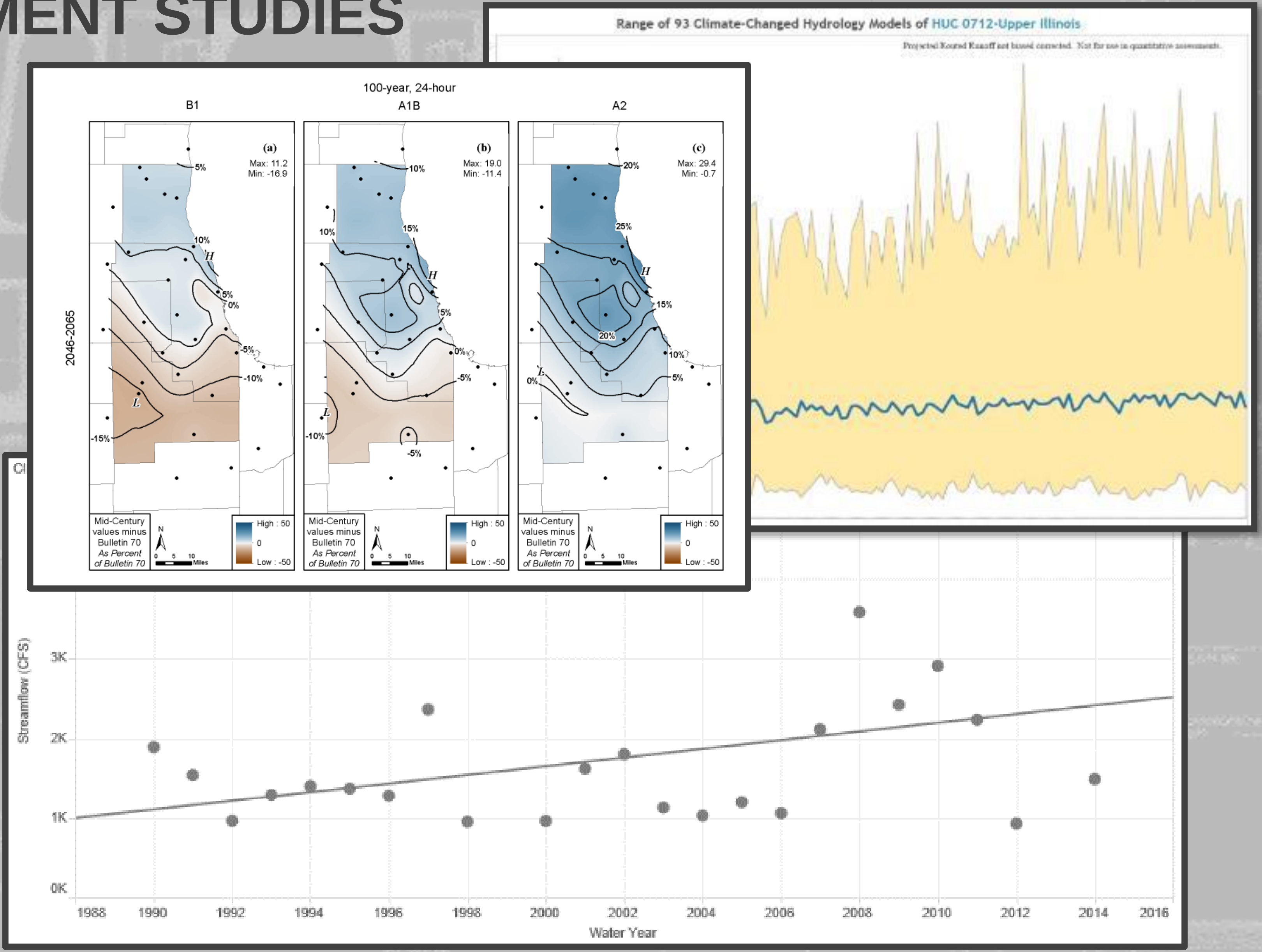
INCORPORATING PRECIPITATION TRENDS INTO FLOOD RISK MANAGEMENT STUDIES



USACE Chicago District

Erin Maloney, PE

Planner, Hydraulic Engineer

Kristine Meyer, PE, CFM

Hydraulic Engineer

IAFSM Conference

March 15, 2018

“The views, opinions and findings contained in this report are those of the authors(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation.”

U.S.ARMY

US Army Corps of Engineers ®

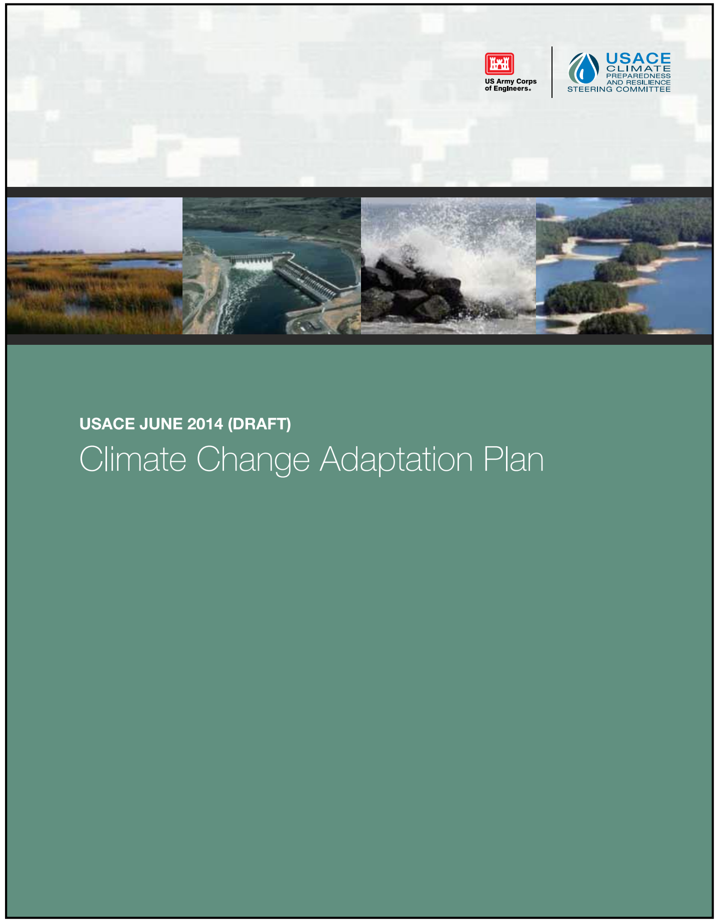
AGENDA

- USACE Policy & Guidance *(Erin)*
- USACE Public Tools (Kristine)
- Application of ISWS precipitation data to economic analysis in Feasibility Studies *(Erin)*

USACE CLIMATE PREPAREDNESS AND RESILENCE

USACE POLICY & GUIDANCE

USACE CLIMATE CHANGE ADAPTATION POLICY, AND CLIMATE ADAPTATION PLAN AND REPORT (2014)

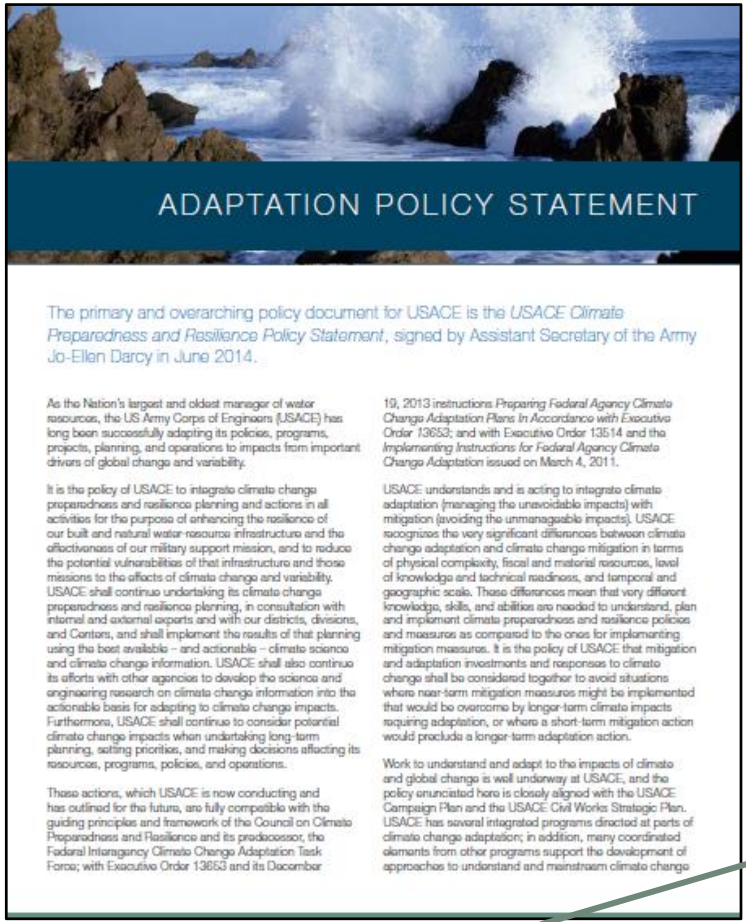


US Army Corps of Engineers.

USACE CLIMATE PREPAREDNESS AND RESILIENCE STEERING COMMITTEE

USACE JUNE 2014 (DRAFT)

Climate Change Adaptation Plan



ADAPTATION POLICY STATEMENT

The primary and overarching policy document for USACE is the *USACE Climate Preparedness and Resilience Policy Statement*, signed by Assistant Secretary of the Army Jo-Ellen Darcy in June 2014.

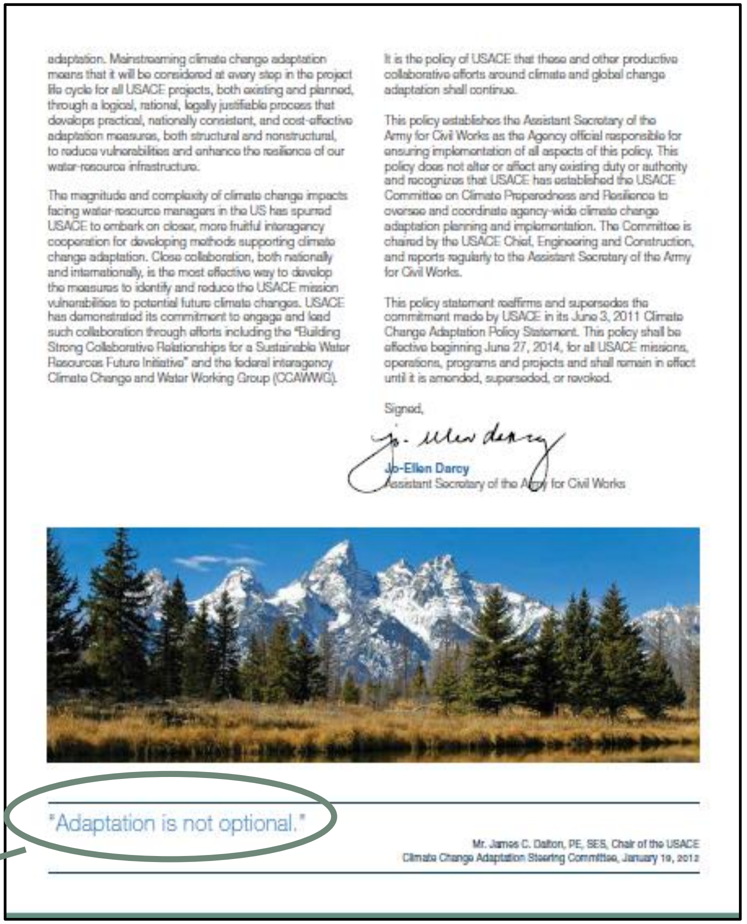
As the Nation's largest and oldest manager of water resources, the US Army Corps of Engineers (USACE) has long been successfully adapting its policies, programs, projects, planning, and operations to impacts from important drivers of global change and variability.

It is the policy of USACE to integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure and the effectiveness of our military support mission, and to reduce the potential vulnerabilities of that infrastructure and those missions to the effects of climate change and variability. USACE shall continue undertaking its climate change preparedness and resilience planning, in consultation with internal and external experts and with our districts, divisions, and Centers, and shall implement the results of that planning using the best available – and actionable – climate science and climate change information. USACE shall also continue its efforts with other agencies to develop the science and engineering research on climate change information into the actionable basis for adapting to climate change impacts. Furthermore, USACE shall continue to consider potential climate change impacts when undertaking long-term planning, setting priorities, and making decisions affecting its resources, programs, policies, and operations.

These actions, which USACE is now conducting and has outlined for the future, are fully compatible with the guiding principles and framework of the Council on Climate Preparedness and Resilience and its predecessor, the Federal Interagency Climate Change Adaptation Task Force; with Executive Order 13653 and its December 19, 2013 instructions *Preparing Federal Agency Climate Change Adaptation Plans In Accordance with Executive Order 13653*; and with Executive Order 13514 and the *Implementing Instructions for Federal Agency Climate Change Adaptation* issued on March 4, 2011.

USACE understands and is acting to integrate climate adaptation (managing the unavoidable impacts) with mitigation (avoiding the unmanageable impacts). USACE recognizes the very significant differences between climate change adaptation and climate change mitigation in terms of physical complexity, fiscal and material resources, level of knowledge and technical readiness, and temporal and geographic scale. These differences mean that very different knowledge, skills, and abilities are needed to understand, plan and implement climate preparedness and resilience policies and measures as compared to the ones for implementing mitigation measures. It is the policy of USACE that mitigation and adaptation investments and responses to climate change shall be considered together to avoid situations where near-term mitigation measures might be implemented that would be overcome by longer-term climate impacts requiring adaptation, or where a short-term mitigation action would preclude a longer-term adaptation action.

Work to understand and adapt to the impacts of climate and global change is well underway at USACE, and the policy enunciated here is closely aligned with the USACE Campaign Plan and the USACE Civil Works Strategic Plan. USACE has several integrated programs directed at parts of climate change adaptation; in addition, many coordinated elements from other programs support the development of approaches to understand and mainstream climate change



adaptation. Mainstreaming climate change adaptation means that it will be considered at every step in the project life cycle for all USACE projects, both existing and planned, through a logical, rational, legally justifiable process that develops practical, nationally consistent, and cost-effective adaptation measures, both structural and nonstructural, to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure.

The magnitude and complexity of climate change impacts facing water-resource managers in the US has spurred USACE to embark on closer, more fruitful interagency cooperation for developing methods supporting climate change adaptation. Close collaboration, both nationally and internationally, is the most effective way to develop the measures to identify and reduce the USACE mission vulnerabilities to potential future climate changes. USACE has demonstrated its commitment to engage and lead such collaboration through efforts including the "Building Strong Collaborative Relationships for a Sustainable Water Resources Future Initiative" and the federal interagency Climate Change and Water Working Group (CCAWWG).

It is the policy of USACE that these and other productive collaborative efforts around climate and global change adaptation shall continue.

This policy establishes the Assistant Secretary of the Army for Civil Works as the Agency official responsible for ensuring implementation of all aspects of this policy. This policy does not alter or affect any existing duty or authority and recognizes that USACE has established the USACE Committee on Climate Preparedness and Resilience to oversee and coordinate agency-wide climate change adaptation planning and implementation. The Committee is chaired by the USACE Chief, Engineering and Construction, and reports regularly to the Assistant Secretary of the Army for Civil Works.

This policy statement reaffirms and supersedes the commitment made by USACE in its June 3, 2011 Climate Change Adaptation Policy Statement. This policy shall be effective beginning June 27, 2014, for all USACE missions, operations, programs and projects and shall remain in effect until it is amended, superseded, or revoked.

Signed,

Jo-Ellen Darcy
Assistant Secretary of the Army for Civil Works

"Adaptation is not optional."

Mr. James C. Dalton, PE, SES, Chair of the USACE Climate Change Adaptation Steering Committee, January 19, 2012

"Adaptation is not optional."

Mr. James C. Dalton, PE, SES, Chair of the USACE Climate Change Adaptation Steering Committee, January 19, 2012

http://corpsclimate.us

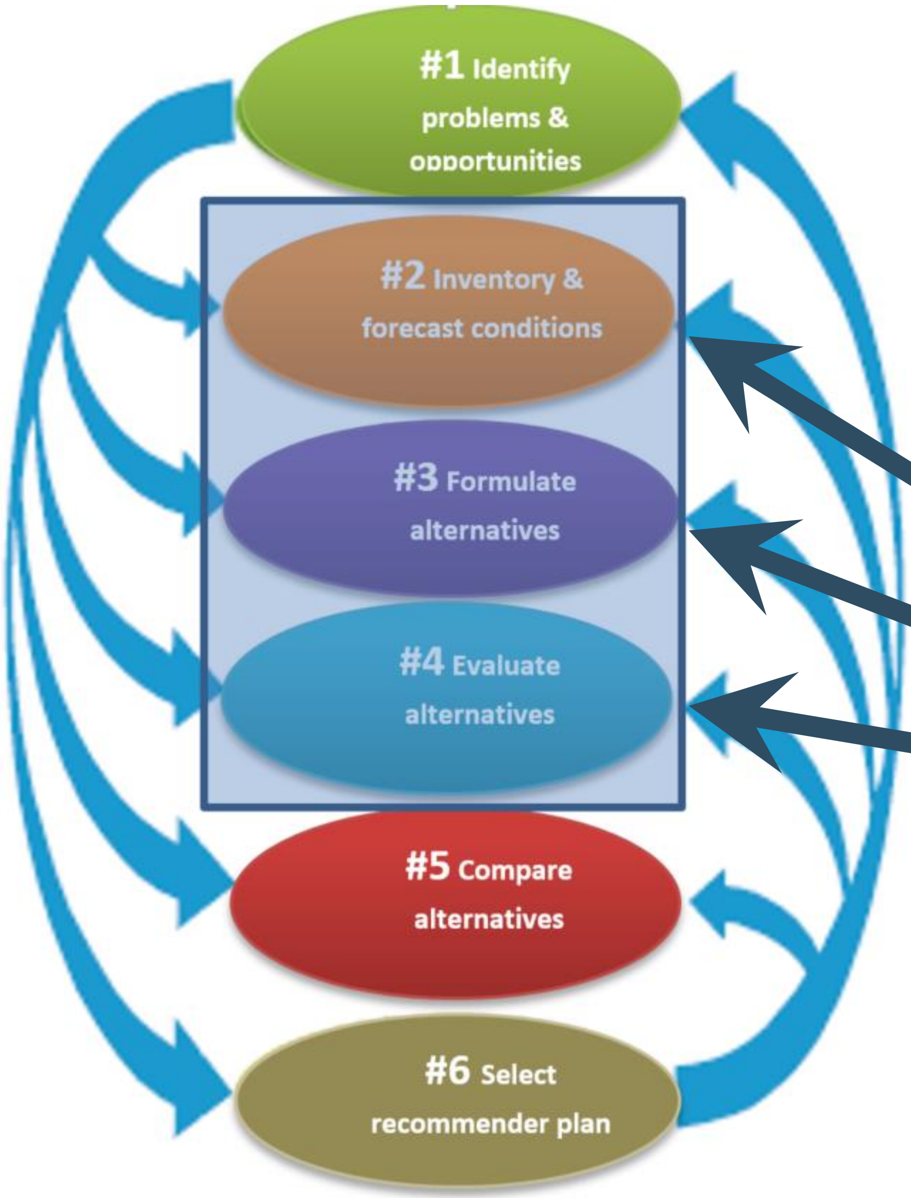
USACE CLIMATE CHANGE ADAPTATION POLICY, AND CLIMATE ADAPTATION PLAN AND REPORT (2014)

“ It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency’s missions, operations, programs, and projects.”

“… using the best available – and actionable – climate science and climate change information.”

“… it shall be considered at every step in the project life cycle for all USACE projects, both existing and planned, … to *reduce vulnerabilities and enhance the resilience of our water-resource infrastructure.*”

USACE FEASIBILITY PLANNING PROCESS



"Formulation and evaluation of alternative plans should be based on the most likely conditions expected to exist in the future with and without the plan."

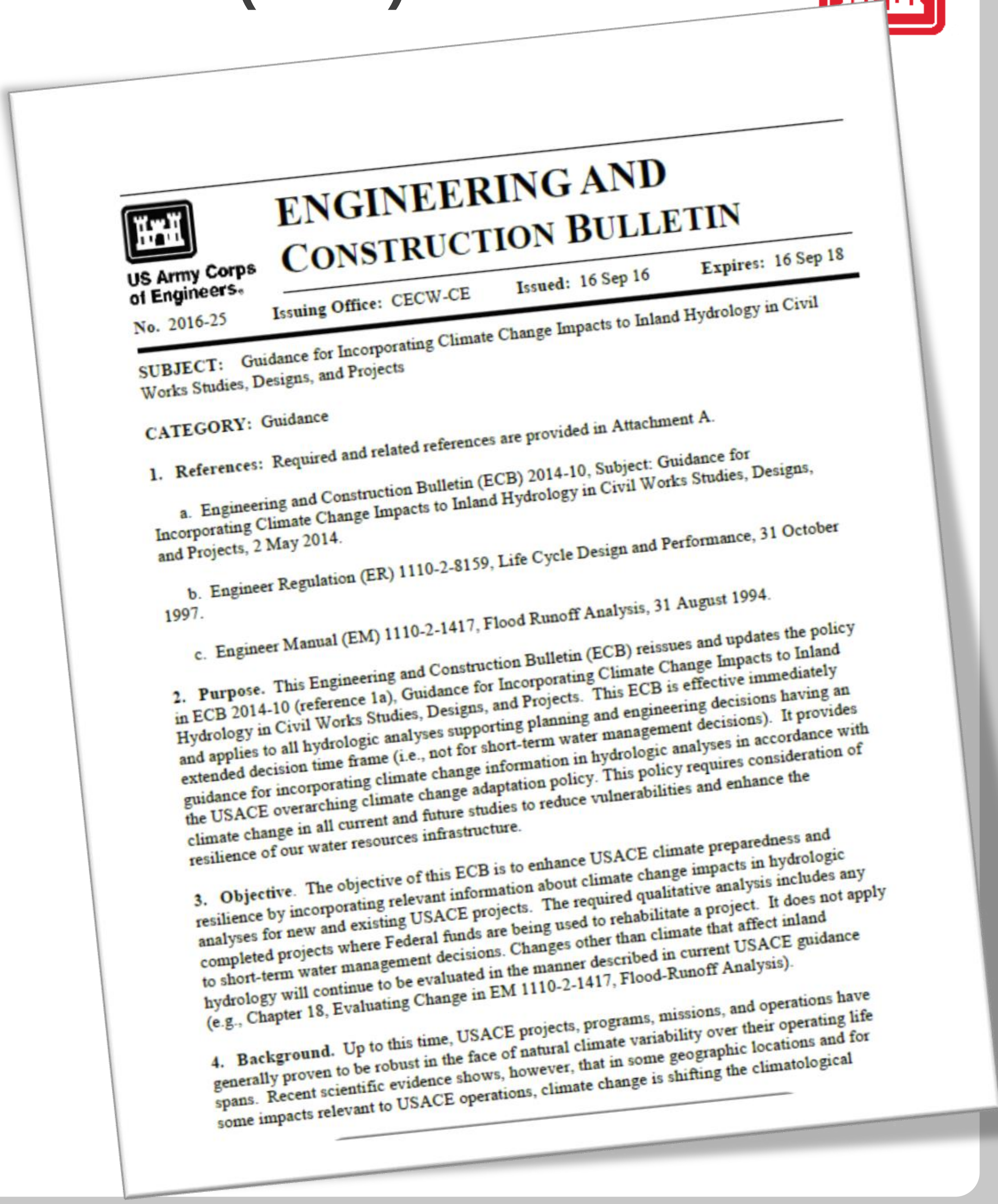
Principles and Guidance - Water Resources Council

Climate Preparedness and Resilience assessments should be focused on steps 2, 3, and 4

POLICY ON INCORPORATING CLIMATE CHANGE (2016)

Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects (ECB 2016-25)

- Requires consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of our water resources infrastructure
- Only a qualitative analysis required
  - Consideration of both past (observed) changes in climate trends as well as potential future (projected) changes to relevant hydrologic inputs
  - Can inform the decision process
- Does not prevent the performance of a quantitative analysis in the future



US Army Corps of Engineers.

ENGINEERING AND CONSTRUCTION BULLETIN

No. 2016-25 Issuing Office: CECW-CE Issued: 16 Sep 16 Expires: 16 Sep 18

SUBJECT: Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects

CATEGORY: Guidance

1. References: Required and related references are provided in Attachment A.

a. Engineering and Construction Bulletin (ECB) 2014-10, Subject: Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, 2 May 2014.

b. Engineer Regulation (ER) 1110-2-8159, Life Cycle Design and Performance, 31 October 1997.

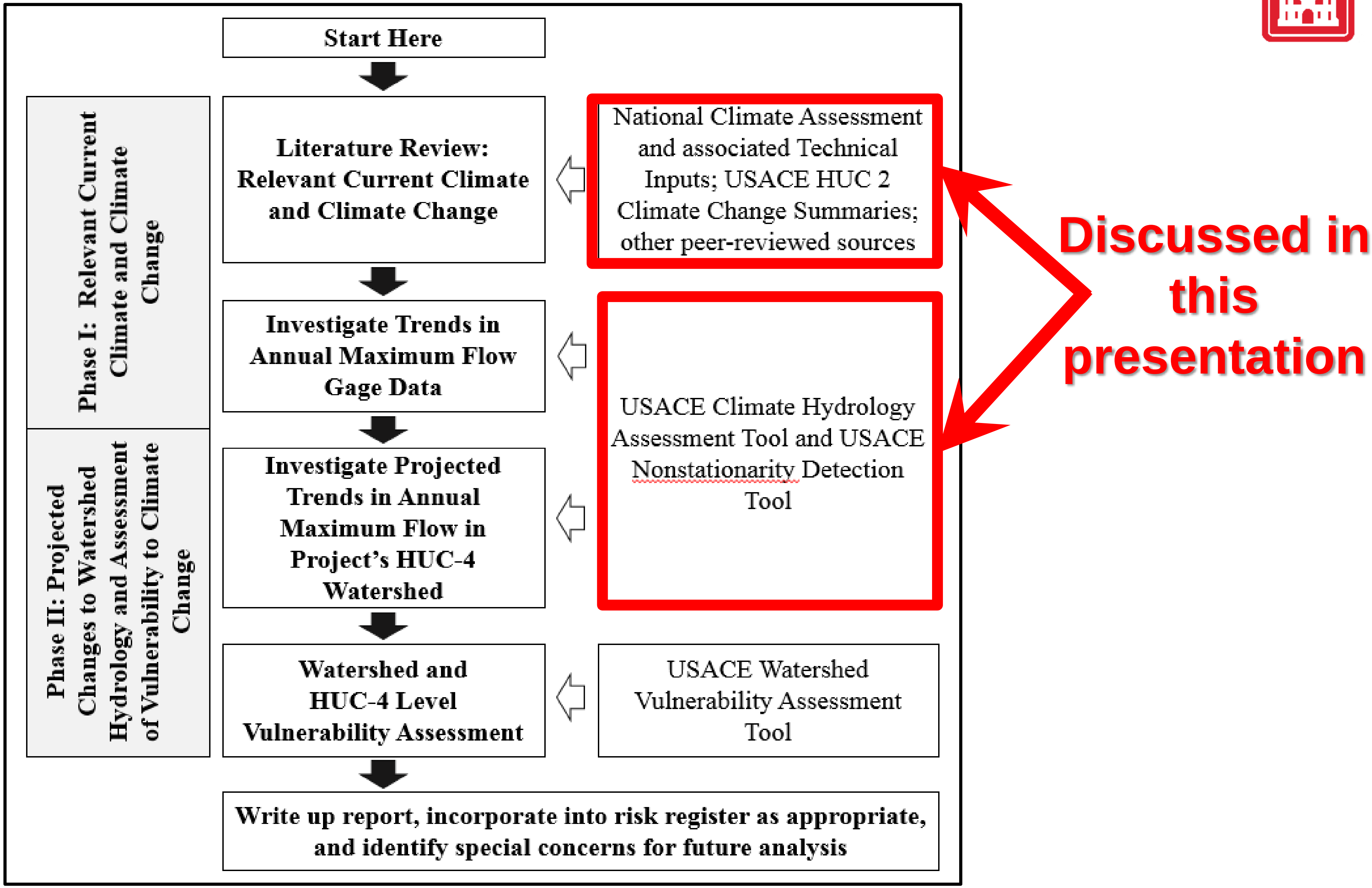
c. Engineer Manual (EM) 1110-2-1417, Flood Runoff Analysis, 31 August 1994.

2. Purpose. This Engineering and Construction Bulletin (ECB) reissues and updates the policy in ECB 2014-10 (reference 1a), Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects. This ECB is effective immediately and applies to all hydrologic analyses supporting planning and engineering decisions having an extended decision time frame (i.e., not for short-term water management decisions). It provides guidance for incorporating climate change information in hydrologic analyses in accordance with the USACE overarching climate change adaptation policy. This policy requires consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of our water resources infrastructure.

3. Objective. The objective of this ECB is to enhance USACE climate preparedness and resilience by incorporating relevant information about climate change impacts in hydrologic analyses for new and existing USACE projects. The required qualitative analysis includes any completed projects where Federal funds are being used to rehabilitate a project. It does not apply to short-term water management decisions. Changes other than climate that affect inland hydrology will continue to be evaluated in the manner described in current USACE guidance (e.g., Chapter 18, Evaluating Change in EM 1110-2-1417, Flood-Runoff Analysis).

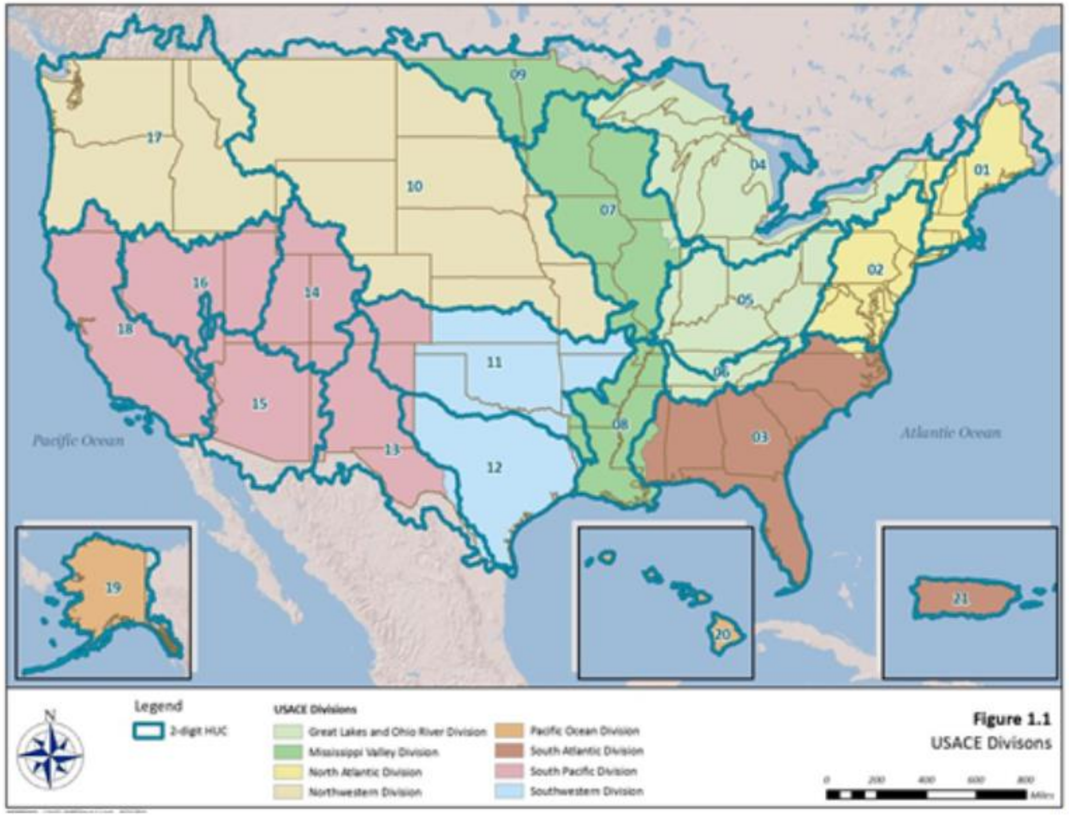
4. Background. Up to this time, USACE projects, programs, missions, and operations have generally proven to be robust in the face of natural climate variability over their operating life spans. Recent scientific evidence shows, however, that in some geographic locations and for some impacts relevant to USACE operations, climate change is shifting the climatological

THE ECB 2016-25 ANALYSIS FRAMEWORK



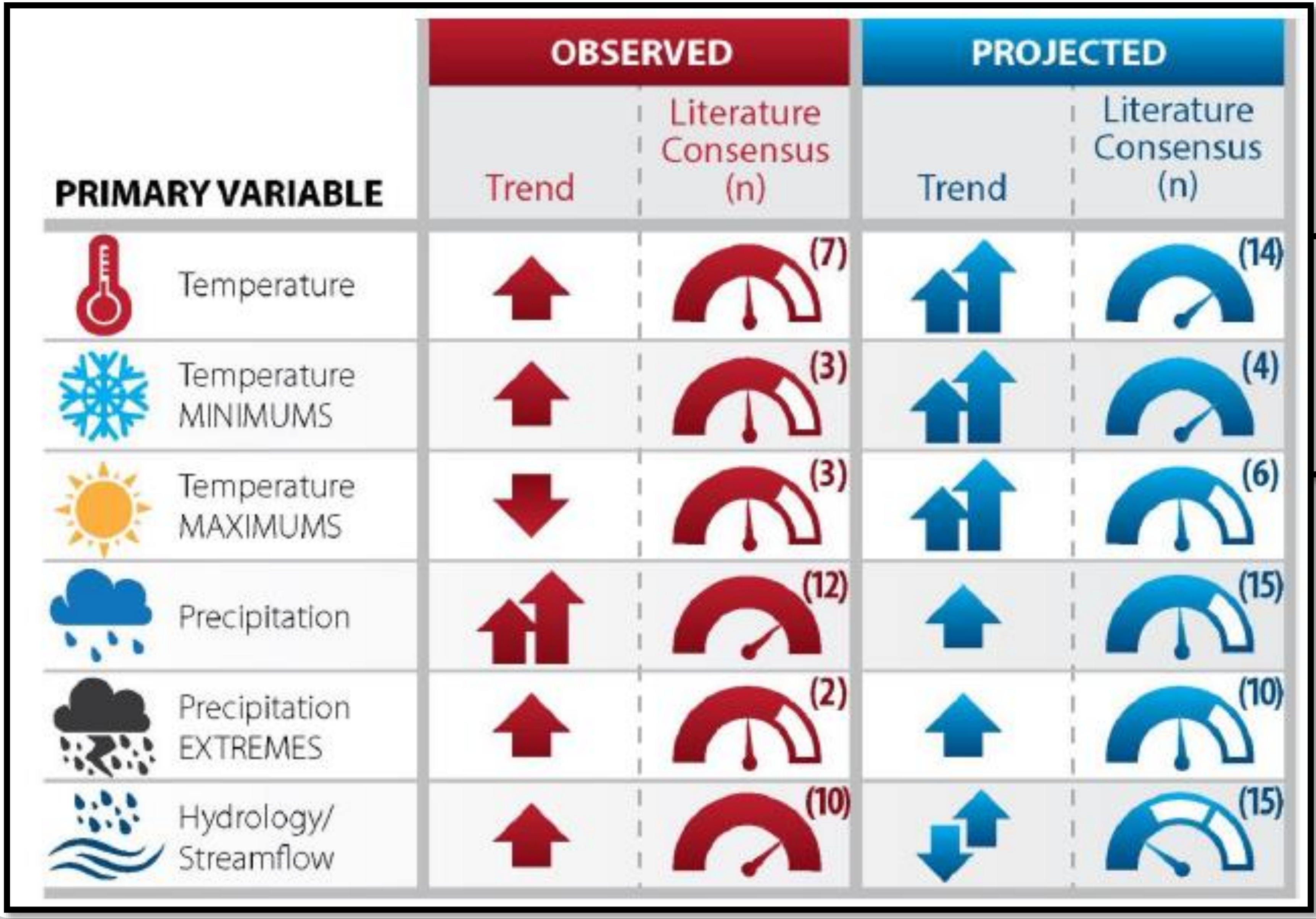
REGIONAL CLIMATE CHANGE AND HYDROLOGY LITERATURE SYNTHESES

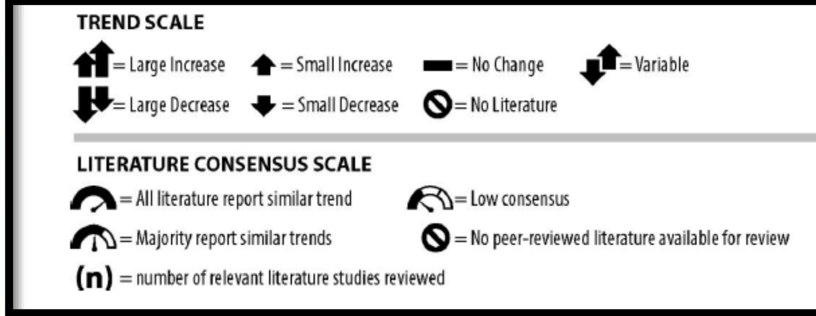
- USACE had developed 21 regional climate syntheses at the scale of 2-digit USGS Hydrologic Unit Codes (HUC)
- Summarizes observed and projected climate and hydrological patterns cited in reputable peer-reviewed literature
- Summary of USACE business line vulnerabilities



http://www.corpsclimate.us/rccciareport.cfm

REGIONAL CLIMATE CHANGE AND HYDROLOGY LITERATURE SYNTHESES

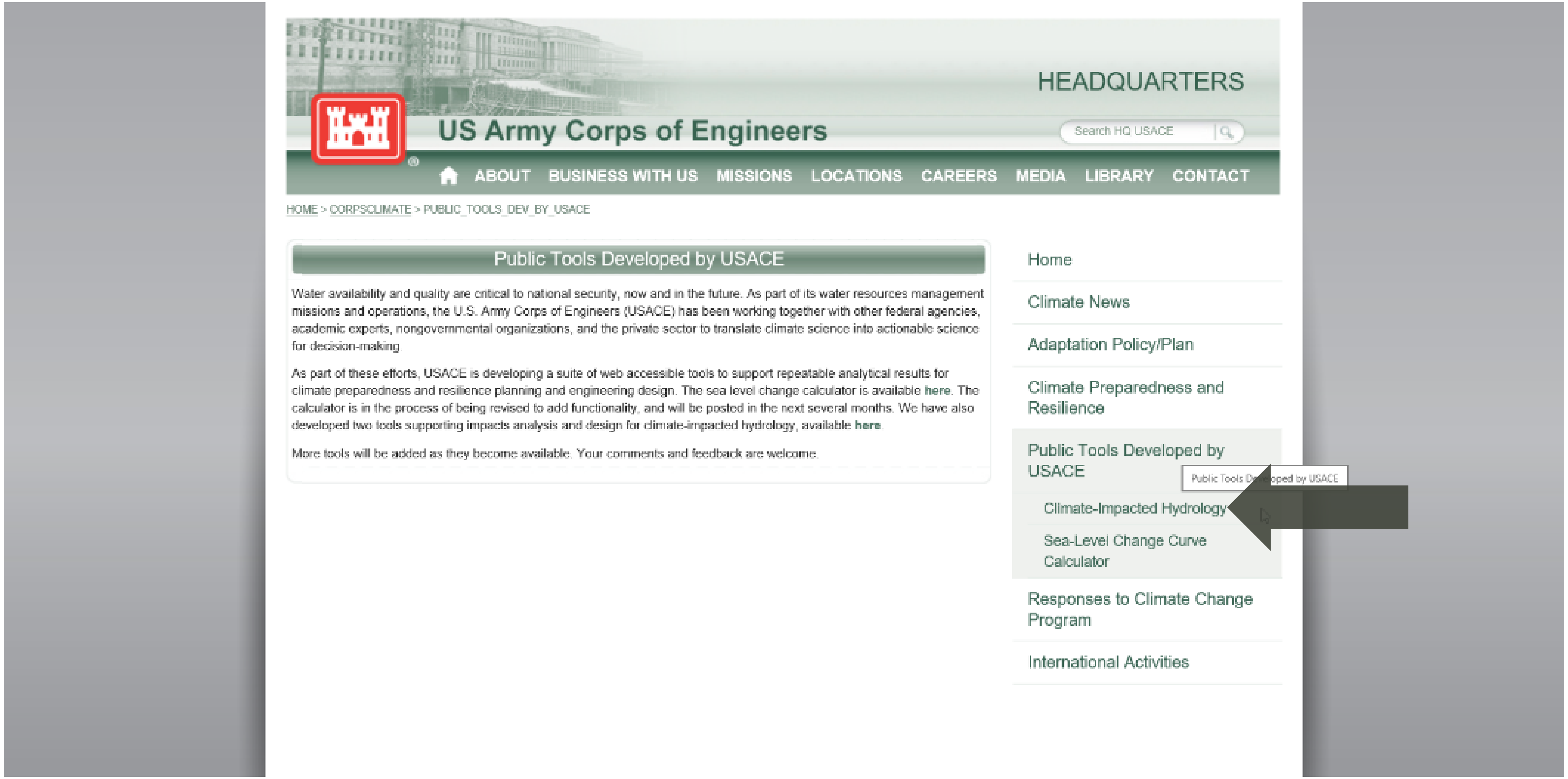




USACE PUBLIC TOOLS

Nonstationarity Detection Tool
Climate Hydrology Assessment Tool

USACE PUBLIC TOOLS



www.usace.army.mil/corpsclimate/Public_Tools_Dev_by_USACE.aspx

USACE PUBLIC TOOLS

guidance for hydrology used in climate change impact assessments and adaptation planning and design.

Nonstationarity Detection Tool

Stationarity, or the assumption that the statistical characteristics of hydrologic time series data are constant through time, enables the use of well-accepted statistical methods in water resources planning and design in which future conditions rely primarily on the observed record. However, recent scientific evidence shows that—in some places, and for some impacts relevant to the operations of the U.S. Army Corps of Engineers (USACE)—climate change and human modifications of the watersheds are undermining this fundamental assumption, resulting in nonstationarity.

The Detection Tool enables the user to apply a series of statistical tests to assess the stationarity of annual instantaneous peak streamflow data series at any United States Geological Survey (USGS) streamflow gage site with more than 30 years of annual instantaneous peak streamflow records through Water Year 2014. The tool aids practitioners in identifying continuous periods of statistically homogenous (stationary) annual instantaneous peak streamflow datasets that can be adopted for further hydrologic analysis. The tool also allows users to conduct monotonic trend analyses on the identified subsets of stationary flow records. The tool facilitates access to USGS annual instantaneous peak streamflow records; does not require the user to have either specialized software or a background in advanced statistical analysis; provides consistent, repeatable analytical results that support peer review processes; and allows for consistent updates over time. USACE technical guidance on the detection of nonstationarities in annual maximum flows is contained in Engineer Technical Letter 1100-2-3.

The User Manual includes a discussion of the technical concepts incorporated into the Nonstationarity Detection Tool, a description of the user interface, an explanation of how to apply the user interface to execute hydrologic analysis, and a series of examples highlighting how the tool is applied. This user guide does not cover all possible situations one may encounter using the tool. The first step in conducting nonstationarity detection is to carry out data preparation and exploratory data analysis, which are described in detail in Section 3. The Nonstationarity Detection Tool is not a substitute for professional engineering judgment. For more information about the tool, you can read the fact sheet. You can also watch a video *(mp4, 54.1 MB)* that explains how to use the tool.

Climate Hydrology Assessment Tool

In releasing Engineering and Construction Bulletin 2014-10, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, USACE took the first step toward developing policy and guidance around projected changes to climate hydrology and how these changes might affect water resources project planning, design, construction, operation and maintenance.

ECB 2016-25, released on 16 Sept 2016, supersedes and updates ECB 2014-10. The qualitative analysis required by this ECB includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs as part of a first-order statistical analysis of the potential impacts to particular hydrologic elements of the study. This analysis can be very useful in considering future without project conditions (FWOP) and the potential direction of climate change. Examples of this type of analysis is provided in Appendix C.

The Climate Hydrology Assessment Tool allows users to easily access both existing and projected climate data to develop repeatable analytical results using consistent information: reducing potential error and increasing the development of information so that it can be used earlier in the decision-making process, ideally in the development of risk registers. This tool steps user through the process of developing information and supplies graphics suitable for use in a report including: trend detection in observed annual maximum daily flow, trend detection in observed annual maximum 3-day flow, climate-modeled annual maximum monthly flow range, and trend detection in annual maximum monthly flow models.

NONSTATIONARITY DETECTION TOOL

NSD Production Environment

Nonstationarity Detection Tool (NSD) - PROD

US Army Corps of Engineers

Home | User Guide | Nonstationarity Detection Tool | Help

Welcome to the Nonstationarity Detection Tool

This Nonstationarity Detection Tool was developed in conjunction with USACE Engineering Technical Letter (ETL) 1100-2-3, Guidance for Detection of Nonstationarities in Annual Maximum Discharges, to detect nonstationarities in maximum annual flow time series. Per this ETL 1100-2-3, engineers will be required to assess the stationarity of all streamflow records analyzed in support of hydrologic analysis carried out for USACE planning and engineering decision-making purposes.

The Nonstationarity Detection Tool enables the user to apply a series of statistical tests to assess the stationarity of annual peak streamflow data series at any United States Geological Survey (USGS) annual instantaneous peak streamflow gage site with more than 30 years of flow record through Water Year 2014. The tool is intended to aid practitioners in identifying continuous periods of statistically homogenous (stationary) annual peak streamflow datasets that can be adopted for further hydrologic analysis.

The web tool detects nonstationarities in the historical record to help the user segment the record into flow datasets whose statistical properties can be considered stationary. The tool also allows users to conduct monotonic trend analysis on the resulting subsets of stationary flow records identified. The web tool facilitates direct access to annual maximum streamflow datasets, does not require the user to have specialized software or a background in advanced statistical analysis, provides consistent, repeatable analytical results that support peer review processes, and allows for consistent updates over time.

This functionality is contained within three different sheets:

Nonstationarity Detector - The Nonstationarity Detector sheet uses a dozen different statistical methods to detect the presence of both abrupt and smooth nonstationarities in the period of record.

Trend Analysis - The Trend Analysis sheet displays the results from four different statistical methods for trend analysis.

Method Explorer - Within the Method Explorer sheet, a user can select any of the twelve nonstationarity detection methods to view independently of the other statistical tests.

If you have any questions or comments, please let us know by contacting: cprsupport@usace.army.mil

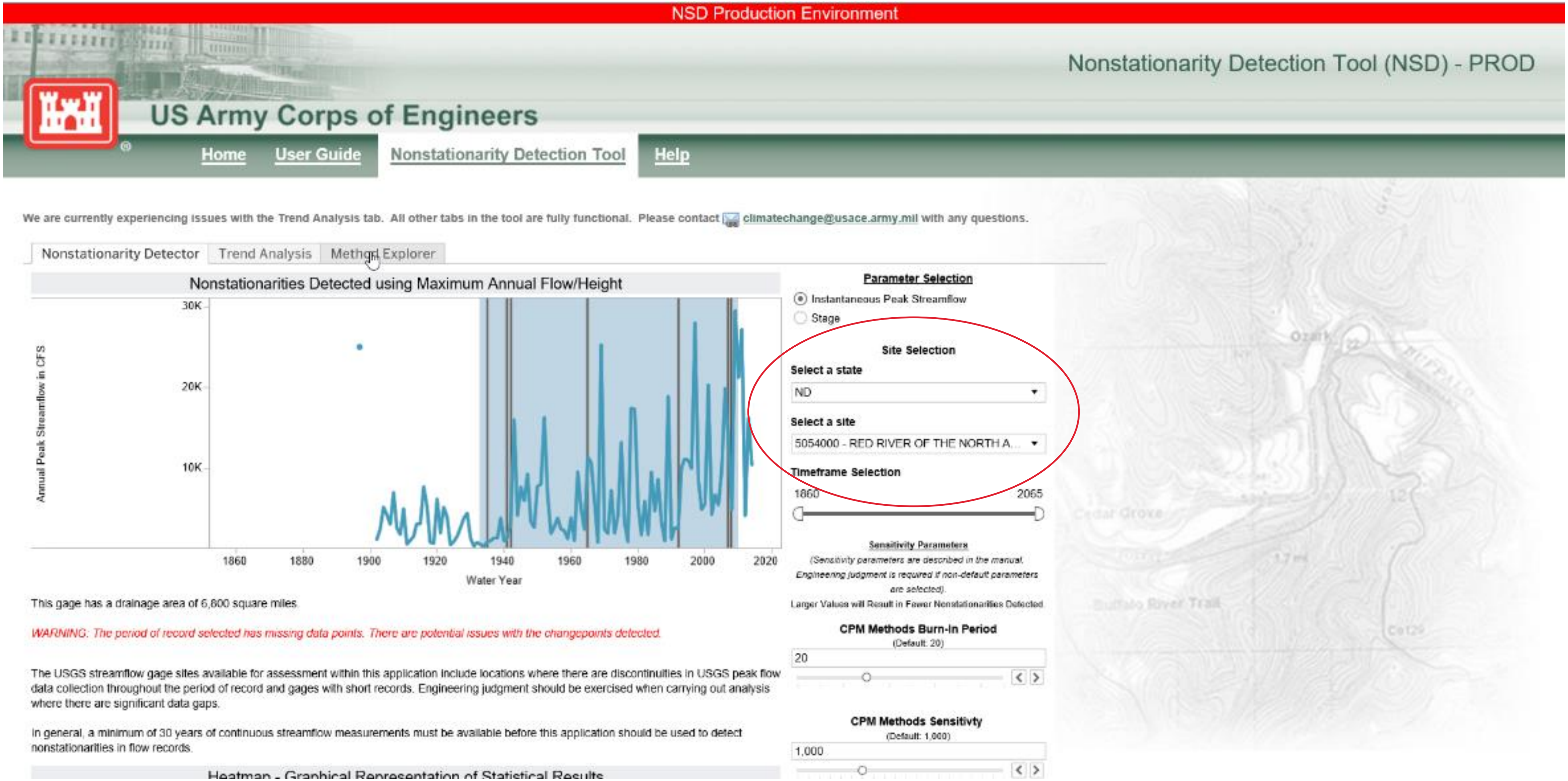
BUILDING STRONG®

Accessibility
Contact Us
FOIA
Information Quality Act
Link Disclaimer
No Fear Act
Privacy and Security
Public Inquiries
Site Map
USA.gov

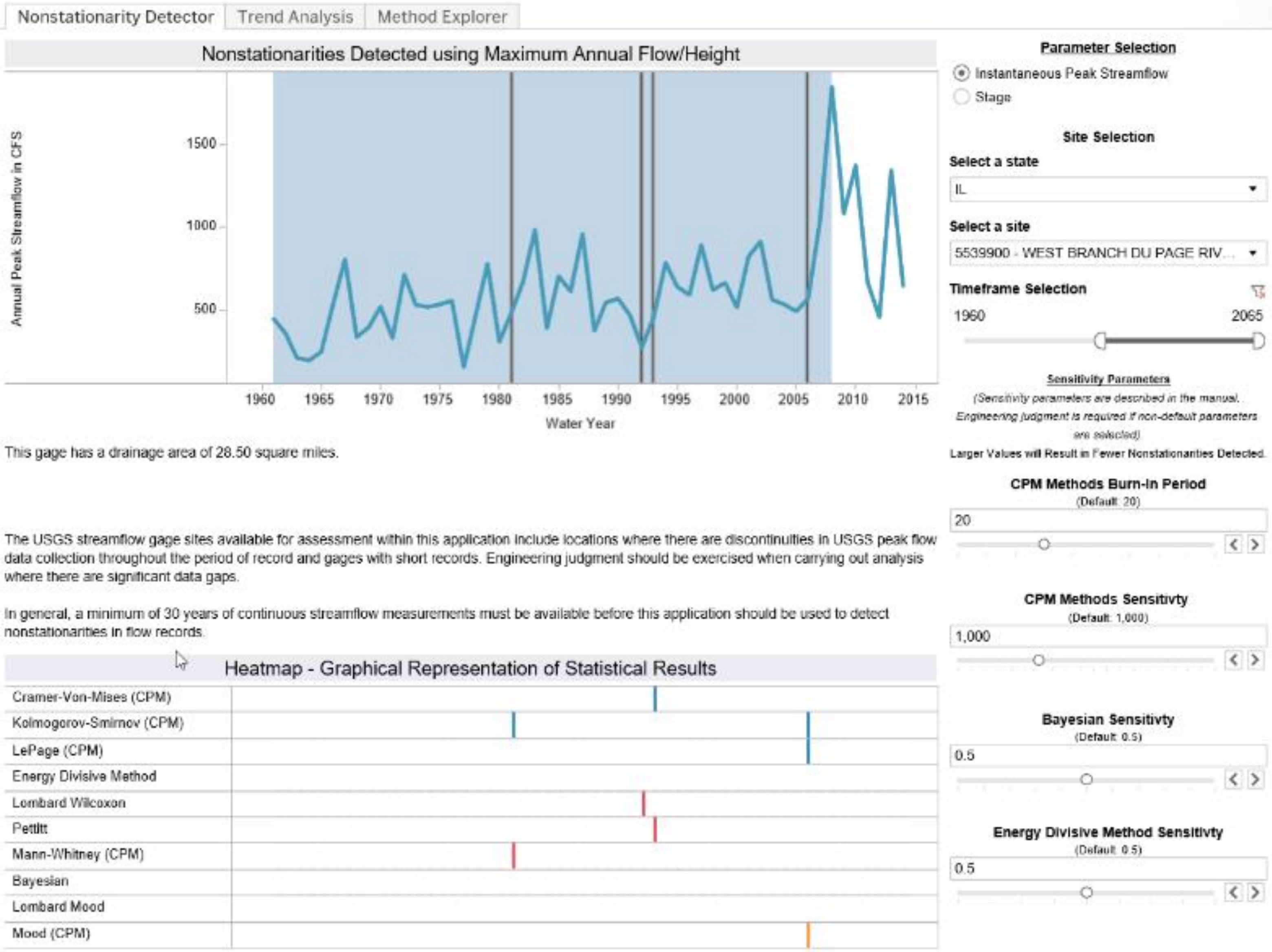
Page #: 257.2

14

NONSTATIONARITY DETECTION TOOL

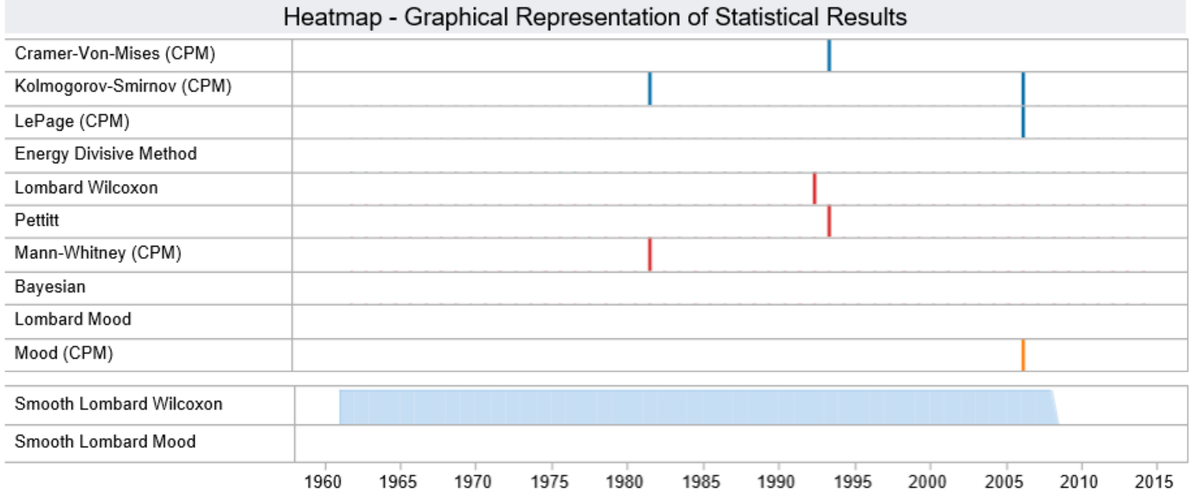


NONSTATIONARITY DETECTION TOOL



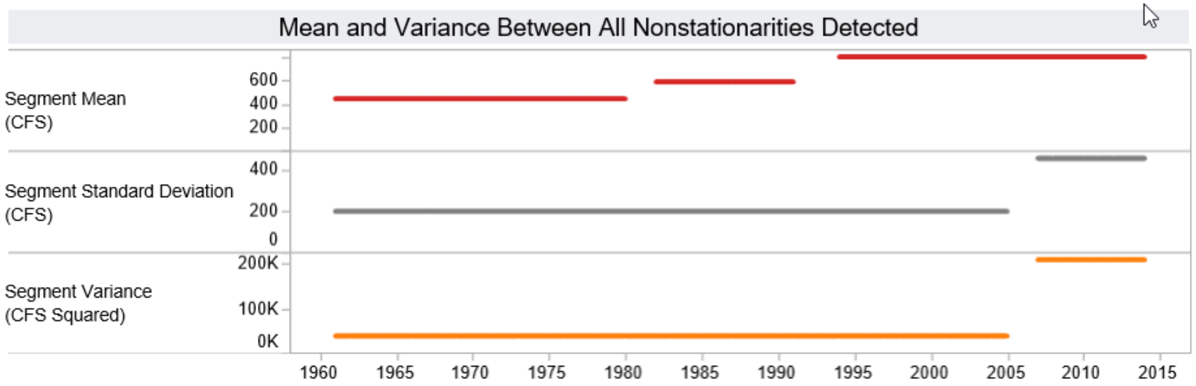
NONSTATIONARITY DETECTION TOOL

In general, a minimum of 30 years of continuous streamflow measurements must be available before this application should be used to detect nonstationarities in flow records.



Legend - Type of Statistically Significant Change being Detected

- Distribution
- Mean
- Variance
- Smooth



CPM Methods Sensitivty
(Default: 1,000)
1,000

Bayesian Sensitivty
(Default: 0.5)
0.5

Energy Divisive Method Sensitivty
(Default: 0.5)
0.5

Larger Values will Result in
More Nonstationarities Detected

Lombard Smooth Methods Sensitivity
(Default: 0.05)
0.05

Pettitt Sensitivity
(Default: 0.05)
0.05

Please acknowledge the US Army Corps of Engineers for producing this nonstationarity detection tool as part of their progress in climate preparedness and resilience and making it freely available.

Undo Redo Revert Refresh Pause Share Download Full Screen

NONSTATIONARITY TESTS

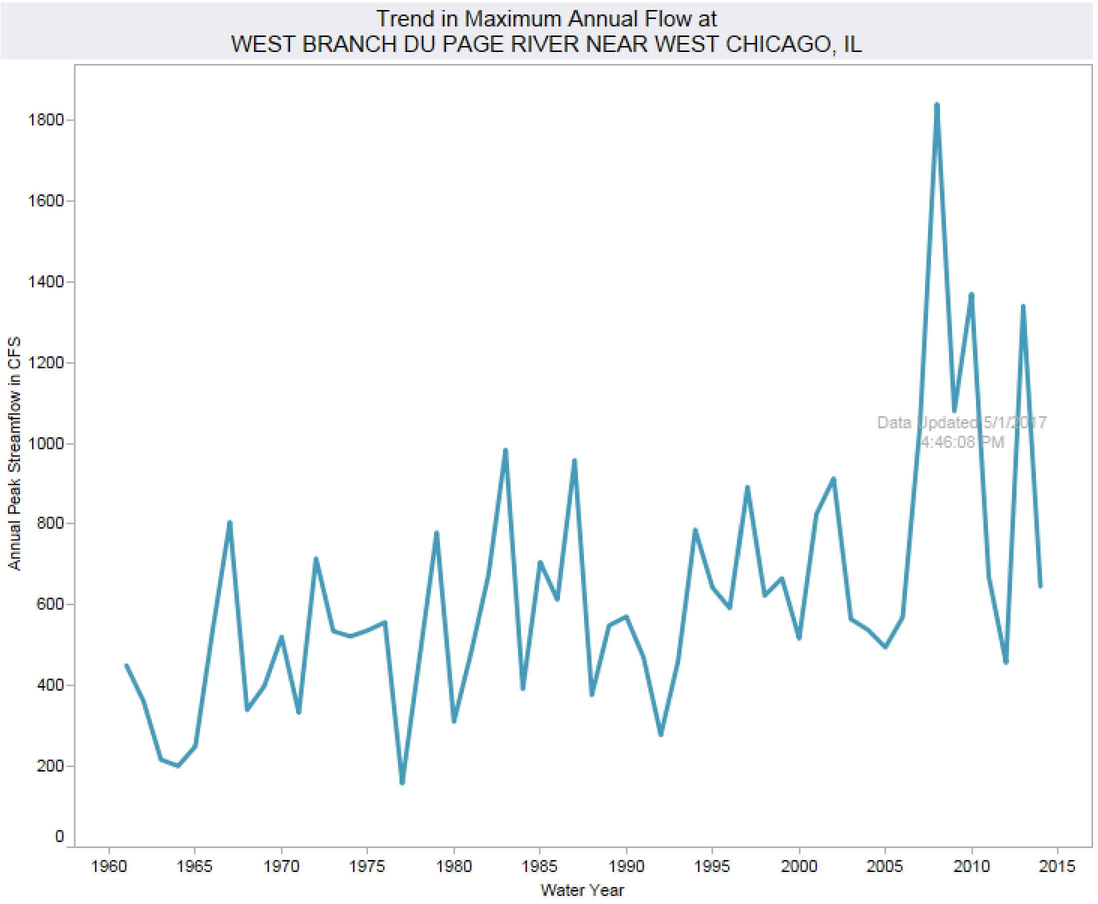
How can I interpret all those results?

– Look for **consensus** among tests e.g. multiple tests find changes in mean

– Look for **robustness** across detected changes e.g. changes in mean and variance – multifaceted change

– Assess **magnitude** of change – changes can be statistically significant but of no practical significance

NONSTATIONARITY DETECTION TOOL



Timeframe Selection
1860 to 2065

Monotonic Trend Analysis

Is there a statistically significant trend?
Yes, using the Mann-Kendall Test at the .05 level of significance.
Yes, using the Spearman Rank Order Test at the .05 level of significance.

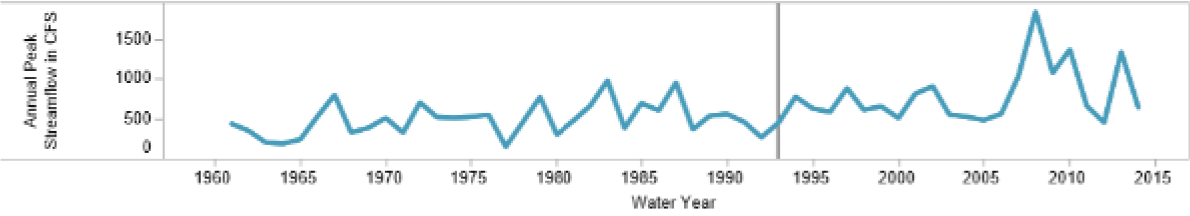
What type of trend was detected?
Using parametric statistical methods, **a positive trend** was detected.
Using robust parametric statistical methods (Sen's Slope), **a positive trend** was detected.

Please acknowledge the US Army Corps of Engineers for producing this nonstationarity detection tool as part of their progress in climate preparedness and resilience and making it freely available.

NONSTATIONARITY DETECTION TOOL

Nonstationarity Detector | Trend Analysis | Method Explorer

Nonstationarities Detected using Cramer-Von-Mises (CPM) at WEST BRANCH DU PAGE RIVER NEAR WEST CHICAGO, IL



Method Selection

Cramer-Von-Mises (CPM)

- Cramer-Von-Mises (CPM)
- Kolmogorov-Smirnov (CPM)
- LePage (CPM)
- Energy Divisive Method
- Lombard Wilcoxon
- Pettitt
- Mann-Whitney (CPM)
- Bayesian
- Lombard Mood
- Mood (CPM)
- Smooth Lombard Wilcoxon
- Smooth Lombard Mood

Larger Values Will Result in Fewer Nonstationarities

CPM Methods Burn-In Period
(Default: 20)

20

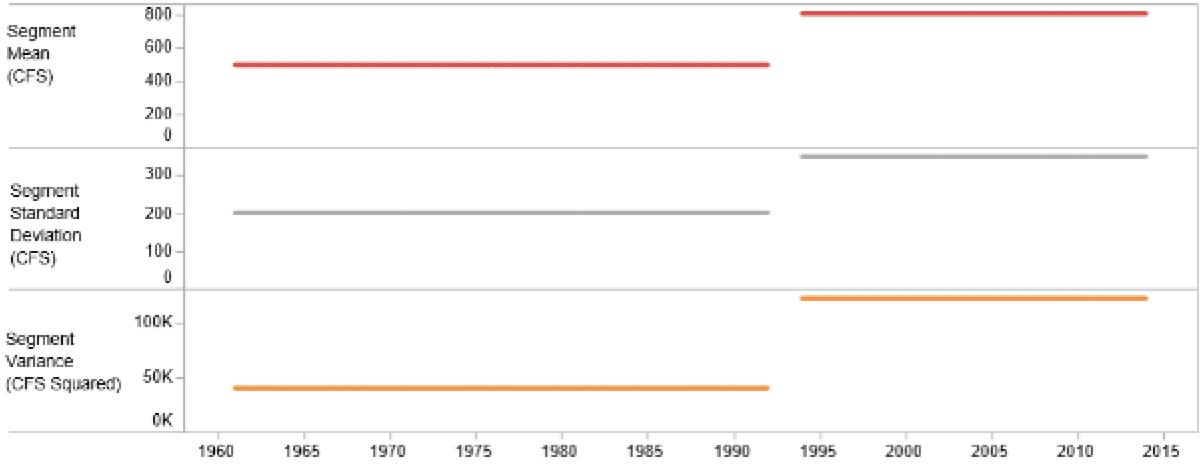
CPM Methods Sensitivty
(Default: 1,000)

1,000

The USGS streamflow gage sites available for assessment within this application include locations where there are discontinuities in USGS peak flow data collection throughout the period of record and gages with short records. Engineering judgment should be exercised when carrying out analysis where there are significant data gaps.

In general, a minimum of 30 years of continuous streamflow measurements must be available before this application should be used to detect nonstationarities in flow records.

Mean and Variance between Nonstationarities Detected with Cramer-Von-Mises (CPM)



USACE PUBLIC TOOLS

guidance for hydrology used in climate change impact assessments and adaptation planning and design.

Nonstationarity Detection Tool

Stationarity, or the assumption that the statistical characteristics of hydrologic time series data are constant through time, enables the use of well-accepted statistical methods in water resources planning and design in which future conditions rely primarily on the observed record. However, recent scientific evidence shows that—in some places, and for some impacts relevant to the operations of the U.S. Army Corps of Engineers (USACE)—climate change and human modifications of the watersheds are undermining this fundamental assumption, resulting in nonstationarity.

The Detection Tool enables the user to apply a series of statistical tests to assess the stationarity of annual instantaneous peak streamflow data series at any United States Geological Survey (USGS) streamflow gage site with more than 30 years of annual instantaneous peak streamflow records through Water Year 2014. The tool aids practitioners in identifying continuous periods of statistically homogenous (stationary) annual instantaneous peak streamflow datasets that can be adopted for further hydrologic analysis. The tool also allows users to conduct monotonic trend analyses on the identified subsets of stationary flow records. The tool facilitates access to USGS annual instantaneous peak streamflow records; does not require the user to have either specialized software or a background in advanced statistical analysis; provides consistent, repeatable analytical results that support peer review processes; and allows for consistent updates over time. USACE technical guidance on the detection of nonstationarities in annual maximum flows is contained in Engineer Technical Letter 1100-2-3.

The User Manual includes a discussion of the technical concepts incorporated into the Nonstationarity Detection Tool, a description of the user interface, an explanation of how to apply the user interface to execute hydrologic analysis, and a series of examples highlighting how the tool is applied. This user guide does not cover all possible situations one may encounter using the tool. The first step in conducting nonstationarity detection is to carry out data preparation and exploratory data analysis, which are described in detail in Section 3. The Nonstationarity Detection Tool is not a substitute for professional engineering judgment. For more information about the tool, you can read the fact sheet. You can also watch a video *(mp4, 54.1 MB)* that explains how to use the tool.

Climate Hydrology Assessment Tool

In releasing Engineering and Construction Bulletin 2014-10, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, USACE took the first step toward developing policy and guidance around projected changes to climate hydrology and how these changes might affect water resources project planning, design, construction, operation and maintenance.

ECB 2016-25, released on 16 Sept 2016, supersedes and updates ECB 2014-10. The qualitative analysis required by this ECB includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs as part of a first-order statistical analysis of the potential impacts to particular hydrologic elements of the study. This analysis can be very useful in considering future without project conditions (FWOP) and the potential direction of climate change. Examples of this type of analysis is provided in Appendix C.

The Climate Hydrology Assessment Tool allows users to easily access both existing and projected climate data to develop repeatable analytical results using consistent information: reducing potential error and increasing the development of information so that it can be used earlier in the decision-making process, ideally in the development of risk registers. This tool steps user through the process of developing information and supplies graphics suitable for use in a report including: trend detection in observed annual maximum daily flow, trend detection in observed annual maximum 3-day flow, climate-modeled annual maximum monthly flow range, and trend detection in annual maximum monthly flow models.

Responses to Climate Change Program

International Activities

CLIMATE HYDROLOGY ASSESSMENT TOOL

Climate Hydrology Assessment Tool - PROD

US Army Corps of Engineers

Home | Analysis Tool | Help

In releasing Engineering and Construction Bulletin 2016-25, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, USACE took the first step toward developing policy and guidance around projected changes to climate hydrology and how these changes might affect water resources project planning, design, construction, operation and maintenance.

The qualitative analysis required by this ECB includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs. A first-order statistical analysis of the potential impacts to particular hydrologic elements of the study can be included as supplemental input to this qualitative assessment, but is not required.

However, this analysis can be very useful in considering future without project conditions (FWOP) and the potential direction of climate change.

The techniques required to obtain the data for the statistical analysis can be cumbersome and the multiple steps required could introduce errors that might adversely impact the results and the interpretations and decisions made based on these results.

Because the intent of ECB 2016-25 is to provide information about future conditions useful to decision-makers, we decided to develop a web-accessible tool to allow USACE staff to easily access both existing and projected climate. This allows districts across the country to develop repeatable analytical results using consistent information. In doing so, we reduce potential error and speed the development of information so that it can be used earlier in the decision-making process, ideally in the development of risk registers.

This tool steps user through the process of developing information shown in the figures of Appendix C, and supplies graphics suitable for use in a report:

• Trend detection in observed annual peak instantaneous streamflow. Here the user selects the desired HUC-4 watershed and obtains data for the desired USGS gauge using the pick list or the map. Hovering over a spot on the map provides information on the gage and a link to open the gage data in a separate window. The graphics reproduce Figure C-1 and include a trend line. Hovering over the trend line provides the equation for the line and also an indication of significance.

• Climate-modeled projected annual maximum monthly flow range. This tab provides a graphic of the projected climate-changed hydrology for the selected HUC-4 watershed that reproduces Figure C-3. The range of the 93 projections of annual maximum monthly flow is shown in yellow, just as it is in Figure C-3. The mean of the 93 projections of annual maximum monthly flow is shown in blue.

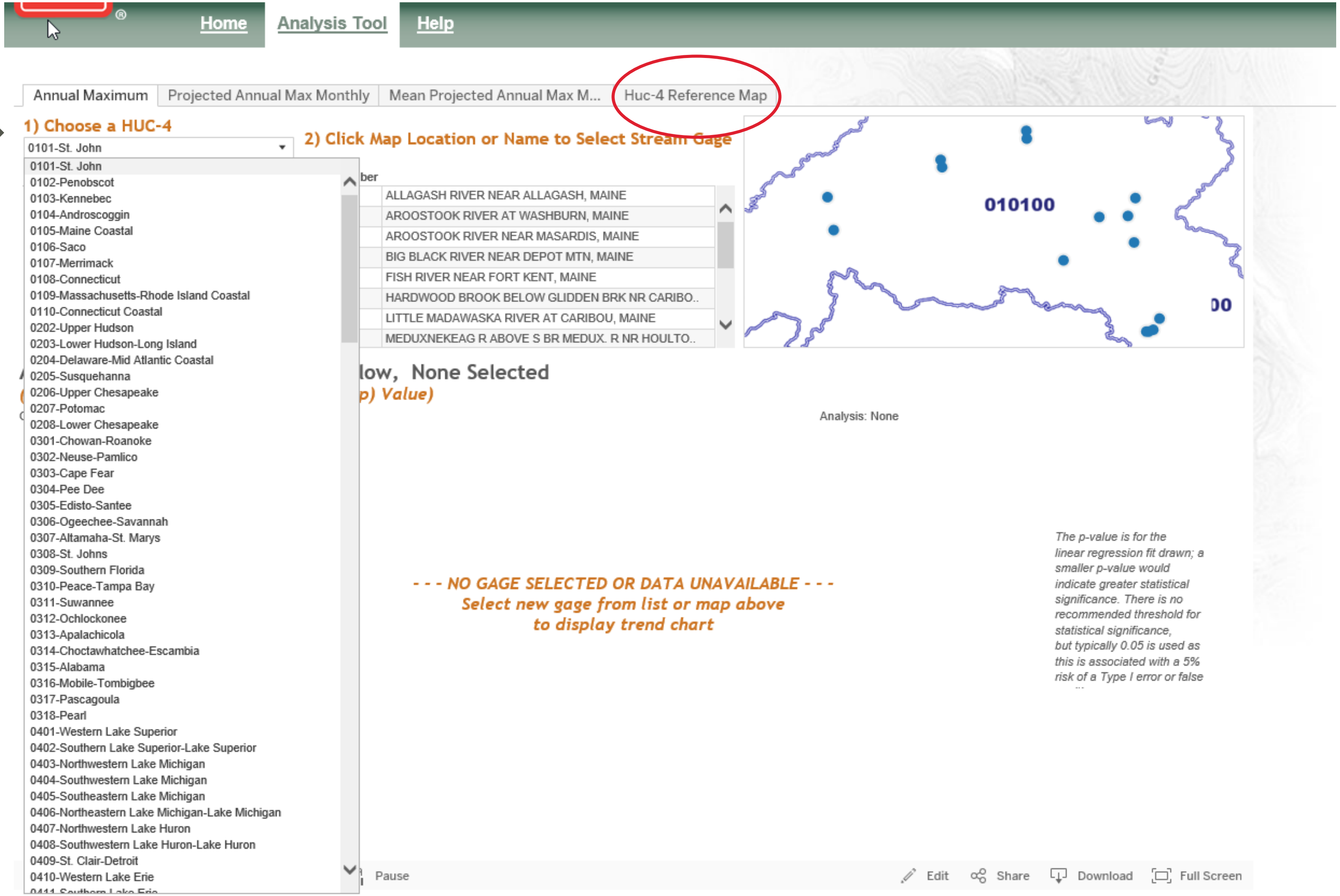
• Trend detection in annual maximum monthly flow models. This tab provides a graphic including the statistical analysis of the mean of the projected annual maximum monthly streamflow projections for the selected HUC-4 watershed, reproducing Figure C-4. Hovering over the trend line provides the equation for the line and also an indication of significance.

BUILDING STRONG®

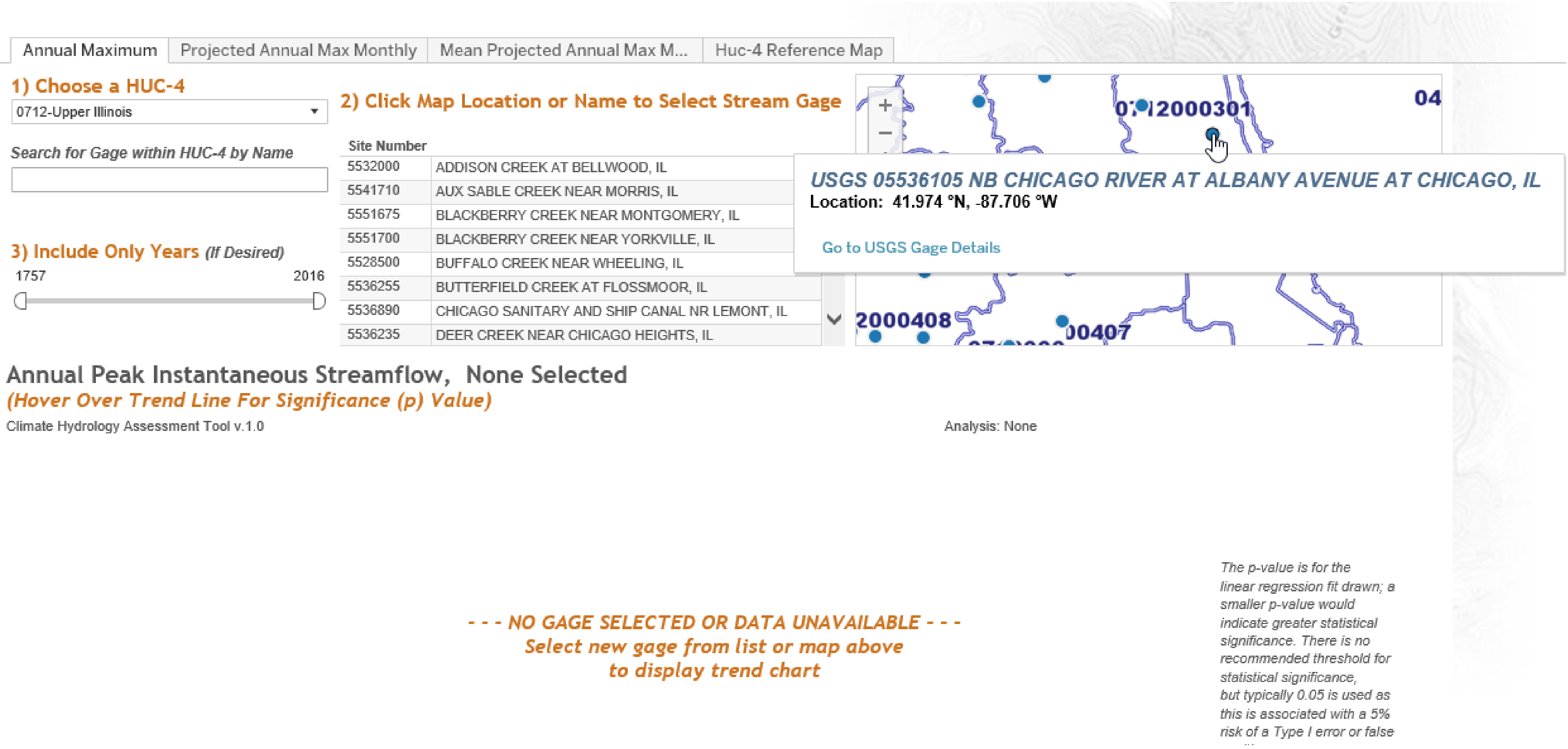
Accessibility
Contact Us
FOIA
Information Quality Act
Link Disclaimer
No Fear Act
Privacy and Security
Public Inquiries
Site Map
USA.gov

Page #: 313:2

CLIMATE HYDROLOGY ASSESSMENT TOOL



CLIMATE HYDROLOGY ASSESSMENT TOOL



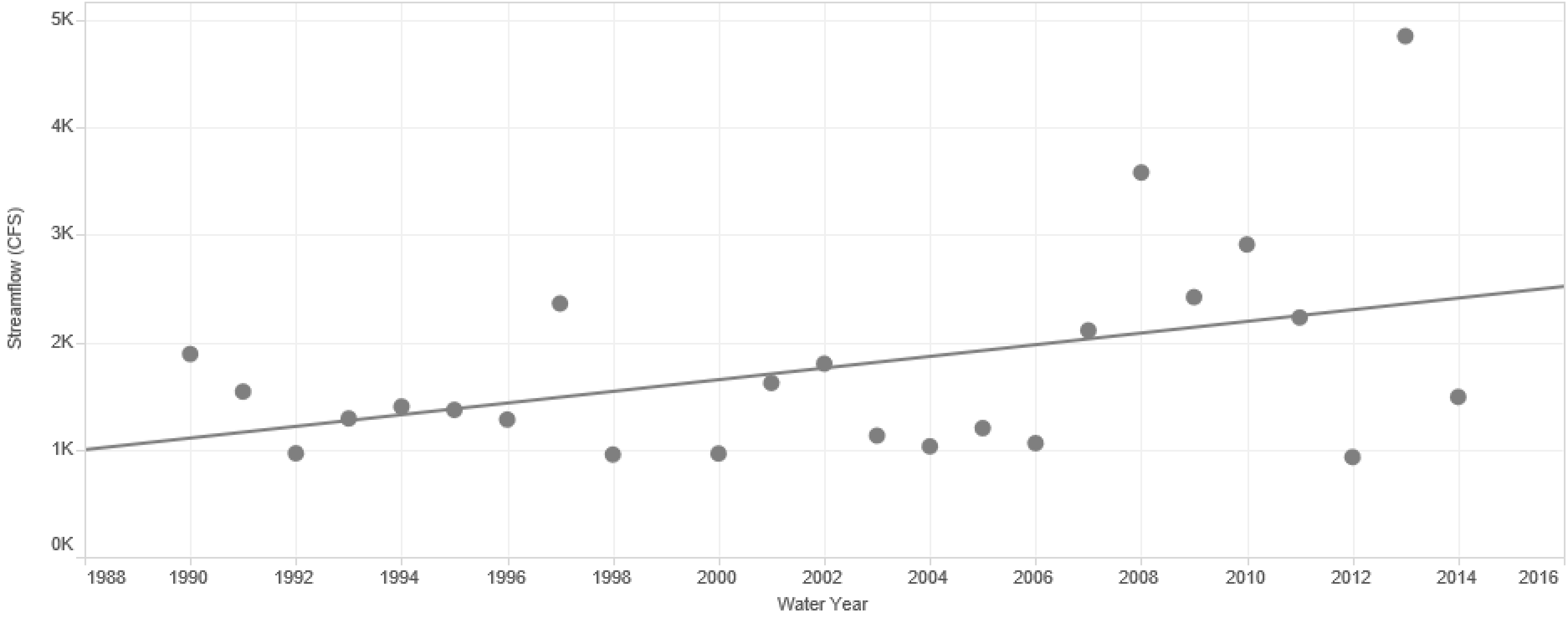
CLIMATE HYDROLOGY ASSESSMENT TOOL

Annual Peak Instantaneous Streamflow, NB CHICAGO RIVER AT ALBANY AVENUE AT CHICAGO, IL Selected

(Hover Over Trend Line For Significance (p) Value)

Climate Hydrology Assessment Tool v.1.0

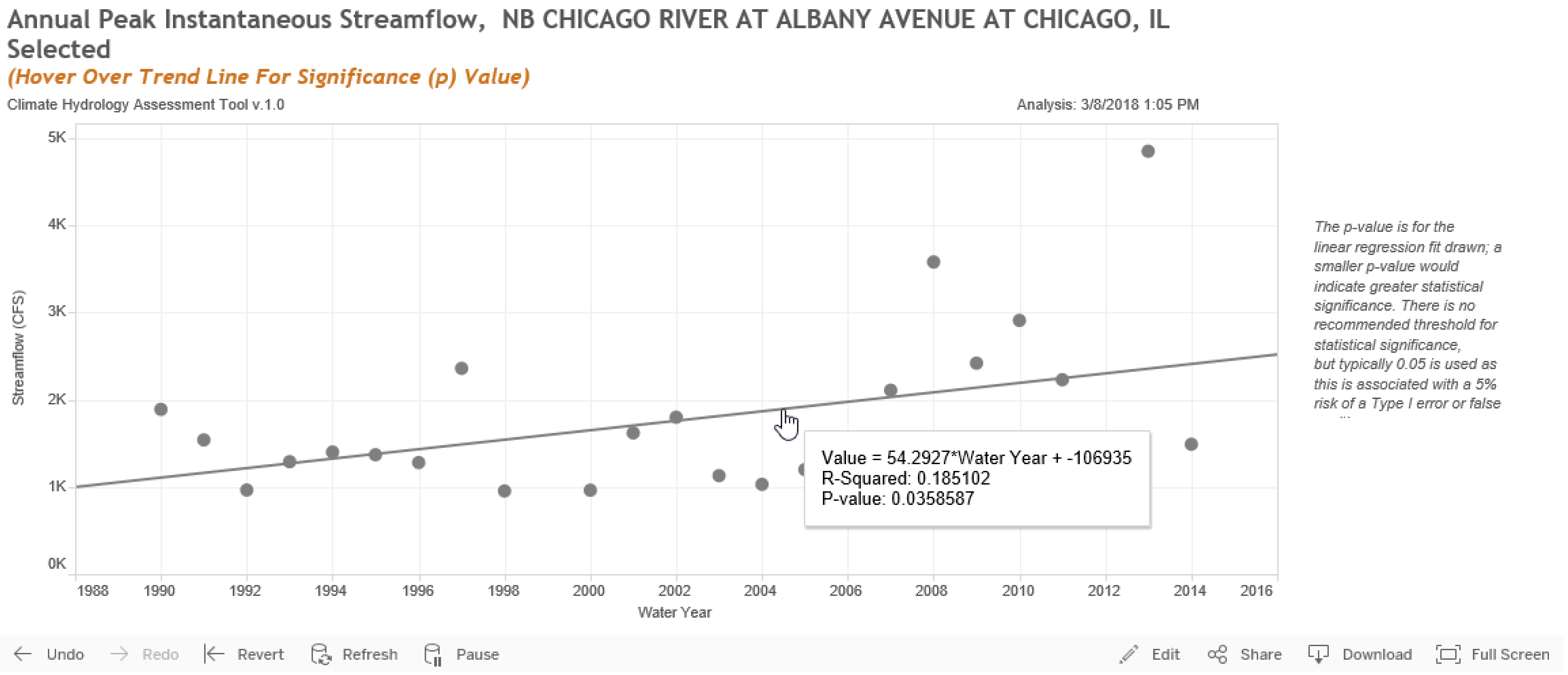
Analysis: 3/8/2018 1:05 PM



The p-value is for the linear regression fit drawn; a smaller p-value would indicate greater statistical significance. There is no recommended threshold for statistical significance, but typically 0.05 is used as this is associated with a 5% risk of a Type I error or false

Undo Redo Revert Refresh Pause Edit Share Download Full Screen

CLIMATE HYDROLOGY ASSESSMENT TOOL



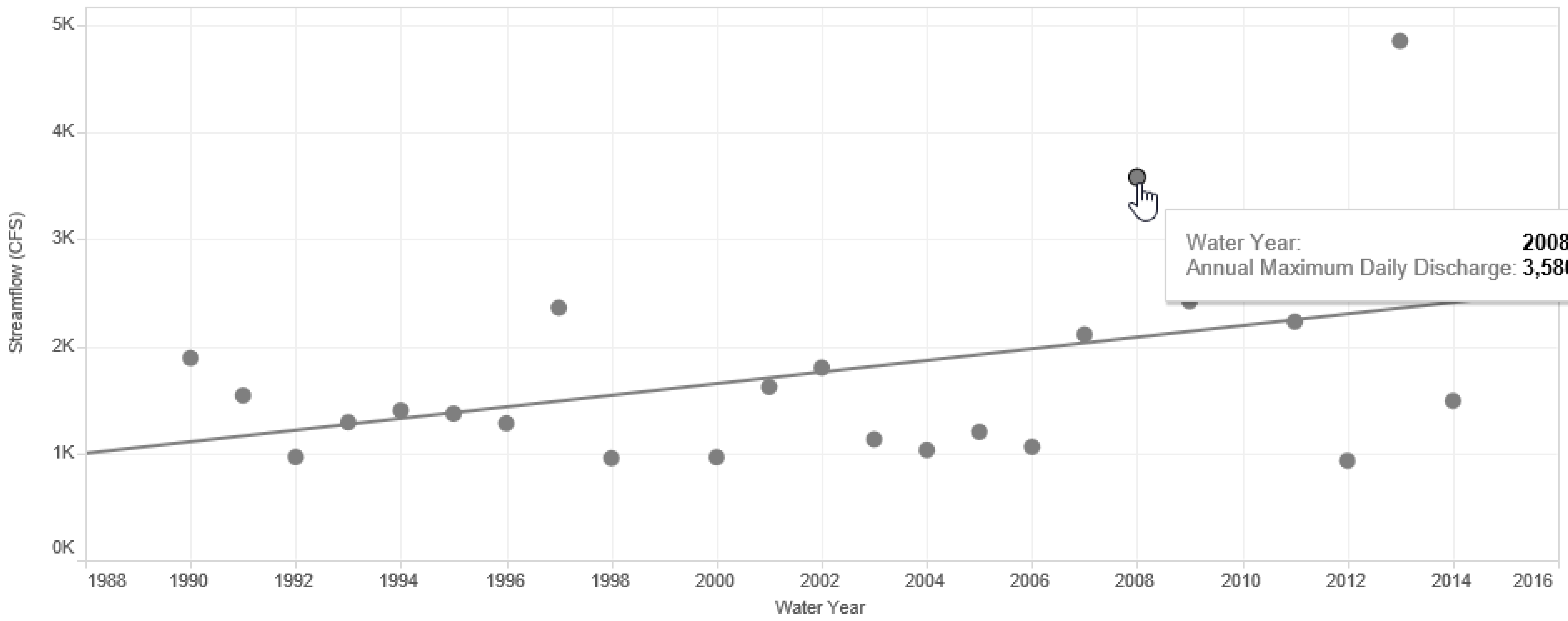
CLIMATE HYDROLOGY ASSESSMENT TOOL

Annual Peak Instantaneous Streamflow, NB CHICAGO RIVER AT ALBANY AVENUE AT CHICAGO, IL Selected

(Hover Over Trend Line For Significance (p) Value)

Climate Hydrology Assessment Tool v.1.0

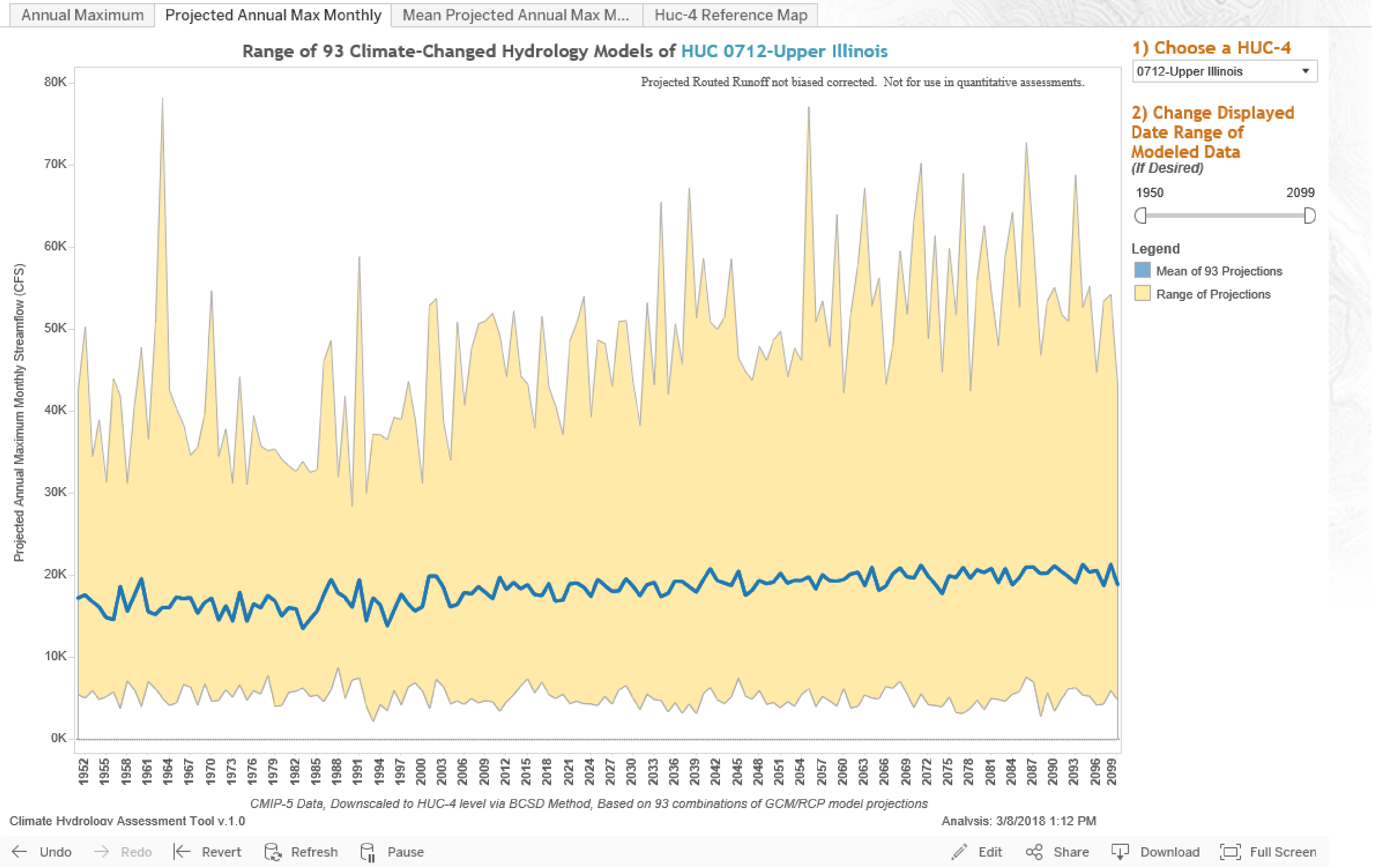
Analysis: 3/8/2018 1:05 PM



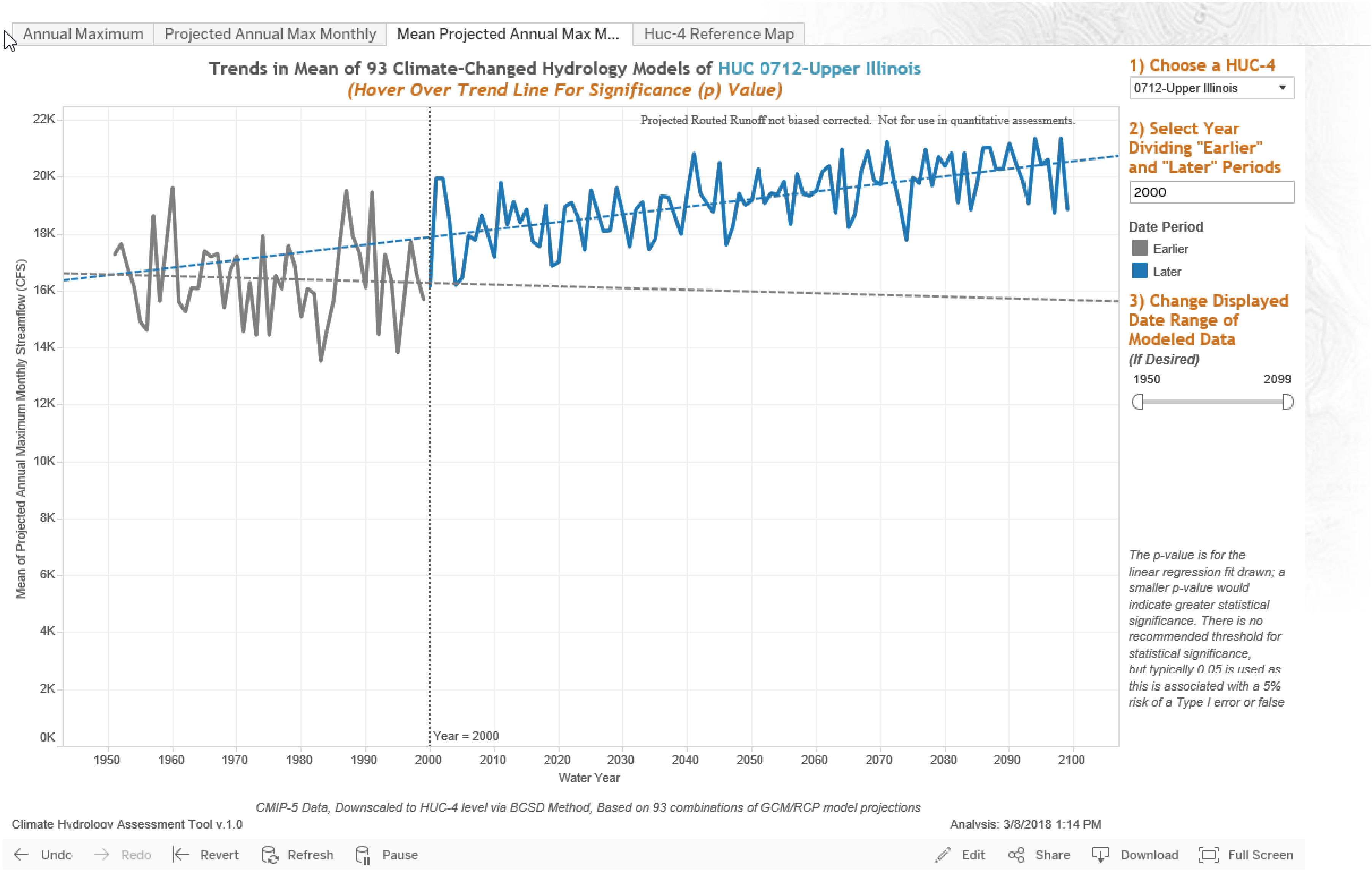
The p-value is for the linear regression fit drawn; a smaller p-value would indicate greater statistical ...icance. There is no ...mmended threshold for ...tical significance, but typically 0.05 is used as this is associated with a 5% risk of a Type I error or false

Undo Redo Revert Refresh Pause Edit Share Download Full Screen

CLIMATE HYDROLOGY ASSESSMENT TOOL



CLIMATE HYDROLOGY ASSESSMENT TOOL

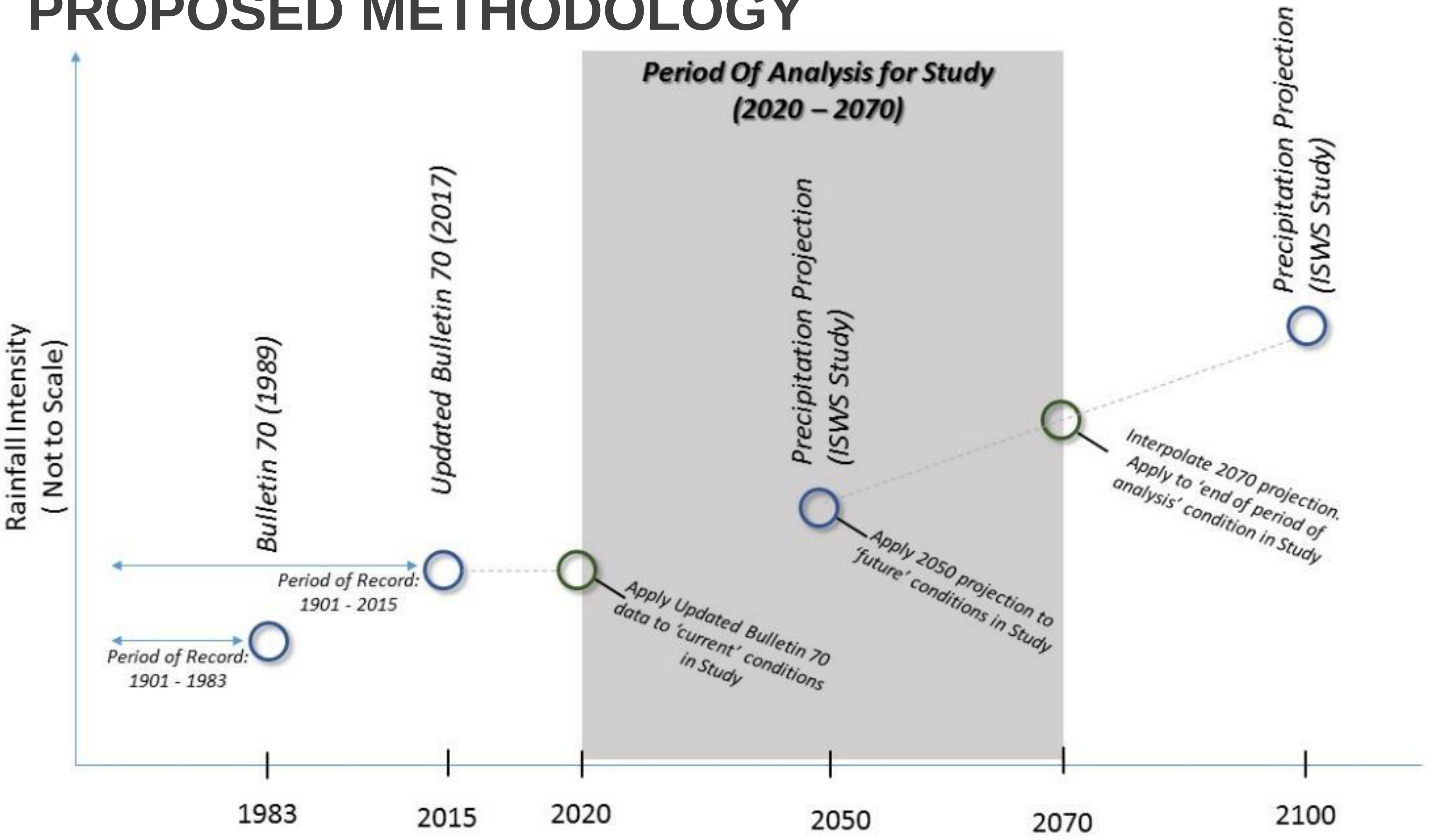


APPLICATION OF ISWS PRECIPITATION DATA TO ECONOMIC ANALYSIS OF PROJECTS IN FEASIBILITY STUDIES

BASIS FOR USING PROJECTED DATA

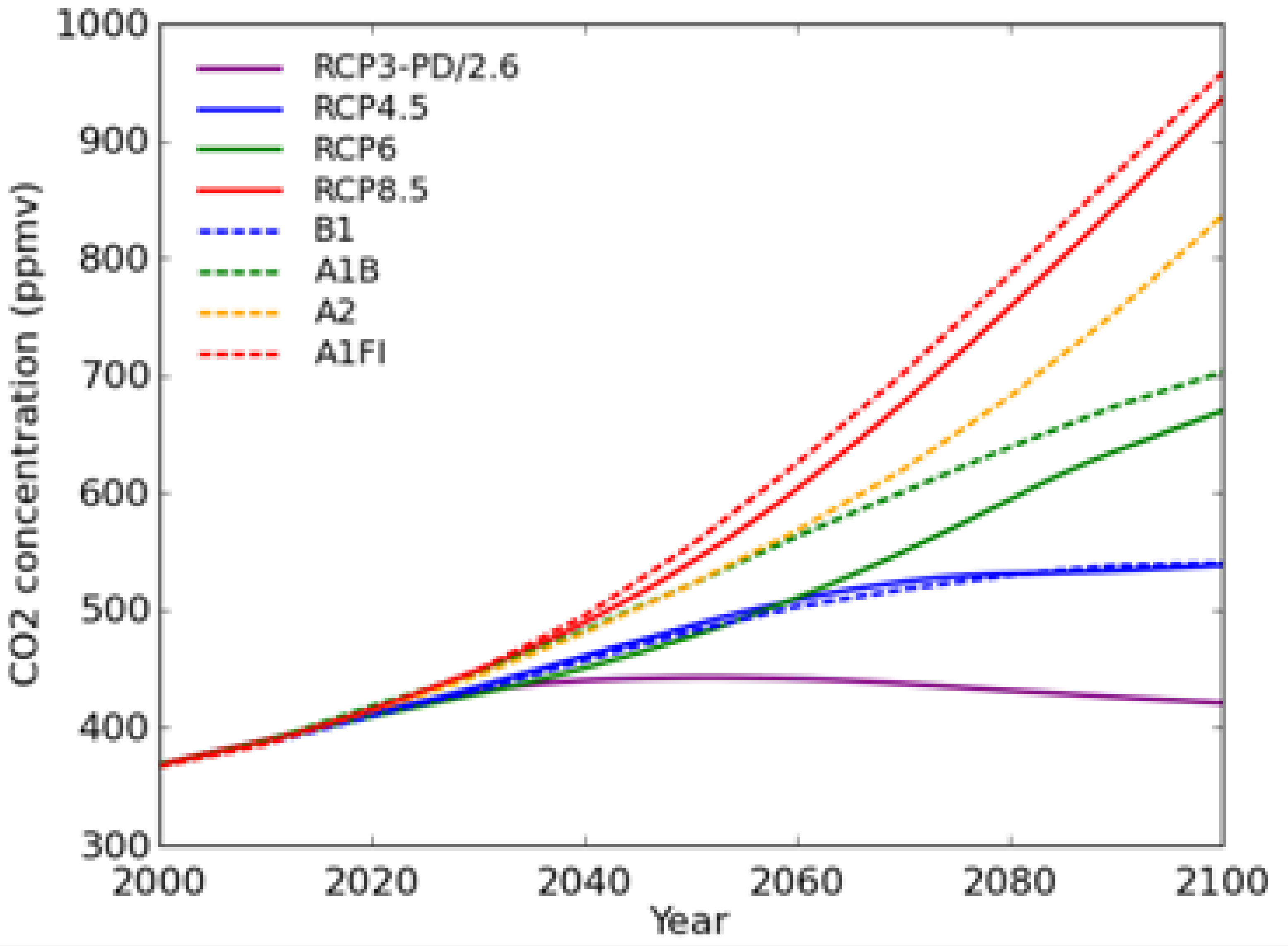
- Consensus on increased peak precipitation and peak flow rates in future
  - ISWS precipitation frequency analysis provides data to apply to hydrology modeling
- USACE feasibility studies use a 50-year period of analysis to determine economic benefits associated with evaluated projects
  - Flood frequency analysis based on precipitation frequency curves relying on observed data (Bulletin 70, period of record: 1901-1983)
  - Flood frequency does not account for observed or anticipated trends towards increasing precipitation in the future
- Not qualitatively including future precipitation trend projection in our project evaluation could impact plan selection, resiliency/reliability of recommended projects, and the level of residual risks following construction.
- The Chicago District proposes that this risk be managed by quantitatively by incorporating precipitation projections in the future conditions.

PROPOSED METHODOLOGY

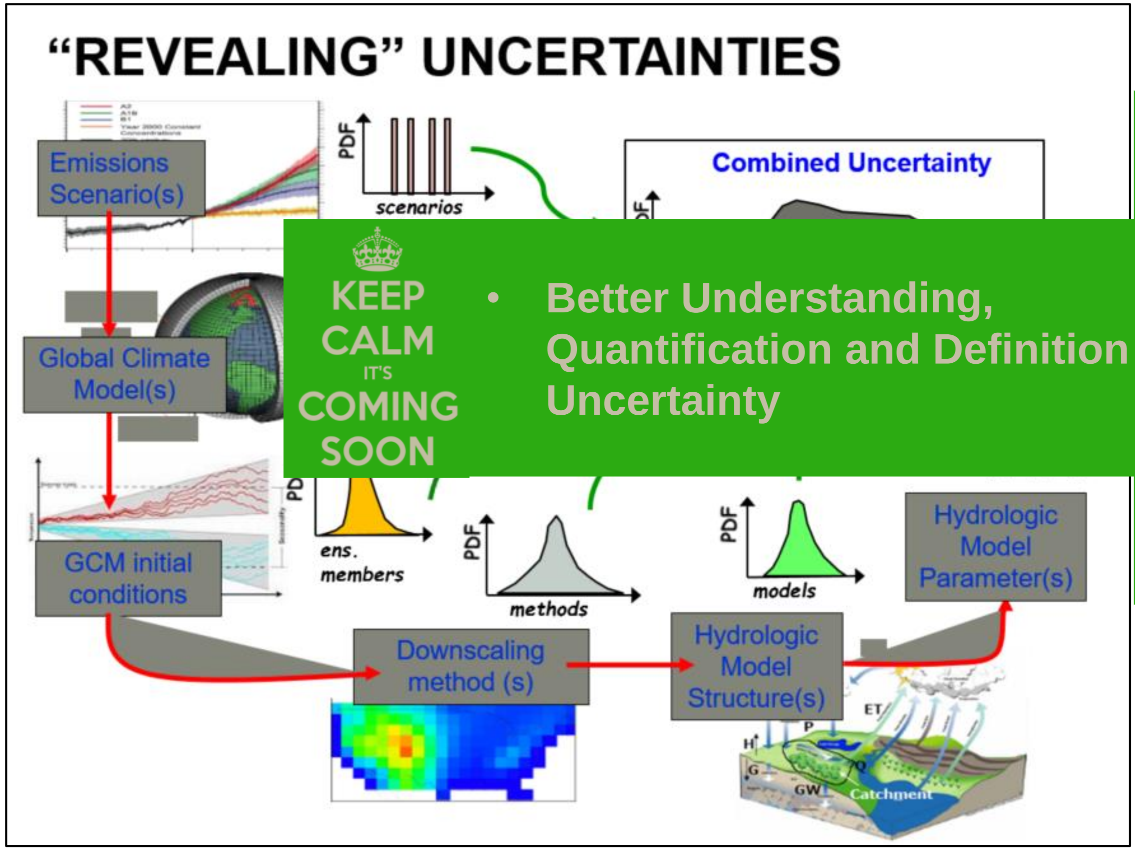


* Under Review through USACE Climate Preparedness and Resilience Community of Practice

WHICH SCENARIO??

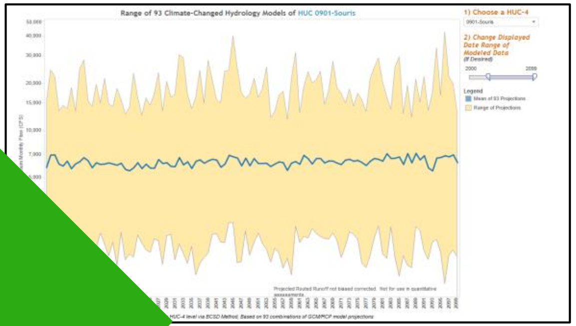


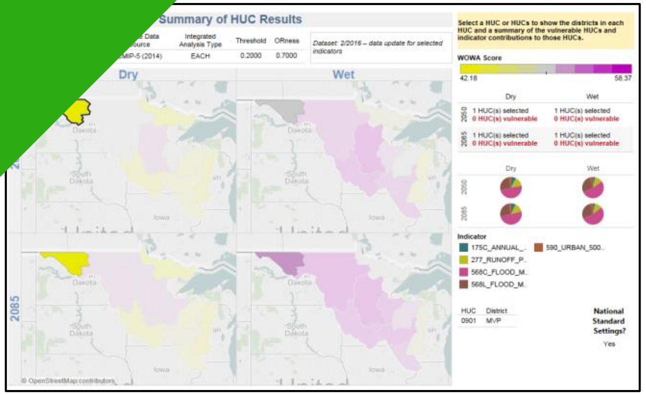
ADDRESSING UNCERTAINTY



KEEP CALM IT'S COMING SOON

- **Better Understanding, Quantification and Definition of Uncertainty**





- Acknowledge Uncertainty Associated with Climate Model Output for Future
- Interpreting Global Climate Model Output
- Hydrologic Model Uncertainty

QUESTIONS?