming will prepare the Task 1 Report and Scope of Work for Tasks 2 and 3. There is remaining effort in the Task 1 budget; therefore, Gannett Fleming will continue to charge to the Task 1 budget during Task 2 until it is exhausted.

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