

# ***Development of Flood Hazard Information Digests for Operating NPP sites***

## **3<sup>rd</sup> Annual Probabilistic Flood Hazard Assessment Research Workshop**

December 4-5, 2017

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Curtis Smith, Ph.D.

[www.inl.gov](http://www.inl.gov)



## ***Project Overview***

- Organize flooding information and build database of currently available site-specific flood hazard information to
  - Support development of a risk-informed analytical approach for flood hazards
  - Help Senior Reactor Analysts (SRAs) develop simple flooding models and reasonable hazard curves that fit into SAPHIRE modeling world
- ...in order to
  - Develop regulatory tools and guidance for NRC staff with regard to probabilistic flood hazard assessment (PFHA) for nuclear facilities
  - Support risk-informed reactor oversight activities such as evaluating the risk-significance of inspection findings
- **Expand the digests to include other natural external hazard information**

# Status

- **Completed**
  - Flooding Hazard Information Needs Workshop
  - Reviewed existing NRC databases
  - Designed and implemented beta of flood hazard information database
  - Beta testing/demonstrations
  - Majority of key flood related data sources have been populated
- **Remaining**
  - Post Fukushima flooding reevaluation information
  - Expansion to other natural external hazards
  - User Guide Updates

# External Hazards Web Application

Welcome



## External Hazards Information Digest

PROCEED TO SITE



\*Available only to authorized NRC staff and contractors

# External Hazards Dashboard

External Hazards Dashboard

Select Plants

Filters

☐ ARKANSAS 1

☐ ARKANSAS 2

☐ BEAVER VALLEY 1

☐ BEAVER VALLEY 2

☐ BRAIDWOOD 1

☐ BRAIDWOOD 2

☐ BROWNS FERRY 1

☐ BROWNS FERRY 2

☐ BROWNS FERRY 3

☒ BRUNSWICK 1

☒ BRUNSWICK 2

☐ BYRON 1

☐ BYRON 2

☐ CALLAWAY

☒ CALVERT CLIFFS 1

☒ CALVERT CLIFFS 2

Activities/Reports Across Selected Plants

View activity related reports, such as SDPs and FSARs by hazard for all currently selected (on dashboard) plants.

Recent

FLOOD

HIGH WIND

EXTREME TEMP

Calvert Cliffs 1

Docket: 317

Region: 1

Type: PWR

Vendor: Combustion Engineering

Location Type: Coastal

Location: Lusby, MD (40 MI S of Annapolis, MD)

Licensee: Baltimore Gas and Electric

Recent

FLOOD

HIGH WIND

EXTREME TEMP

Brunswick 1

Docket: 325

Region: 2

Type: BWR

Containment Type: Mark I(C)

Vendor: General Electric

Location Type: Coastal

Location: Southport, NC (2 MI N of Southport, NC)

Licensee: Carolina Power and Light

Recent

FLOOD

HIGH WIND

EXTREME TEMP

Brunswick 2

Docket: 324

Region: 2

Type: BWR

Containment Type: Mark I(C)

Vendor: General Electric

Location Type: Coastal

Location: Southport, NC (2 MI N of Southport, NC)

Licensee: Carolina Power and Light

Recent

FLOOD

HIGH WIND

EXTREME TEMP

Calvert Cliffs 2

Docket: 318

Region: 1

Type: PWR

Vendor: Combustion Engineering

Location Type: Coastal

Location: Lusby, MD (40 MI S of Annapolis, MD)

Licensee: Baltimore Gas and Electric

Recent

FLOOD

HIGH WIND

EXTREME TEMP

Diablo Canyon 1

Docket: 275

Region: 4

Type: PWR

Vendor: Westinghouse

Location Type: Coastal

Location: Avila Beach, CA (12 MI WSW of San Luis Obispo, CA)

Licensee: Pacific Gas and Electric

Recent

FLOOD

HIGH WIND

EXTREME TEMP

Snow/Ice Loads

Seismic

5

# Drill-down to Plant Specific Activities...

Flood Hazard References

←

Activity References

FSAR

IPEEE

SDP

Data References

COASTAL DATA

DESIGN BASIS / REEVALUATION DATA

PRECIPITATION DATA

RISK MODELS

STREAM FLOW DATA

WATERSHEDS

Flood Related **FSARs** for Brunswick 1

FSAR-ALL in /Flooding Group/FSARs

Master list of FSARs

Ⓜ

✎

NRC FSAR Link

Note: link is inside NRC firewall.

Publish Date:

Upload Date: 2017-01-11

Flood Related **IPEEEs** for Brunswick 1

IPEEE NUREGS in /Flooding Group/IPEEE

Publicly available reference to IPEEE NUREGs

Ⓜ

✎

NUREG-1742

Perspectives Gained From the Individual Plant Examination of External Events (IPEEE) Program (NUREG-1742)

Publish Date:

Upload Date: 2017-02-07

IPEEE BSD1 in /Flooding Group/IPEEE

Ⓜ

✎

Flood Related **SDPs**

🔍

Enter search text

×

Sort by ▾

SUPPORTING DOCUMENTS

SDP

Document Links and Description

Aug 1, 2012

SDP: EA-14-048

White

IR: [ML14080A229](#) 05000324/2013011 and 05000325/2013010

IR: [ML14108A306](#) 05000324/2013011 and 05000325/2013010

Letter: [ML14149A149](#) EA-14-048 Final SDP Letter

SDP Finding: The NRC characterized the finding as White, a finding of low to moderate risk significance

NRC inspectors at Brunswick identified that the licensee failed to identify and correct conditions adverse to quality involving degraded and nonconforming flood penetration seals and openings in multiple safety-related buildings. In August and September of 2012, the licensee performed walkdowns of flood protection features in accordance with NEI 12-07 and identified degraded and/or nonconforming flood protection features, the majority of which were attributed to degraded or nonconforming flood penetration seals. Based on these findings, the inspectors determined the licensee had not fully

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# ...and Plant Specific Data Sources

Flood Design Basis
Brunswick 1

Activity References
FSAR
IPEEE
SDP
Data References
COASTAL DATA
**DESIGN BASIS / REEVALUATION DATA**
PRECIPITATION DATA
RISK MODELS
STREAM FLOW DATA
WATERSHEDS

CURRENT DESIGN BASIS FLOOD HAZARDS
R2.1 REEVALUATED FLOOD HAZARDS

Current Design Basis Flood Hazards
Demo Data

Mechanism	Stillwater Elevation	Waves/ Runup	Design Basis Hazard Elevation	Reference
Local Intense Precipitation				
East Switchyard	100.0 ft msl	100.0 ft	100.0 ft msl	FHRR Section 3.4.1
Lower plant area	100.0 ft msl	100.0 ft	100.0 ft msl	FHRR Section 3.4.1
West Channel	100.0 ft msl	100.0 ft	100.0 ft msl	FHRR Table 11-1
Streams and Rivers				
	100.0 ft msl	100.0 ft	100.0 ft msl	FHRR Section 3.4.2 FHRR Section 3.4.8
Failure of Dams and Onsite Water Control/Storage Structures				

Sources: NRR's Mitigating Strategies Flood Hazard Information Database and Army Corp of Engineers (ACE)



# Risk Models

Flood Risk Models

Brunswick 1

Activity References

FSAR

IPEEE

SDP

Data References

COASTAL DATA

DESIGN BASIS / REEVALUATION DATA

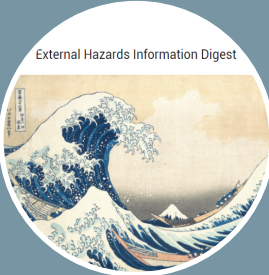
PRECIPITATION DATA

RISK MODELS


STREAM FLOW DATA

WATERSHEDS

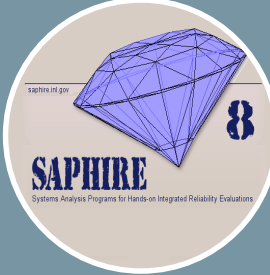
Flood Hazard Risk Models



External Hazards Digest



Safety Portal

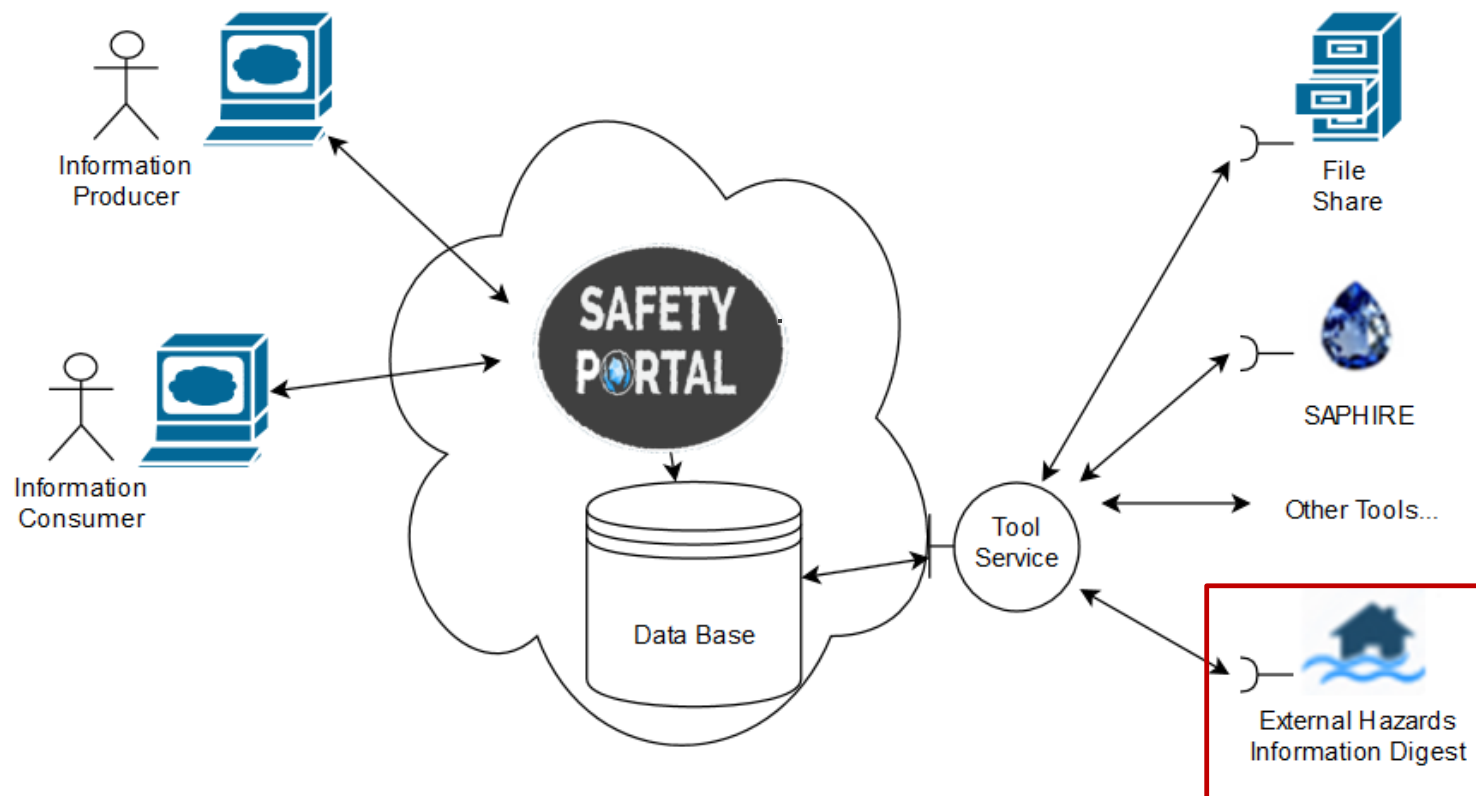


SAPHIRE

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# Integration with Safety Portal



# Watershed Data

Watersheds

Brunswick 1

Activity References

FSAR

IPEEE

SDP

Data References

COASTAL DATA

DESIGN BASIS / REEVALUATION DATA

PRECIPITATION DATA

RISK MODELS

STREAM FLOW DATA

WATERSHEDS

Watersheds for Brunswick 1

Longitude & Latitude -78.010278, 33.958333

Hydrological Unit Codes (12 digit)

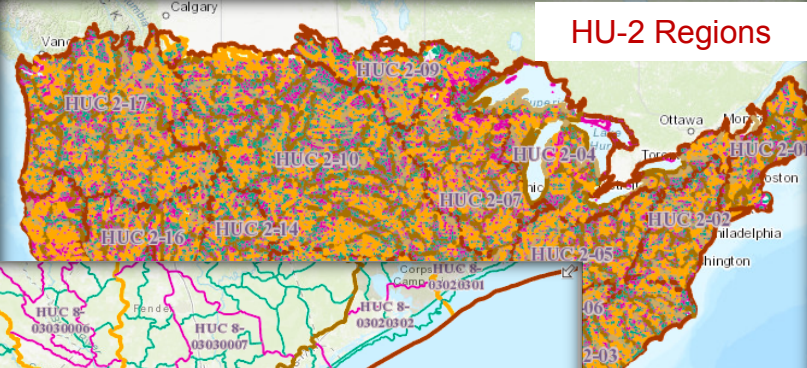
030300050801

030300050803

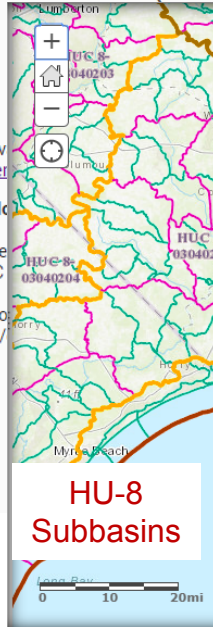
Watershed maps are available at the [Boundaries Map Viewer](#).

- Copy/paste the location into the search bar,
- then press the search button.
- Click on the HUC box,
- then click the "Zoom In" button.
- Use the zoom in/out buttons to zoom in/out.

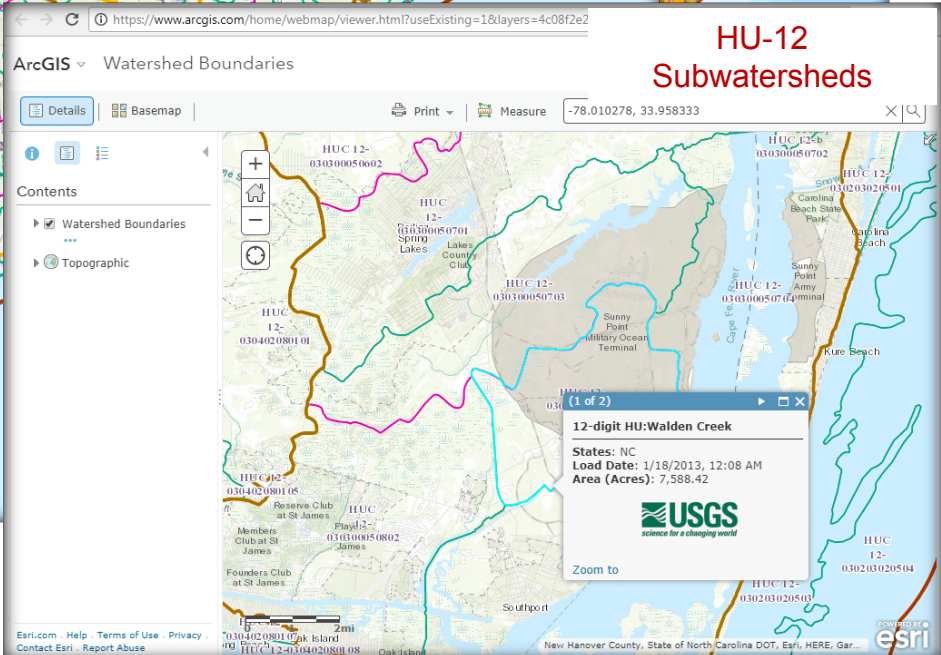
HU-2 Regions



HU-8 Subbasins



HU-12 Subwatersheds



Sources:

USGS and ArcGIS

# Precipitation Data

Precipitation Data

Brunswick 1



Activity References

FSAR

IPEEE

SDP

Data References

COASTAL DATA

DESIGN BASIS / REEVALUATION DATA

**PRECIPITATION DATA**

RISK MODELS

STREAM FLOW DATA

WATERSHEDS

## Precipitation Data for Brunswick 1

Latitude & Longitude 33.958333, -78.010278



NOAA Atlas 14 Precipitation Data Downloads

[Partial duration series \(PDS\) CSV file](#)

[Frequency annual maximum series \(AMS\) CSV file](#)



[NOAA Atlas 14 Database precipitation frequency information](#)

The Precipitation Frequency Data Server (PFDS) is a point-and-click interface developed to deliver NOAA Atlas 14 precipitation frequency estimates and associated information. Enter the latitude and longitude of the plant to display its precipitation estimates.



[Current NWS Probable Maximum Precipitation \(PMP\) Documents](#)

Index of Hydrometeorological regional reports for Probable Maximum Precipitation (PMP) guidance and studies.

[HMR51](#) (1978) Probable Maximum Precipitation Estimates, United States East of the 105th Meridian

[HMR52](#) (1982) Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian

[HMR53](#) (1980) Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates, United States East of the 105th Meridian



[Isopleth plots](#) for 100 year interval

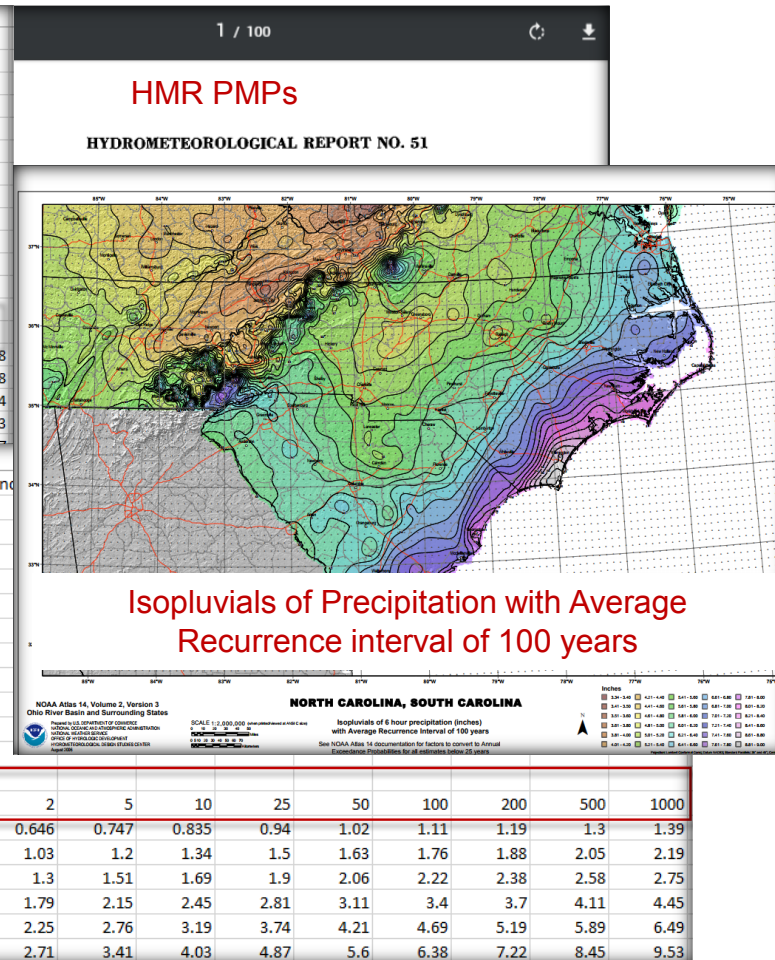
NOAA Atlas 14 cartographic maps of precipitation frequency estimates for selected average recurrence intervals.

[1 hour](#), [6 hour](#), [24 hour](#), [48 hour](#), [10 day](#), [30 day](#), [60 day](#)

# Examples of precipitation data

1	Point precipitation frequency estimates (inches)									
2	NOAA Atlas 14 Volume 2 Version 3									
3	Data type: Precipitation depth									
4	Time series type: Annual maximum									
5	Project area: Ohio River Basin									
6	Location name (ESRI Maps): None									
7	Station Name: None									
8	Latitude: 33.958333°									
9	Longitude: -78.010278°									
10	Elevation (USGS): None None									
11										
12										
13	PRECIPITATION FREQUENCY ESTIMATES									
14	by duration for AEP:	'1/2	'1/5	'1/10	'1/25	'1/50	'1/100	'1/200	'1/500	'1/1000
15	5-min:	0.594	0.73	0.826	0.936	1.02	1.1	1.18	1.29	1.38
16	10-min:	0.951	1.17	1.32	1.49	1.62	1.75	1.88	2.04	2.18
17	15-min:	1.2	1.48	1.67	1.89	2.05	2.21	2.37	2.57	2.74
18	30-min:	1.65	2.1	2.42	2.8	3.09	3.39	3.68	4.09	4.43
19	60-min:	2.07	2.69	3.15	3.73	4.18	4.57	4.97	5.57	6.17
20	2-hr:	2.5	3.34	3.99	4.85	5.48	6.07	6.67	7.57	8.43
21	3-hr:	2.66	3.58	4.31	5.32	6.03	6.72	7.41	8.61	9.71
22	6-hr:	3.36	4.51	5.45	6.74	7.75	8.76	9.77	11.57	13.17
23	12-hr:	3.94	5.34	6.47	8.07	9.38	10.69	12.00	14.20	16.10
24	24-hr:	4.55	6.26	7.6	9.6	11.2	12.8	14.4	17.4	19.7
25	2-day:	5.21	7.09	8.56	10.7	12.6	14.5	16.4	20.0	22.9
26	3-day:	5.45	7.37	8.85	11	13.0	15.0	17.0	21.0	24.0
27	4-day:	5.69	7.65	9.14	11.3	13.4	15.5	17.6	21.7	24.8
28	7-day:	6.42	8.57	10.2	12.4	14.7	17.0	19.3	24.0	27.3
29	10-day:	7.16	9.41	11.1	13.4	15.9	18.4	20.9	25.7	29.2
30	20-day:	9.55	12.4	14.4	17.1	20.2	23.3	26.4	32.0	36.1
31	30-day:	11.8	15.1	17.3	20.3	23.8	27.3	30.8	37.0	41.1
32	45-day:	14.5	18.2	20.8	24.1	28.1	32.1	36.1	43.0	47.1
33	60-day:	17.8	22.1	24.9	28.6	33.1	37.1	41.1	49.0	53.1
34										
35	PRECIPITATION FREQUENCY ESTIMATES AT UPPER BOUND OF 90%									
36	by duration for AEP:	'1/2	'1/5	'1/10	'1/25					
37	5-min:	0.641	0.787	0.891	1.01					
38	10-min:	1.03	1.26	1.43	1.61					
39	15-min:	1.29	1.6	1.8	2.04					

Sources:  
National Weather Service  
and NOAA Atlas 14



Average Recurrence Intervals



# Stream Flow Data

## Stream Flow Data Brunswick 1

Activity References

FSAR

IPEEE

SDP

Data References

COASTAL DATA

DESIGN BASIS / REEVALUATION DATA

PRECIPITATION DATA

RISK MODELS

STREAM FLOW DATA

WATERSHEDS

### Stream Flow Data for Brunswick 1

United States Geological Survey

02105769  
[Cape Fear R A](#)  
Summary of a

02105500  
[Cape Fear R A](#)  
Summary of a

National Weather Service

NWSWLON7  
Cape Fear R  
[Hydrological I](#)

NWSRDEN7  
Atlantic Coa  
[Hydrological Prediction Service](#)

USGS  
science for a changing world  
National Water Information System: Web Interface  
USGS Water Resources  
Data Category: Site Information  
Unit

USGS 02105769 CAPE FEAR R AT LOCK #1 NR KELLY, NC

Available data for this site

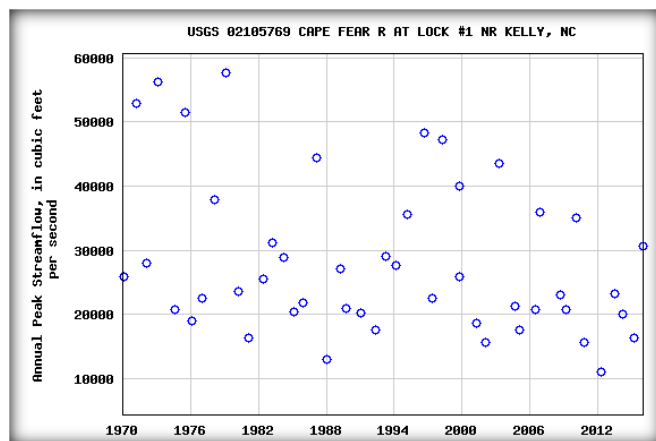
SUMMARY OF ALL AVAILABLE DATA  
SUMMARY OF ALL AVAILABLE DATA  
Location map  
Time-series: Current/Historical Observations  
Time-series: Daily data  
Time-series: Daily statistics  
Time-series: Monthly statistics  
Time-series: Annual statistics  
Surface-water: Peak streamflow  
Surface-water: Field measurements  
Water-Quality: Field/Lab samples  
Water-Year Summary  
EPA Surf your watershed: Offsite

Stream Site

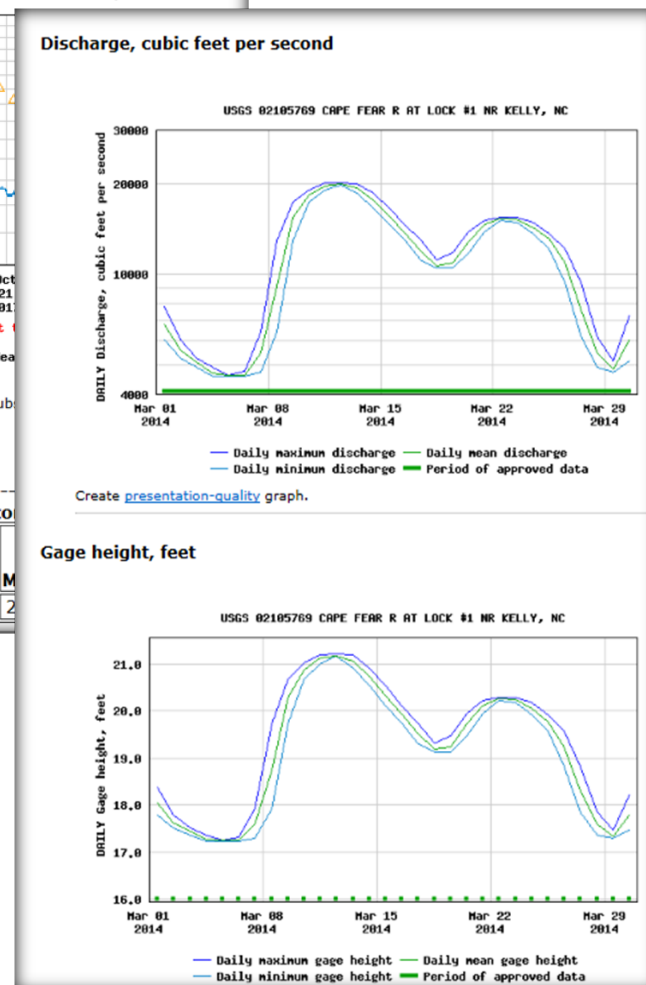
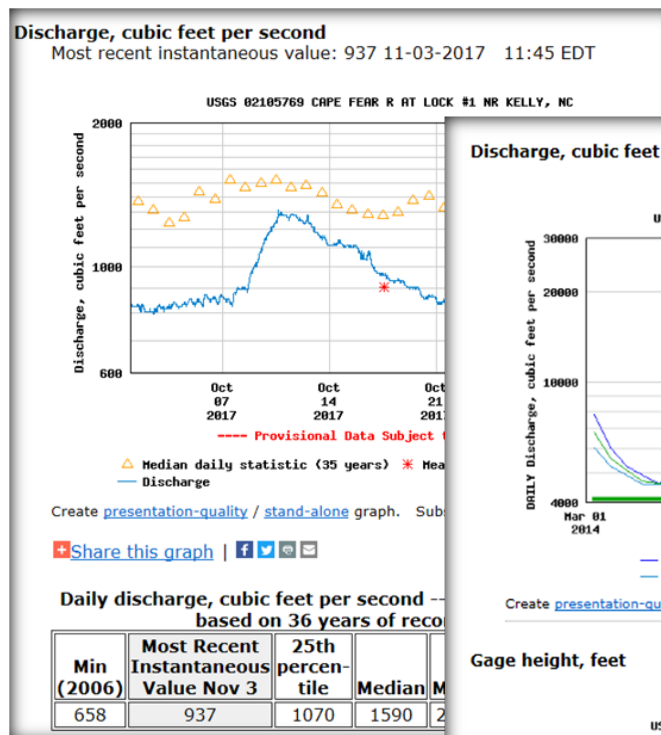
DESCRIPTION:  
Latitude 34°24'16", Longitude 78°17'37" N  
Bladen County, North Carolina, Hydrologic Unit  
Drainage area: 5,255 square miles  
Datum of gage: -2.90 feet above NGVD29.

# Examples of stream flow data

Annual maximum series of peak flow



Discharge data in the past seven days, available in 15 minute detailed increments



Source:  
USGS



Discharge and gage height for a peak event

# Coastal and Great Lakes Data

## Coastal Data for Brunswick 1

Flood Hazard Re
Activity References
FSAR
IPEEE
SDP
Data References
COASTAL DATA
DESIGN BASIS / REEVAL
PRECIPITATION DATA
RISK MODELS
STREAM FLOW DATA
WATERSHEDS

NOAA Tides and Currents

[Tide and Current Stations Overview Map](#)  
This map displays the available tide and current stations. The list below for specific links to gages that contain a mix of datums, sea level trends, and other information.

Tide and Current Station direct links

- [8658120 Wilmington, NC](#)
- [8658163 Wrightsville Beach, NC](#)
- [8661070 Springmaid Pier, SC](#)

NOAA National Hurricane Center

[National Storm Surge Hazard Maps](#)  
This ArcGIS map depicts storm surge hazards along the U.S. East and Gulf coasts for categories 1-5 hurricanes. You can view the predicted above ground storm surge heights and download the data in GeoTIFF format for use in GIS applications.

[National Storm Surge Hazard Information](#)  
Additional details about the storm surge hazard maps and how to use them.

Secure | <https://tidesandcurrents.noaa.gov/map/index.shtml?lat=33.958333&lng=-78...>

NOAA/NOS/CO-OPS - ODIN MAP

Search for station (Active Stations)

Zoom to region:  Show:

Require type:

Active Stations ☒ Plot Data

Water Levels Only ☒ Met Only ☒ Water Levels and Met ☒ Currents ☒

NOAA TIDES & CURRENTS

PRODUCTS Data, Analyses, and Publications

PROGRAMS Serving the Nation

Home / Stations / 8658120 Wilmington, NC

Station Info Tides/Water Levels Meteorological Obs. Phys. Oceanography

**Wilmington, NC - Station ID: 8658120**

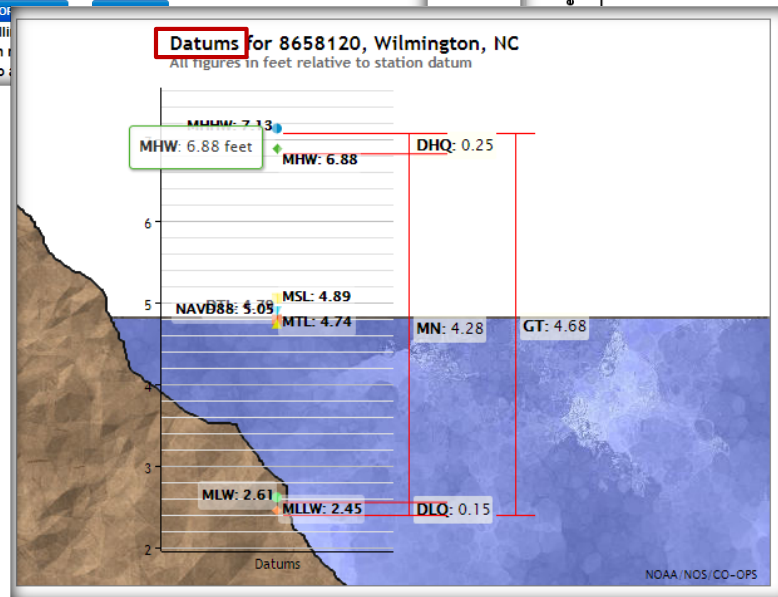
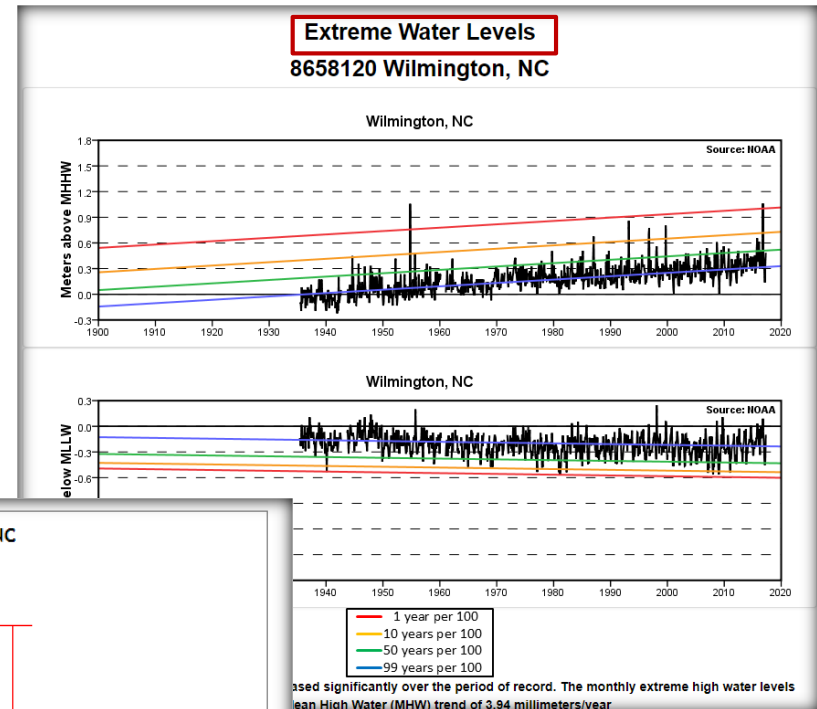
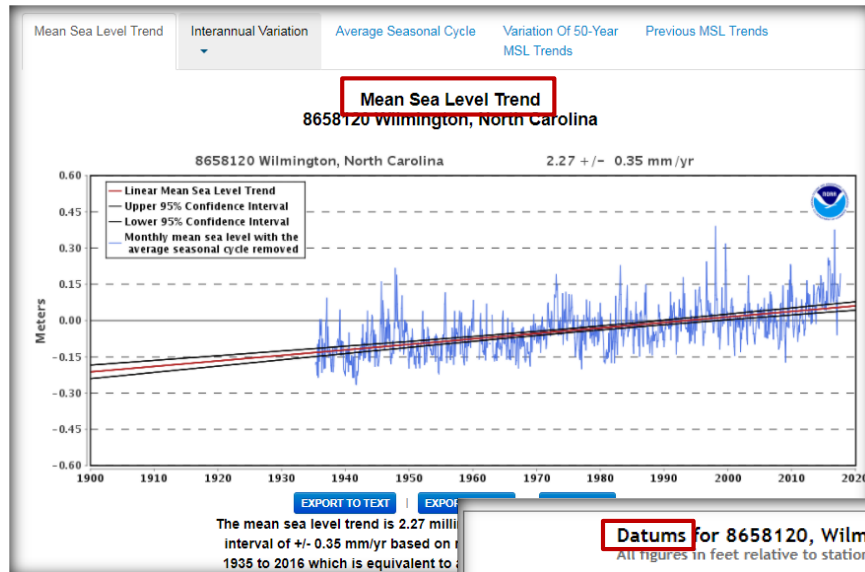
Station Info Today's Tides Photos Sensor Information Observations

Baro
8658120
1019mb.
8658163
1019mb.
8661070
1019mb.

Graphic Products & (NOS) National S. Department of Currents



# Examples of coastal data







Source:  
NOAA



# Activity/Report Drill Down Across Plants


### External Hazards Dashboard



Select Plants

Filters  



Filter by state  




Filter by region  





Filter by name 

Coastal  

Locate plants according to nearby water body type

Filter by HUC  

26 filtered matches   

-  BRUNSWICK 1
-  BRUNSWICK 2
-  CALVERT CLIFFS 1
-  CALVERT CLIFFS 2

#### Activities/Reports

Across Selected Plants

View activity related reports, such as SDPs and FSARs, by hazard for all included on the dashboard


Recent

**FLOOD** HIGH WIND EXTRA




#### Calvert Cliffs 1




Docket: 317  
Region: 1  
Type: PWR  
Vendor: Combustion Engineering  
Location Type: Coastal  
Location: Lusby, MD (40 MI S of Annapolis, MD)  
Licensee: Baltimore Gas and

### Activity Reports For Selected Plants



#### Flood Related Activity Reports For Selected Plants

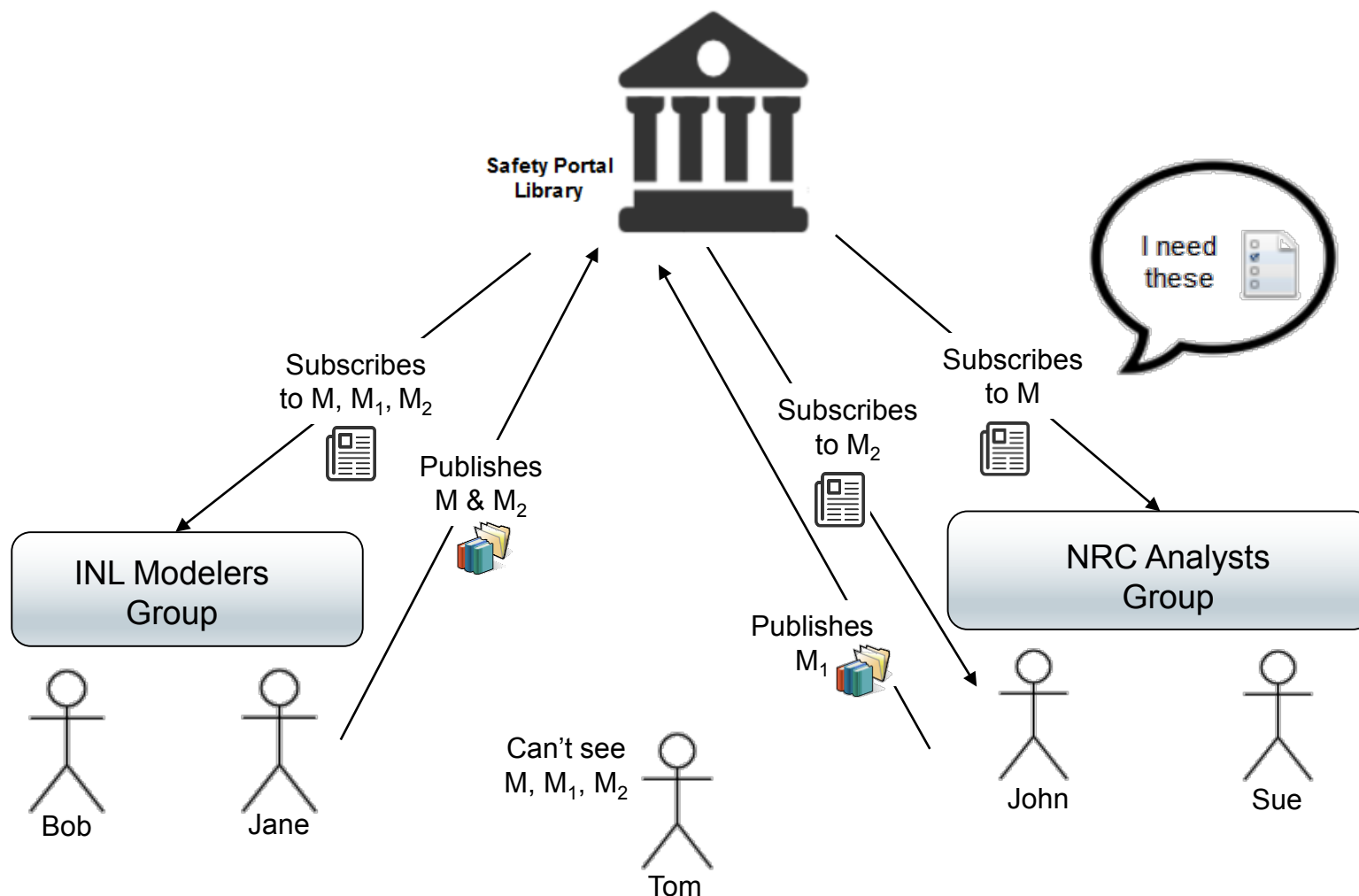
 Enter search text  Sort by  SUPPLEMENTAL DOCUMENTS

Doc	Document Links and Description
<b>Brunswick Steam Electric Plant</b>	
<b>Aug 1, 2012</b> SDP: <a href="#">EA-14-048</a> White	IR: <a href="#">05000324/2013011 and 05000325/2013010</a> IR: <a href="#">05000324/2013011 and 05000325/2013010</a> Letter: <a href="#">EA-14-048 Final SDP Letter</a> SDP Finding: The NRC characterized the finding as White, a finding of low to moderate risk significance Description:  NRC inspectors at Brunswick identified that the licensee failed to identify and correct conditions adverse to quality involving degraded and nonconforming flood penetration seals and...
<b>Brunswick Steam Electric Plant</b>	
<b>Apr 20, 2011</b> SDP: <a href="#">EA-11-251</a> White	IR: <a href="#">05000325/2011014 and 05000324/2011014</a> Letter: <a href="#">EA-11-251 Final SDP Letter</a> SDP Finding: The NRC characterized the finding as White, a finding of low to moderate risk significance. Description:  On April 20, 2011, NRC inspectors at Brunswick identified that the EDG fuel oil tank chamber enclosure contained openings that would adversely impact the ability...
<b>Hope Creek Generating Station</b>	
<b>Jun 2, 1997</b> LER: <a href="#">97-011-00</a>	Description: 

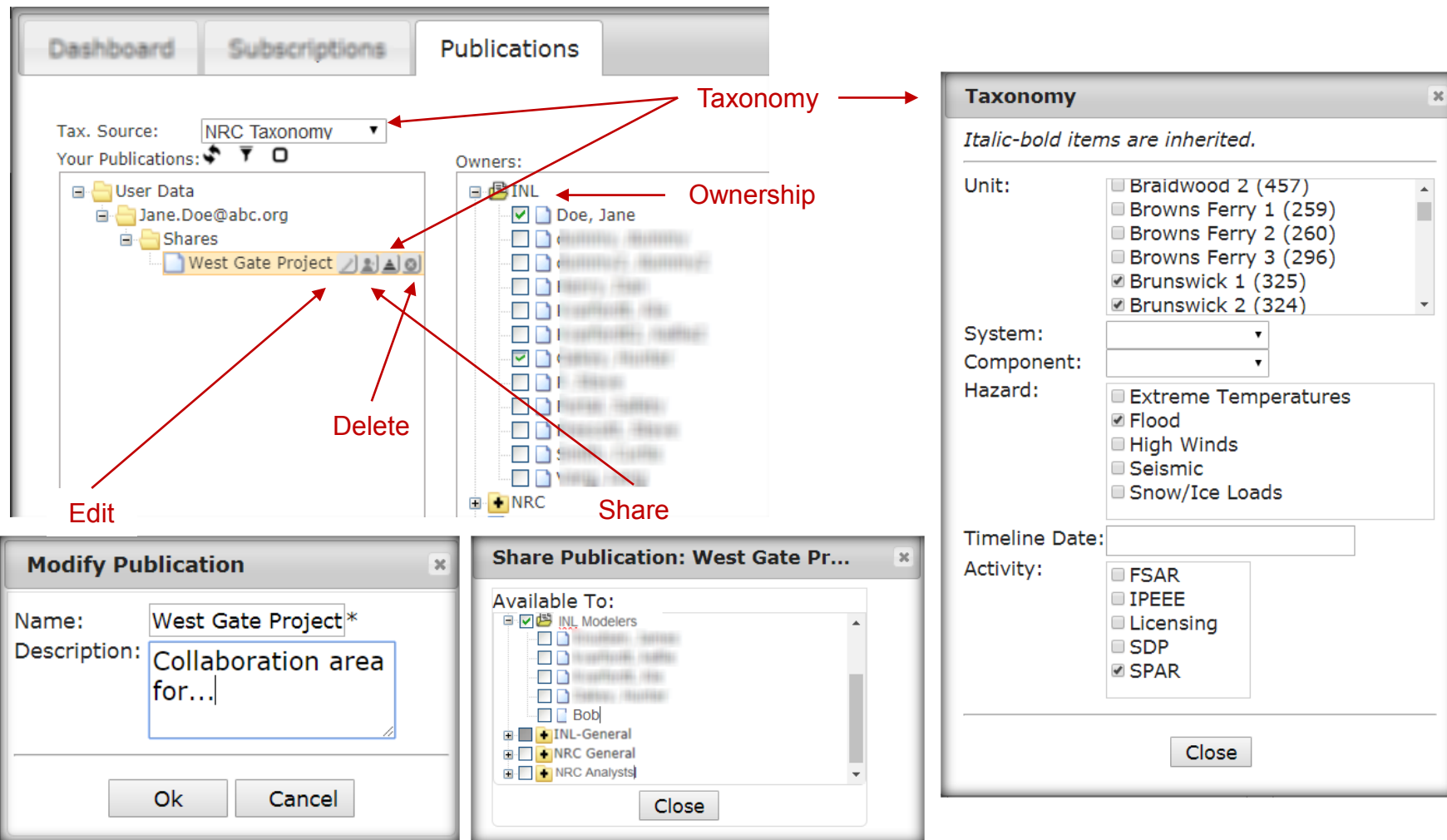
## ***Expansion to Other Natural External Hazards***

- The work on other natural hazards is in progress and is being coordinated with the NRC External Hazards Center of Expertise (EHCOE)
- High winds
  - Tornado
  - Hurricane
- Extreme temperatures/humidity
  - High and low temperature extremes
  - Wet-bulb temperature
- Snow/Ice loads
- Seismic

# Publications and Subscriptions



# Anatomy of a Publication



The main interface shows the 'Publications' tab with a 'Tax. Source' dropdown set to 'NRC Taxonomy'. Under 'Your Publications', a tree view shows 'User Data' > 'Jane.Doe@abc.org' > 'Shares' > 'West Gate Project'. The 'West Gate Project' is highlighted, and red arrows point to its 'Edit' (pencil icon), 'Delete' (trash icon), and 'Share' (person icon) buttons. To the right, the 'Owners' list shows 'INL' as the parent and 'Doe, Jane' as the owner, with a red arrow pointing to 'Ownership'.

Three modal windows are shown:

- Modify Publication:** Contains 'Name: West Gate Project\*' and 'Description: Collaboration area for...'. Buttons: 'Ok', 'Cancel'.
- Share Publication: West Gate Pr...:** Contains 'Available To:' with a list of users including 'INL Modelers', 'INL-General', 'NRC General', and 'NRC Analysts'. Button: 'Close'.
- Taxonomy:** Contains settings for 'Unit', 'System', 'Component', 'Hazard', 'Timeline Date', and 'Activity'.
  - Unit:** List of units with checkboxes: Braidwood 2 (457), Browns Ferry 1 (259), Browns Ferry 2 (260), Browns Ferry 3 (296), Brunswick 1 (325) [checked], Brunswick 2 (324) [checked].
  - System:** Dropdown menu.
  - Component:** Dropdown menu.
  - Hazard:** List of hazards with checkboxes: Extreme Temperatures, Flood [checked], High Winds, Seismic, Snow/Ice Loads.
  - Timeline Date:** Text input field.
  - Activity:** List of activities with checkboxes: FSAR, IPEEE, Licensing, SDP, SPAR [checked].
 Button: 'Close'.

## Summary

- Flood Hazard Information Digest is being adapted to be a more broadly defined External Hazards Information Digest
- The External Hazards Information Digest organizes and presents a variety of relevant, plant specific information
  - This mix of publicly and non-publicly available information is available to select NRC staff
  - Also available to contractors with appropriate authorization
  - Access to individual items is controlled by those authoring the information
- Major flood hazard data sources have been identified and most are currently available in the digest
- Additional natural external hazard data sources are being identified for inclusion to the digest during FY18

## Questions?

For questions, feedback, suggestions, or access to the External Hazards Information Digest, please contact us

### INL

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301.415.1920



