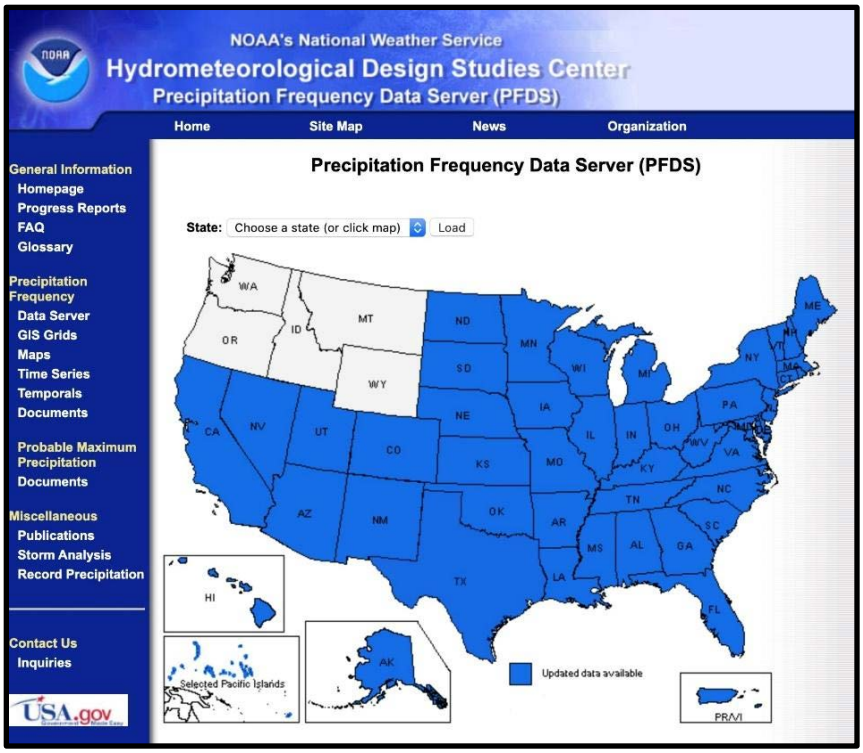
NOAA's Atlas 14:

Use Cases and User Feedback



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EXECUTIVE SUMMARY

NOAA's Atlas 14 is an analysis of current and historical observations and recorded data about precipitation to produce a comprehensive set of estimates on precipitation frequency that cover intensity, duration, and frequency.

The information is provided online at NOAA's Precipitation Frequency Data Server. Some of the information used to update the frequency estimates is outdated and inadequate for future planning. Some areas have gone without updates in 20 or even 50 years. These deficiencies are problematic, as understanding precipitation and its potential impacts is an important part of any development design process, particularly when working with infrastructure.

The nation's largest infrastructure investment bill was recently signed into law, and in a parallel move, NOAA may get federal funding to improve Atlas 14. This report aims to inform the Atlas 14 update process. The information in this report was generated by interviewing current Atlas 14 users and obtaining their feedback regarding how they use the data products and their suggested improvements.

Summarizing this feedback is difficult because of the variety of users interviewed, which is why the author is encouraging the Atlas 14 team to read the report in its entirety. There were, however, several consistent themes, many of which are listed here.

NEEDS

- **Comprehensive and updated Atlas 14 coverage.** Not all states have Atlas 14 coverage and some that do are significantly outdated.
- **Inclusion of non-stationarity assumptions**. Climate change is increasing rainfall intensity. Characterizations of precipitation frequency should include climate projections to best consider the impacts of a changing climate.
- **Federal leadership to select the best scientific method to account for climate-induced precipitation intensity increases.** Absent federal guidance, there are numerous inconsistent ways to incorporate future climate projections. A federally approved, consensus-based approach would allow standardized use and implementation of the NOAA product.
- **Provide equal data access.** States that cannot pay for Atlas 14 updates nor afford estimates about climate-induced precipitation increase are left to make critical infrastructure decisions with inadequate information. This further separates the data haves from the data have nots.

IDEAS FOR IMPROVEMENTS

- **Gain consensus on a process to include non-stationary and climate-based projections.** Since NOAA is seen as a trusted-federal partner, users would like NOAA to facilitate a consensus-based expert panel to determine the best process for projecting future precipitation frequency values.
- **Improve user experience and web-based data services.** User-suggested website updates and "one stop shopping" for those seeking NOAA climate-related data should improve usability and increase informed decision making.
- **Catalyze new partnerships.** Partnerships across other NOAA programs, with other federal agencies, and with user-based associations could result in increased product use, increased application of data incorporating future conditions, and ultimately, more resilient communities.

- **Provide training and extension to users**. Training, resources, and support for Atlas 14 data translation, technical assistance, and on-the-ground use would increase appropriate and informed end users.

As the nation contemplates improving existing infrastructure and starting new projects, having the best available precipitation science will help ensure the projects are safe and resilient. The Atlas 14 users who participated in this study were appreciative of the opportunity to provide their thoughts and contribute to this user-centered effort designed to help the nation address water-related challenges.

CURRENT USE CASES

Understanding how people and organizations use the product is helpful. Eighteen users were interviewed and divided into two groups.

- **As-is Users** -They apply Atlas 14 data directly as provided from the Precipitation Frequency Data Server.
- **Climate Informed Users** -They use Atlas 14 data as a baseline and add climate change data to create future precipitation frequency projections.

Data use cases are summarized below.

- Storm Analysis - NOAA's National Weather Service uses Atlas 14 estimates for monitoring observed and forecasted rain to indicate flooding threats and to estimate the severity of historic events.
- Infrastructure Design - Atlas 14 serves as a common standard for designing, building, and operating infrastructure with respect to heavy precipitation and floods. Examples include stormwater management systems, construction site sediment control measures, culverts, roads and bridges, and wastewater treatment plants.
- Modeling Neighborhood Flooding - Atlas 14 is used to get storm depths and temporal distributions over time, which can be converted into hourly precipitation amounts. Hydrology and hydraulic (H&H) modeling uses Atlas-14 as an input to compute rainfall runoff and flow and predict potential water levels and flooding.

For those who use other datasets to augment Atlas 14, the following represents a sample of other data sets they use.

- National Centers for Environmental Information's Local/Regional Daily Climate Normals
- National Centers for Environmental Information's Nested Grid Model
- U.S. Association for Computational Mechanics data
- NOAA Digital Elevation Model
- NOAA Weather radar data sets
- Rain gauge and weather observations data - served up separate from Atlas 14
- NASA's Earthdata
- NASA's GIOVANNI web portal.
- Northeast Regional Climate Center data
- Technical Paper 40 (TP40)
- NOAA Atlas 2
- Technical Paper 29
- Technical Paper 49
- Hydro 35
- National Weather Service Technical Report 3

USER INTERVIEW SUMMARIES

As-is Users

- *Madison, Wisconsin - Stricter Runoff Standards for New Development at Regulated Sites* Working with a data assessment that was done at the University of Wisconsin, Madison, this state took an updated look at its runoff standards for development at regulated sites. The assessment looked at rainfall data over a much shorter and more frequent time period than Atlas 14 and substituted space (geography) for time. The resultant output illustrated that Atlas 14 numbers understated the current rainfall amounts. Knowing that Atlas 14 was the "go-to" source for these types of analysis for development, Madison chose to stick with Atlas 14 as the

source of the numbers for runoff calculations and regulated developers up to the 200-year storm versus the 100-year storm.

> *"Professional training was done on TP40. Training on Atlas 14 has been "on the job" learning. "*

- *Philadelphia, Pennsylvania - Sewer Design and H&H Models*
  Philadelphia's Water Utilities use Atlas 14 to model sewer designs to meet a five-year level of service. Additionally, Philadelphia's flood risk planners use Atlas 14 in hydrologic and hydraulic modeling to inform stormwater management and to run post-storm analyses. For example, every time there is a major storm, Atlas 14 is used to determine the intensity and frequency of the storm compared to other past storms.

- *National Weather Service Offices - Post Storm Analysis and Flash Flooding Warnings*
  The use of Atlas 14 has been very helpful as comparing a storm to Atlas 14 data helps determine the severity of an event compared to past storms.

  Additionally, a NOAA product called FLASH - the Flooded Locations And Simulated Hydrographs - can compare rainfall in real-time to Atlas 14 numbers. This comparison has been useful during flash flood events to determine when there is a need to issue warnings and to inform flood thresholds. For example, after a storm is modeled to surpass an Atlas 14 10- to 25-year storm event, flooding can be expected within cities.

  Within the last two years, as more and more flash floods have been occurring and more storms have become intense, the National Weather Service's triggers for issuing their flash flood warning threat tags have changed. Atlas 14 data helps the National Weather Service Offices answer questions such as "when will houses start to flood" and "when should we use what tags." Presently, only forecasted "considerable flash flooding" or "catastrophic" flash flooding results in a warning. This is a change from before when all the categories of flash flood warnings would result in alerts. Now people have started to take action because they know a phone alert means the threat is significant.

- *Hydropower Dams: Probable Maximum Floods*
  Most dams, depending on the regulatory body, have several different regulatory requirements. While states typically regulate non-power generating dams, the Federal Energy Regulatory Commission regulates the dams that produce power. The use of Atlas 14 is common for dams that do not have direct federal regulations. In these cases, a probable maximum flood is established for most dams, and Atlas 14 is used for decisions around the design of the dam, especially as it relates to downstream hazards. These design floods are produced for new dams and also for existing dam maintenance and emergency designs.

Climate-Informed Users

- *Minnesota - Design Guidelines*
  In Minnesota, stormwater managers and the Department of Transportation use Atlas 14 numbers in their design guidelines. These users, desiring to add a factor for climate change, find that no one is doing it the same way, even regionally. Despite the expense, Minnesota's Department of Transportation worked with a private consultant to produce climate-informed numbers for future design use.

- *Future Projected Intensity Duration Frequency (IDF) Curves for the Chesapeake Bay*
  Requested by the Chesapeake Bay stakeholders, a project to better understand the future intensity duration frequency curves for the Chesapeake Bay used Atlas 14 as the basis of the work to plan, design, and build infrastructure assets to be more resilient. Proactively including climate science data, the Commonwealth of Virginia, via the Virginia Transportation Research Council and the Planning District Commission, choose to apply an adjustment factor to each Atlas 14 station. Presented as an online tool with tabular and graphical data (https://midatlantic-idf.rcc-acis.org), county-level intensity duration frequency curves are now publicly available for two different 50-year time periods (2020 to 2070 and 2050 to 2100) to match the Atlas 14's 50-year record.

  > *"There is a balance between a robust scientific method and something that people can use on the ground."*

- *New Jersey's Department of Environmental Protection's Atlas 14 Update to Inform Climate-Based Decision-Making*
  The state of New Jersey desired the best available climate science to inform the Department of Environmental Protection's decision-making. Since the last Atlas 14 update in New Jersey was done in 2000, New Jersey's Department of Environmental Protection wanted to update the data to reflect information up to 2020 and to include a climate adjustment factor to be applied to each existing NJ Atlas14 station.

  > *"People are concerned about it but don't exactly know what to ask for."*

- *What Will a Future Rainstorm Mean? Rutgers NJAdapt.org Platform*
  As the go-to place for state-specific climate data, information, and resources, Rutgers University's applied climate team has started the development of a new tool for the NJAdapt.org platform that will use Atlas 14 as a baseline and include climate projection data to illustrate predicted future rainfall.

- *New England's Precip.net*
  In 2005, when New England still hadn't been included in Atlas 14, decision-makers worked with Cornell University and the United States Department of Agriculture to produce www.Precip.net. This product uses sub-daily rainfall amounts and applied blanket climate-based adjustments to precipitation data for projected intensities. New Hampshire is the most active state in using these data, adopting Precip.net numbers as part of their state regulations. Atlas-14 Volume 10 was provided to the New England region in 2015 (and updated in 2019) as an update to Technical Paper 40 published in 1961.

  > *"If you can include non-stationarity in Atlas 14 you have changed the data for a lot of people, and we should be going there."*

- *Federal Highways Administration*
  The Federal Highway Administration recognizes Atlas 14 as the preeminent source of data to analyze and design transportation infrastructure for various rainfall volumes and coverage areas. It is viewed as an authoritative source to use when large events occur and event statistics

are being reported. The Federal Highway Processing Tool is a web-based software package that processes the Coupled Model Intercomparison Project Phase 5 (CMIP5) downscaled climate data at the local level into relevant statistics for transportation planners and designers. This agency views the Coupled Model Intercomparison Project Phase 5 data as an actionable source of projected estimates, and the funded National Weather Service's research into considering and applying climate projections to NOAA Atlas 14. The findings of these analyses were released in January 2022.

- *New York State Department of Transportation*
  As mandated by New York's Climate Risk and Resiliency Act, the best available climate science was sought regarding precipitation future projections for DOT planning and design criteria. Cornell University incorporated the climate data, which resulted in a 10-15% increase in the precipitation numbers projected by Atlas 14. Updated intensity duration frequency curves and accompanying graphics are publicly available and can be found online. This information is currently being used extensively by New York City.

  > *"This is really urgent. Right now, we have a large opportunity to get it right or a chance that we might get it wrong. Communities are going to be writing grants to get money for designing for the climate. People think they are doing enough, and they are not. Even a near-term best practice would be helpful."*

- *Department Of Defense - Incorporation of the Effects of Future Anthropogenically Forced Climate Change in Intensity Duration Frequency Values*
  As the Department of Defense looks at increasing the resilience of their infrastructure, they are looking to incorporate the effects of climate change into their planning. Using the current Atlas 14 numbers as their baseline, the Department of Defense is working with researchers to use statistical techniques to globally downscale meteorological (specifically water vapor) models. Nationwide in scope, these climate adjusted Atlas 14 values will be hosted on a website where users can retrieve climate-informed Atlas 14 numbers, with error bars. These data can then be applied in models to inform the planning at specific Department of Defense sites. More information can be found on the project's website.

  > *"The challenge lies with making leadership comfortable with making policy with this information."*

- *Massachusetts Climate Resilience Design Standards and Guidelines*
  The Commonwealth of Massachusetts, via statewide Executive Order 569 on climate change policies, developed "Climate Resilience Design Standards and Guidelines" for state-funded projects to assess climate resilience as part of its capital planning process. Now in beta, the Climate Resilience Design Standards Tool provides state-funded projects a preliminary climate change exposure and risk rating; recommends climate resilience design standards for projects with physical assets, and guidelines with best practices to support implementation. Grounded in scientific methodology using available climate science data for Massachusetts, the design guidance will be enhanced over time to incorporate new science, additional or changing climate

hazards, and ongoing stakeholder feedback. The design tool allows for flexibility to add in climate factors, exports the data into a table format and a GIS platform, and allows for climate-informed data to be directly included in a project. These updated Atlas 14 (extreme) precipitation standards are part of other updated resilience standards, including temperature and heat.

- Massachusetts Bay Transportation Authority - Planning Buildings and Modeling Flooding on the Tracks
  As part of climate resilience design, the Massachusetts Bay Transportation Authority applied climate-adjusted Atlas 14 numbers to build stations and perform flood modeling for the tracks.
- Quincy, Massachusetts' Bus Maintenance Facility
  The City of Quincy, Massachusetts used climate-informed Atlas 14 precipitation data in the design and building of a bus maintenance facility. The incorporation of these data allowed for greater facility efficiency and sustainability.

> *"This issue goes beyond just the water utility perspective. This is a city-wide issue. So much of this is land use and development."*

- *Stormwater Flood Modeling: Philadelphia and Camden, New Jersey*
  The cities of Philadelphia, Pennsylvania, and Camden, New Jersey worked with Drexel University to get updated, climate-informed, and precipitation-based stormwater amounts and durations. Using Atlas 14 as a baseline and then applying the Storm Water Management Model (SWMM) and Storm Water Management Model Climate Adjustment Tool (SWMM-CAT) based on Coupled Model Intercomparison Project Phase 3 (CMIP3) from EPA, these efforts factored climate into delta change factors and then applied the output to calculate the 100- and 50-year storms of the future.

> *"Federal and local climate change informed Atlas 14 versions would be a necessary next step. We want to be able to use it, but they need some sort of mandate to have to use it. Currently the messiness stands in the way of implementation."*

- *State of Illinois: Proactive Analysis of Rainfall Statistics*
  The state of Illinois updated its rainfall statistics at the state level with the intent of being proactive about stormwater flood mitigations. While they started using Atlas 14 as their baseline data, they updated it with new rainfall data, including more recent storms, and only included the past 75 years in their analysis. Illinois undertook this proactive approach to climate-informed planning and building to ensure these important projects reflect the most current data available.

- *Wisconsin's Department of Natural Resources and Department of Transportation Statewide Rainfall Analysis*

Wisconsin's Department of Transportation updated its statewide, climate-informed rainfall analysis. As part of the applied use of this updated data, the state's Department of Natural Resources is undertaking a review of all policies to better understand where rainfall statistics are applied and where the new rainfall data can be applied.

> *"It is in our business model to be risk-informed and future-focused"*

- *Philadelphia, Pennsylvania - Water Utility Climate Adaptation*
  Philadelphia, Pennsylvania is working on climate adaptation planning and design guidelines for its water utilities. They recently completed a climate-risk assessment of their utility and have begun ground-truthing existing infrastructure to determine risks across anticipated useful life. Additionally, for planning purposes, Philadelphia is creating future hourly timescales for Hydrologic and Hydraulic modeling and sewer design work by taking 117 years' worth of data from their airport rain gauge. Using this information, produced products will lead to the development of updated Intensity duration frequency curves which will be compared against the baseline Atlas-14 data. Considered by Philadelphia as actionable science, these curves will be used as future planning and design guidelines are developed.

- *New York City's Stormwater Flood Maps and Projects*
  In 2018, New York City Council passed Local Law 172, which required the city to produce maps showing areas most vulnerable to increased flooding due to anticipated climate change. This law also required a published, long-term plan to prevent or mitigate increased flooding. The resultant Stormwater Resiliency Plan and maps will be updated at least every four years, and periodically as new modeling is available and as climate change projections are updated. Used more for planning than design, New York City is offering the public the chance to "see" the climate-informed 10- and 100-year rain events on a beta interactive online map server. This data sharing represents the first time New York City is illustrating a flood risk beyond the coastal flood risk.

  > *"Given the nature of large infrastructure systems, you just cannot start rebuilding things that frequently. We could start gradually enforcing higher standards on developers."*

  Additionally, when New York City designs a stormwater project with an infiltration component, they typically plan using a 2040 to 2050 timescale. They used an Atlas 14 baseline with a climate-projections change factor for their design, obtaining this data from the NE Regional Climate Center.

- *New York City Transit System: Coney Island Transit Yard*
  The Coney Island Transit Yard is a home for New York City subway car storage. To protect this critical infrastructure, the New York City Transit System has been designing floodways around the structure using the historical Atlas 14 data and climate projected rainfall data. While one approach to flood mitigation was the installation of emergency stormwater pumps, this

approach wasn't deemed cost-effective. The most practical approach became the projected 25-year storm versus the 100-year storm.

> *"We need federal leadership on this issue. That would send signals to the states and in turn to the locals."*

- *Emergency Action Planning: Dams*
  In the field of dam design and maintenance, understanding emergency inundation, or what happens if the dam fails, is important. Questions to be answered include: is there enough downstream space; is the reservoir able to pass high flows; is the structure adequate to withstand that flow, and is the emergency response adequate to lessen impacts?

  Used especially for small projects, Probable Maximum Precipitation informs the Probable Maximum Flood. Planning for these emergency events can include numbers up to 1 in the 10,000-year event. This planning requirement exceeds what Atlas 14 can provide, so statewide flood studies are often used, along with regression equations and site-specific Probable Maximum Precipitation studies. As a comparison to the resultant output, the Atlas 14 output would be checked and a longer, extended data set would be used for a future projected hypothetical storm.

DATA CHALLENGES AND LIMITATIONS

While Atlas 14 is a widely used product, users noted several challenges and limitations. None of these are new, but the issues have taken on increased importance as the impacts of climate-induced, extreme precipitation has increased, and issues with unequal access to products and services have been highlighted. This input is summarized in the following categories:

- ***Data Update Frequency***
  A noted challenge of the current Atlas 14 product was the length of time between updates. Users expressed concerns that the length of time between updates could result in more recent (and sometimes extreme) precipitation events not being factored into designs for infrastructure projects, projects that usually have a very long life expectancy.

- ***Funding***
  Atlas 14 updates are currently funded on a state-by-state or regional basis, commonly with state departments of transportation and the Federal Highway Administration. States or regions that do not have funding for updates may have data sets that are 50 or more years old.

- ***Nationwide Coverage***
  Atlas 14 does not currently cover the Pacific Northwest. Users expressed a desire for nationwide coverage, noting this regional gap is very constraining when working on projects across the United States. For some of the projects where there are regional volumes, Atlas 14 can be used, pending engineering review and consideration of the data period represented. For projects in the Pacific Northwest, you cannot use Atlas 14, which leads to an inconsistent federal approach.

- ***Data Update Timelines***
  Depending on the timing of a volume update, primarily regarding the Pacific Northwest, Atlas 14 can use precipitation data only as far back as 50+ years. Past storms that may have occurred since the time of the last update are not being captured. Users feel the Atlas 14 data can be a significant underestimate, especially where recent, intense storms are not included and when the data period of record may not cover a statistically reliable period of time.

- ***Stationarity Assumption***
  Atlas 14's precipitation frequency studies make the implicit assumption that the past provides a means for predicting the future, i.e. that climate is stationary. The Atlas 14 methodology used to derive Intensity Duration Frequency curves is based on this assumption of stationarity - or that the variability seen in the historic record will be the same variability seen in the future. Climate scientists note recent increases in extreme precipitation and climate models predict more extreme precipitation increases. Users expressed a desire for the Atlas 14 data to include non-stationarity assumptions so that there is federal consistency regarding the availability of climate-informed Atlas 14 data.

  This challenge is not a new one for Atlas 14 users. Previous documents have taken a close look at the current status of Atlas 14 and the procedures needed to update calculations to include climate change. Here are two examples.
  - National Academy report that was financed by the National Weather Service
  - Advisory Committee on Water Information: Product Needs Documents

- ***Future Projection Methods***
  There are currently numerous methods for adding climate-informed projections to Atlas 14 figures. While diversity in methodology was noted as a strength by one user, many others were interested in federal leadership when adding climate-informed data into Atlas 14 (a.k.a. the use of a non-stationarity assumption). Users also noted that as climate projection information gets updated, the data incorporated into Atlas 14 would have to get updated as well. More ideas around future update methods and data update frequency are included in the sections below.

- ***Equitable Data Access***
  Users expressed concerns with equitable data access as it relates to Atlas 14: who has updated numbers and who can afford to add in climate prediction information? The small regional wastewater commissions and regional utilities lack the knowledge and the staff to add climate projected data to what is provided by Atlas 14. One user said, "Where places are lacking in resources, lacking Atlas 14 creates haves and have nots." Further, there are concerns that outdated information being used for designs of water maintenance infrastructure in many small communities will further reduce the resilience of these communities.

USER IDEAS

Updating the Web Portal. Study participants were asked to provide input regarding web portal improvements. Their suggestions included the following.

- Adding the ability to export data straight into Excel.
- Regarding the ability to put in a city location or latitude and longitude points for a specific location - adding clarity to whether data output is point data or interpolation of the region.
- Adding more context and data use suggestions for the content located in "other tabs."
- Ensuring NOAA lets users know when website data updates and new features are added. Some users mentioned they did not even know that the precipitation frequency data server had gone live, and data could be retrieved on a website as opposed to paper versions.
- Users requested that not only the Atlas 14 numbers be available for download, but the Intensity Duration Frequency curves also be made available for download.
- To be used in multi-hazard assessments and enhance GIS modeling, the addition of GIS mapping layers with Atlas 14 information was cited as a need.
- Clear identification (especially at the bottom of graphics) that specifies what years the data represents.
- Documentation and messaging to users when new data gets incorporated.
- If climate projections are added to Atlas 14, there was a suggestion that both data sets (assuming stationarity and assuming nonstationary) be made available.

Provide Federal Leadership on a Consensus Climate Projections Approach. Lacking federal guidance for incorporation of climate projections into Atlas 14, users cite frustration with "all different projection approaches" and admit to "confusion on the ground." Users say federally agreed upon climate-informed precipitation values would be very beneficial, as the data would be provided by a "trusted-federal source." From a process standpoint, it was suggested that NOAA's Hydrometeorological Design Studies Center compile all the existing best practices and determine a consensus practice, using a National Academy of Sciences panel approach. Suggestions for the makeup of the panel included:

- Climate modelers for data, statistics, regionalization, and downscaling.
- End users to include science and engineering professional societies, meteorological societies, the American Society of Engineers and compound flooding group, and the Water Utility Climate Alliance.
- Professionals familiar with design standards and guidelines for incorporation of output into regulations.
- State climatologists; and,
- Science translators.

Once a consensus approach is agreed upon, it could be put into practice, along with updated Atlas 14 numbers, and published via the existing precipitation frequency data platform. It was also suggested that extended recurrence intervals out further than 1000 years, even with reduced confidence, would be useful in preparing for the most extreme events.

If implemented, this consensus process would be analogous to the process that NOAA undertakes, with other federal agencies, when it updates, and releases sea level rise technical reports used in the National Climate Assessment process.

Explore New or Expanded Partnerships.

- A Partnership with FEMA - Like the way sea level rise now has to be factored into federally funded projects as a future condition under the Federal Flood Risk Management Standard, the use of updated Atlas 14 data with non-stationarity assumptions could be used the same way. NOAA could establish a partnership with FEMA to make connections between future non-stationarity versions of Atlas 14 data and federally funded projects under FEMA's Hazard Mitigation Grants and Building Resilient Infrastructure and Communities program.
- Partnerships Within NOAA - Users suggested a coordinated platform be developed to highlight and provide the alignment and integration of NOAA's climate change data efforts. NOAA's offices, such as the National Weather Service, NOAA's Climate Program Office, National Centers for Environmental Information, and NOAA's National Climatic Data Center, could share an integrated platform allowing their complementary data to be more easily retrieved, cross-promoted, integrated, and shared. This collaborative approach would help data users understand how their risks are changing and aid users in making informed climate-related decisions.
- A Partnership with the Water Utility Climate Alliance - Another suggestion was a partnership with the Water Utility Climate Alliance who is actively putting together a list of ways in which climate models are being used in precipitation projections.

Develop and Offer User Training and Extension.

- Training Courses - Users cite numerous niche National Weather Service products (such as Atlas 14) which could use more explanation to ensure appropriate use. Inspired by NASA's applied remote sensing courses - Applied Remote Sensing Training - it was suggested that NOAA offer training focused on the use of precipitation and other weather-related data. The NASA courses are structured as life-long learning modules focused on delivering skills and concepts, with a certification at completion. This model is analogous to an informal professional development program. A similarly offered NOAA National Weather Service course could focus on NOAA National Weather Service data, how to use it, and how not to use it. NOAA could also consider a related or similar training course on NOAA's National Centers for Environmental Information data.
- Extension to Users - Users want to be supported in their use of Atlas 14, especially if the proposed data changes are realized. Resources or support for each state were suggested to help with the data translation, technical assistance, and use. Resources should be targeted toward different types of end-users to ensure the information is actionable. The NOAA Regional Integrated Sciences and Assessments programs were cited as potential "within NOAA" partners who could be used for local extension with the right resources provided.

Provide for More Frequent Atlas 14 Updates. When asked to provide an ideal Atlas-14 update frequency, users provided a range of responses. While there was some synergy around a 5–10-year timeframe for updates, a sample of specific responses is provided as illustrative of the context given.

- *"A full Atlas 14 update could happen every 10-20 years or when new climate projections are released."*
- *"A 10-year update is an ideal timeframe. Once a project starts, 'the data is the data.' Whatever is the standard at that time, it gets carried over to the project."*
- *"Doing an update every 5-10 years makes sense because any changes to the 2-year and 100-year storms are based on periods of record and how much it shifts."*

- *"In an ideal world, we would see it updated every year, where an analysis is done with a specific selection of different periods - i.e., select the whole record or just the past 2--30 years. But five years is probably more realistic, and 10 years might be too spaced out."*
- *"Frequent updates would incorporate the actual events that we see and allow us to be adaptable in the face of a changing climate future. This is the same way we are asking communities to adapt to the changing futures. These updates can become parts of the monitoring piece of adaptation. For example, if things emerge in regions more frequently in one than in other regions, an update may be needed there. Observations may lead to updates."*
- *"The update frequency should be every 5 years; the way things are changing with climate. This would be along with an Intergovernmental Panel on Climate Change update schedule."*

Explore Data Crowdsourcing and Sharing. Atlas 14 Users were asked about the idea of crowdsourced precipitation data and data sharing with NOAA's National Centers for Environmental Information. Perspectives on this topic ranged from supportive to uncertain to unsupportive. Thoughts on the challenges, opportunities, and important considerations associated with this idea are provided here.

Challenges	**Opportunities**	**Important Considerations**
Quality control can be quite variable with all sorts of data being ingested	The Community Collaborative Rain, Hail and Snow (CoCoRaHS) networks could get involved, adding a significant number of local data sources.	Data analytics would need to be run to ensure the format for the data was the format that Atlas 14 wants the data in.
The length of records for the observations may not be long enough to be considered "long-term" like some of the Atlas 14 stations	More data is better, especially for localized events. By interpolating the data, analyses such as, "does the rainfall over the past 24 hours match the frequency of a 1/25 year storm or 1/50 year storm?"	"Other data" may be considered "unofficial data." Without information on how that station is maintained and if it has quality controls, it would not be considered official.
Quality assurance and Quality control can be an issue - Who collected it? How was it collected?	It is useful to bring in more data because there is a lot available out there.	For analytical purposes, more than general information about the data collected would be needed.
	For anyone in the GIS world, data sharing is key. "Don't recreate it, share it."	Proper citing of the collector and knowing details about the type of gauge being used in important information.
	The more data there is available, the more realistic the data models will be, especially considering non-stationarity.	

Challenges	Opportunities	Important Considerations
	The National Center for Environmental Information archives other information including some paleo-flooding information. Since Atlas 14 is so accessible as at least as a baseline, integration with some of these other datasets would give a fuller picture and make all the data accessible.	

CLOSING

Atlas 14 is an important NOAA product, and NOAA is a trusted source of data and information. The author of this report, and the people who participated in these interviews, hope this report will be used to ensure this data resource stays relevant and does its part to prepare the coast for future generations.

APPENDIX

ATLAS 14 BACKGROUND

Defining NOAA's Atlas 14

Since the early 2000s, NOAA's National Weather Service has collected observations and recorded data on rainfall and precipitation amounts. Additionally, the National Weather Service has used these historical data in statistical analyses that assign probabilities to rainfall depths. These probabilities are expressions of the likelihood of a certain volume of rainfall to happen at a given time and are provided as precipitation frequency estimates. Historical precipitation volume data, which is important for these estimates, is based on rainfall intensity, duration, and frequency estimates using data collected from observing stations across each geographic region. NOAA's National Weather Service's Office of Water Prediction's Hydrometeorological Design Studies Center provides these data in a variety of formats (digital data downloads, geospatial maps, graphs, and tables), along with supplementary information and documentation. These statistical analyses, collectively known as 'Atlas-14', are provided online at NOAA's Precipitation Frequency Data Server.

Funding and Frequency of Updates

Currently, as updated estimates and relevant supplementary information are obtained, the information is published in NOAA Atlas 14 in volumes for various geographic regions of the country. There is currently no set update timeline, with some Northwestern states lacking updated data for more than 50 years, and others not having updates for 20 or more years. The last completed volume, Volume 11, was focused on Texas. Volume 12 is now actively being updated with Idaho and Montana, with an acknowledged gap in Wyoming. Additionally, there is currently an interagency agreement with the Federal Highways Administration to do a small update in the Mid-Atlantic region (Maryland, Delaware, Virginia, and North Carolina), which would be Volume 13. Volume 14 is set to be an update for Louisiana. It is currently typical for states to work with their state Departments of Transportation and the Federal Highway Administration to fund updates relevant to their region.

RECENT DISCUSSIONS REGARDING ATLAS 14

Recently, there have been plenty of discussions regarding Atlas 14. These conversations are focused on known challenges such as:

- the lack of data for the entire US.
- the need for data updates; and
- the desire to include non-stationarity to account for climate factors.

NOAA's National Weather Service's Hydrometeorological Design Studies Center has been active in these conversations, acknowledging that small individual studies are not an effective practice and recognizing the need to assess the opportunities and challenges in the current Atlas 14 approach. As such, the Hydrometeorological Design Studies Center and the Federal Highway Administration contracted with Penn State and the University of Illinois to review current practices and discuss the inclusion of non-stationarity and climate projections in future volumes. These findings were released in January 2022.

Additionally, federal decision-makers have taken note of the importance of updated and actionable precipitation information through a variety of recent actions on the Hill including bills and pending funding. Some of these include:

- S. 4462 "Flood Level Observation, Operations and Decision Support Act" or the FLOODS Act" (Passed the Senate 11/16/2020)
- H. R. 1437 To amend the Weather Research and Forecasting Innovation Act of 2017 to direct the National Oceanic and Atmospheric Administration to provide comprehensive and regularly updated Federal precipitation information, and for other purposes. (February 26, 2021)
- Infrastructure Act, Provision 3 Spend plan under review at OMB (January 2022) would provide funds to update Atlas-14.

PROCESS USED TO OBTAIN REPORT INFORMATION

Initial Interviews

One-on-one conversations with Atlas 14 users were conducted during the late summer and fall of 2021. These conversations followed a semi-structured interview process and occurred virtually through the use of online meeting platforms. The interviews were not recorded but notes were taken.

Use Case Participants

The initial list of users, provided by NOAA's Climate Program Office and NOAA's National Centers for Environmental Information, grew via the snowball method - interviewees recommended other appropriate parties to include in the process. A total of nineteen users were interviewed, representing the following user types and titles:

Applied Users

- Water Resource Engineer/Climate Adaptation
- Physical scientist
- Design Engineer
- Stormwater Practitioner/Professional Engineer
- Water District Climate Adaptation Program
- Technical Precipitation Analyst
- Integrated Water Management
- Climate Resilience Extension
- Hydrologist
- Meteorologist
- Hydrologic Modeler
- Civil engineer/stormwater management
- Hydraulics and Hydrology Specialist
- Hydraulic Engineer

Academic Users

- Applied Scientist
- Applied Climate Scientist
- Applied Climate Scientist
- Climate change and Sustainability
- Civil and Environmental Engineering

Interview Questions

Topics covered by the interview questions included:

- What data sets are being used for your rainfall frequency calculations?
    - If you are using Atlas 14, Why and how are you using the data?
    - What is your use of NOAA's Atlas 14 tool/data or other existing (NOAA and non-NOAA) data sets?
    - If Atlas 14 is not the "go-to" place for this type of information, what is and why?
- Do you work with users of rainfall information? If so, who are they?
- Do you want to/need to integrate changing climate conditions into your work?
    - Is this a mandate? By whom?
    - Are clients asking for it?

- What are your thoughts on introducing crowdsourcing and data sharing/sharing data into the National Center for Environmental Indicators?
    - Where are the opportunities? Where are the challenges?
- Thinking about the future, what would be the ideal ways to access and interact with Atlas 14 data?
    - Ideal update frequency?
    - Ideal platform for data download/analysis?
    - Ideal model and statistics alignment?