TVA Nowcast Aids for Emergency Preparedness

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Meteorological tower data must be available at all times for estimating the dispersion and transport characteristics of releases.

- Real-time data can be crucial to making correct protective action recommendations in the event of an accidental release.
- ANS-3.11-2005 (ANS-3.11) requires "a valid, accurate, and representative meteorological data base" for evaluating environmental impacts and consequences of radiological releases (both routine and accidental). Modeling applications often need values for every data point and time.

Routine data collection is not expected to provide values at every data point for all times, and even backup and redundant measurement systems cannot guarantee a 100% data availability.

Therefore, another approach is sometimes necessary.

The Nowcast Aids methodology provides a means to substitute suitable data values when they cannot be obtained by other means.

Background and History

- NRC Regulatory Guide 1.23 (published in 1972) requires meteorological data collection to ensure a 90% data recovery rate.

- TVA meteorological programs consist of a single meteorological tower at each plant site, dedicated local maintenance personnel, and extensive data validation support.

- This approach met the 90% data recovery requirement, and often achieved data recovery rates of 98% or greater.

Background and History

- In 1980, following the Three-Mile-Island accident, NRC issued NUREG-0654.
  - Equipment shall be available for “continuously assessing” the impact of a release--**essentially 100% data availability**.
  - Since a 100% data availability rate would be impossible to achieve using a single set of meteorological sensor on one tower, NUREG-0654 requires both primary and backup meteorological measurements systems.

Background and History

- TVA decided against using backup measurements because of the need to establish data relationships between the primary and backup data values.

- A backup measurements system would be too costly to upgrade its existing system for only a slight gain in data availability.

Instead, TVA developed Nowcast Aids to substitute replacement values from existing sources whenever actual measurements were unavailable.

Background and History

- 1982-1983: Nowcast Aids were developed to reflect the specific information required by the computer model used for dose assessment.
- 1984-1985: NRC evaluated Nowcast Aids as part of the Watts Bar Nuclear Plant emergency appraisal and determined them to be acceptable.
- 1986: Nowcast Aids were consolidated into a procedure format for ease of use.
- 1989-1991: Nowcast Aids were updated to incorporate additional analysis, fill some gaps in the reference variables, customize some variables based on regional weather conditions, and provide a more user-friendly format.

General Information

- The specific data required depend on the release type. Releases are classified as **ground-level** or **elevated** based on the release point and the possible influence of building wake effects.

- Any partial or total meteorological system outage (which includes both missing and invalid data) during an emergency will require an alternative source for the necessary variables.

- The Nowcast Aids provide procedures for estimating required values.

General Information

- Reference variables are used to establish estimated values. Reference variables include earlier values of the missing data, other onsite data, offsite data, and time of day and month.

- Priorities for substitution have been established for each missing parameter. They are arranged in order of effectiveness, with the most effective listed first.

General Information

Procedures are provided for estimating missing values of the following variables at each site

91-46 meter stability class
91 meter wind direction
91 meter wind speed

46-10 meter stability class
46 meter wind direction
46 meter wind speed

Development of Nowcast Aids

Key principles in developing Nowcast Aids:

1. **Nowcast Aids must be quick.**

2. **Nowcast Aids must be simple.**

3. **One or more Nowcast Aids must be available at all times.**

Development of Nowcast Aids

Types of TVA Nowcast Aids:

1. **Persistence.**
2. **Inter-Level and Other Site Comparisons.**
3. **Power Law Exponents.**
4. **Geostrophic Wind Methodology.**
5. **Average Values.**

Development of Nowcast Aids

Precision limits assumed for Nowcast Aids:

- **Wind direction - ± 45 degrees (± 2 sectors).**
- **Wind speed - ± 2.2 m/s (± 5 mph)**
- **Stability class - ± 1 Pasquill category.**

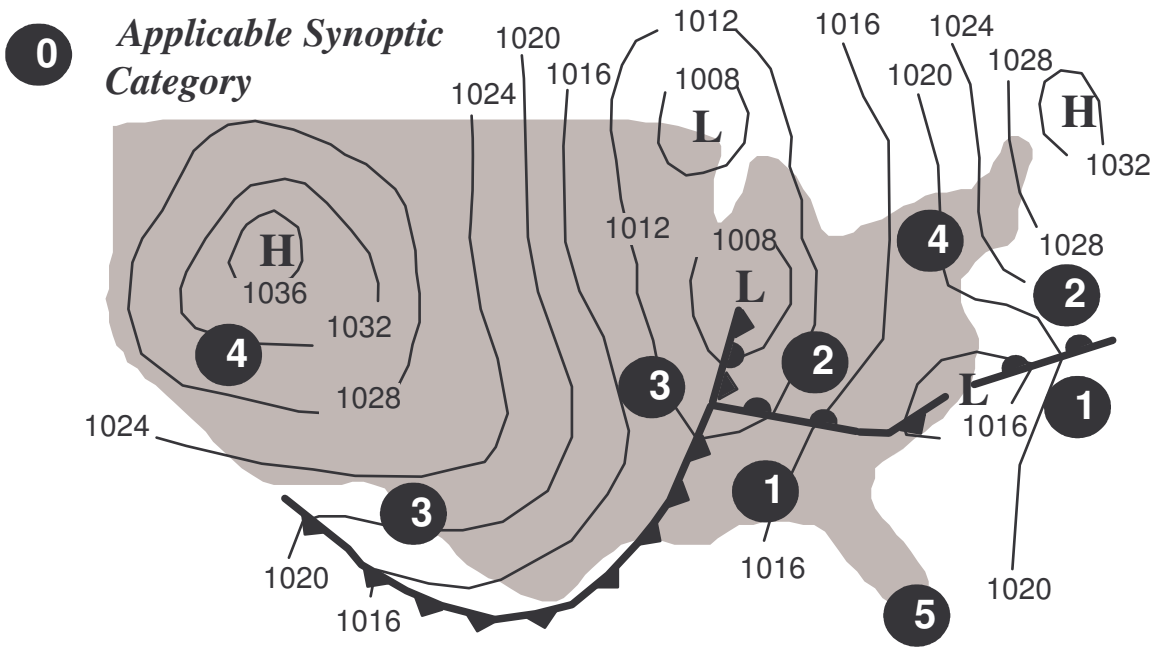
Development of Nowcast Aids

Comparison method is:

- **Acceptable** if results were within precision limits at least 90% of the time.
- **Unacceptable** if results were within precision limits less than 50% of the time (*unless no alternative*).
- **Acceptable** if the results were between these two limits, but confidence limits are specified as < 90%.

To determine if subdivision improves the comparison method, the results were classified by season and/or synoptic category, and the confidence limit was calculated for each subdivision.

Development of Nowcast Aids
Determining Synoptic Category



1. Warm sector of an extratropical cyclone.
2. Ahead of the warm front.
3. Behind the cold front.
4. Under a polar high.
5. In the vicinity of a subtropical ridge.

Based on NUREG/CR-3882, "A Method to Characterize Local Meteorology at Nuclear Facilities for Application to Emergency Response Needs"

Using Nowcast Aids

The Nowcast Aids contain a separate section for each variable.

- The first page lists the reference variables and the procedures for estimating the missing variable.
- The procedures are arranged in the order of effectiveness with the most effective listed first .
- To estimate a missing variable, the user turns to the appropriate section and reads down the list to the first variable(s) that is (are) available.
- The user then turns to the applicable procedure and follows the instructions.

Sequoyah 91 m Wind Direction

Read down the table to locate the first reference variable(s) for which data are available. Read across to locate the appropriate procedure to use.

Reference Variable(s)	Table No.
1. SQN concurrent 46 m wind direction	4-1
2. SQN 91 m wind direction $\leq$ 1 hr old	4-2
3. SQN concurrent 10 m wind direction	4-3
4. WBN concurrent 91 m wind direction	4-4*
5. SQN 91 m wind direction $>$ 1 hr, $\leq$ 2 hrs old	4-2*
6. Chattanooga NWS concurrent wind direction	4-5*
7. SQN 91 m wind direction $>$ 2 hrs, $\leq$ 4 hrs old	4-2*
8. WBN concurrent 46 m wind direction	4-6*
9. WBN concurrent 10 m wind direction	4-7*
10. Geostrophic wind direction	4-8*
11. Time of day, synoptic category	4-9
12. Time of day	4-10

* Also check table 4-9 to determine if an estimate with a better confidence level is possible.

Using Nowcast Aids

- Preferably, a Nowcast Aid will satisfy the precision limits at least 90% of the time (90% confidence limit).
- If the 90% confidence level applies, only the Nowcast value is given in the procedure.
- If the 90% confidence level does not apply, the expected percent of success (the actual confidence level) is given. These confidence factors (± values and confidence levels) are provided as the estimated (Nowcast) value.
- The data users interpret their information based on the reliability of the meteorological data.

Using Nowcast Aids

Applying Precision Limits

A. Historical wind direction is within 37º of the reference value 90% of the time (*37º < 45º precision limit*).
   - **Nowcast value = ± 37º**
     (90% confidence is assumed)

B. Historical wind speed is within 5.4 mph of the reference value 90 percent of the time, but is within 3.8 mph of the reference value 75 percent of the time (*5.4 mph > 5 mph precision limit while 3.8 mph < 5 mph precision limit*).
   - **Nowcast value = ± 3.8 mph, 75%**

Nowcast Aids Examples

A. On the Sequoyah (SQN) meteorological tower, no temperature data (and hence no ΔTs) and no 10-m wind speed data are available.

Determine low-level (46-9 m) Pasquill stability class.

1) Determine which reference data are available by reading down the reference variable list for SQN 46-9 Stability Class.

Nowcast Aids Examples

Reference Variable(s)	Availability Status
SQN 91-9 m stability class	***Not available*, SQN has no temperature data.**
SQN 91-46 m stability class	***Not available*, SQN has no temperature data.**
SQN 10-m wind speed, ceiling height, time of day	***Not available*, SQN has no 10-m WS data.**
Watts Bar (WBN) 91-10 m stability class	**Available.**
WBN 46-10 m stability class	**Available.**
WBN 91-46 m stability class	**Available.**
Time of day	**Always available.**

Nowcast Aids Examples

2) Identify the specific reference variable to be used.

- None of the SQN variables are available because there is no ΔT information or 10-m WS from SQN.
- All of the WBN variables are available.
- The time of day is always known.

Since the variables are listed in decreasing order of effectiveness, the highest available reference variable (**WBN 91-10 m stability class**) should be used.

Nowcast Aids Examples

3) Go to the specific table for the **WBN 91-10 m Stability Class** and determine the Nowcast value that applies.

WBN 91-10 m Stability	SQN 46-9 m Stability
A	**A ± 1**
B	**A ± 1, 80%**
C	**A ± 1, 86%**
D	**D ± 1, 74%**
E	**E ± 1**
F	**F ± 1**
G	**G ± 1**

4) Based on the current **WBN 91-10 m Stability Class**, nowcast the SQN 46-9 m Stability Class (and include confidence limits if applicable).

Nowcast Aids Examples

B. On the Browns Ferry (BFN) meteorological tower, no wind direction data are available for any level for more than 4 hours; synoptic category is 5 (in the vicinity of a subtropical ridge); and one required sea-level pressure reading is missing for the Geostrophic Wind Direction method.

Determine tower top (90-m) Wind Direction for BFN.

1) Determine which reference data are available by reading down the reference variable list for BFN 90-m Wind Direction.

Nowcast Aids Examples

Reference Variable(s)	Availability Status
BFN concurrent 46-m WD	***Not available*, BFN has no WD data.**
BFN 90-m WD ≤ 1 hour old	***Not available*, BFN data have been unavailable more than 4 hours.**
BFN concurrent 10-m WD	***Not available*, BFN has no WD data.**
BFN 90-m WD > 1 hour old, ≤ 2 hours old	***Not available*, BFN data have been unavailable for more than 4 hours.**
Geostrophic WD	***Not available*, one sea-level pressure reading is missing.**
BFN 90-m WD > 2 hours old, ≤ 4 hours old	***Not available*, BFN data have been unavailable more than 4 hours.**
Huntsville NWS concurrent WD	**Available.**
Time of day, synoptic category	**Always available.**

Nowcast Aids Examples

2) Identify the specific reference variable to be used.

- None of the BFN variables are available.
- At least one of the sea-level pressure readings for the Geostrophic WD is missing.
- Huntsville NWS data are available.
- If all else fails, the meteorologist knows time of day and the synoptic category.

The highest available reference variable (**Huntsville NWS concurrent WD**) should be used.

Nowcast Aids Examples

3) Go to the specific table for the **Huntsville NWS concurrent WD** and determine the Nowcast value.

   The table lists equations for each synoptic category. The equation for category 5 will be used.

$$WD_{90} = 27.4 + (0.9 * WD_{HSV}) \quad \pm 29^{o}, 50\%$$

where: WD_{90} **= BFN 90-m Wind Direction**
WD_{HSV} **= Huntsville Wind Direction**

4) Based on the current **Huntsville NWS concurrent WD**, nowcast the BFN 90-m Wind Direction using the applicable equation. Inform the data users that the value is accurate to ± 29º for only 50% of the time.

Nowcast Aids Examples

C. On the Watts Bar (WBN) meteorological tower, the 46- and 91-m wind sensors have failed within the past hour.

Determine the 46-m Wind Speed for WBN.

1) Determine which reference data are available by reading down the reference variable list for WBN 46-m Wind Speed.

Nowcast Aids Examples

Reference Variable(s)	Availability Status
WBN concurrent 91-m wind speed	***Not available*, 91-m wind sensor has failed.**
WBN 46-m wind speed ≤ 1 hour old	**Available.**
• • •	
Sixteen other combinations of variables based on persistence, power law relationships, and concurrent observations at other locations. All of these cases are less accurate than WBN 46-m wind speed ≤ 1 hour old.	
• • •	
Time of Day	**Always available.**

Nowcast Aids Examples

2) Identify the specific reference variable to be used.

   WBN 46-m wind speed ≤ 1 hour old is the best available reference value.

3) Go to the specific table for the **WBN 46-m wind speed ≤ 1 hour old** and determine the Nowcast value.

Nowcast Aids Examples

The last available observation should be used unaltered. The confidence level is based on how long data have been unavailable.

Time since last available observation	Confidence Level
≤ 1 hour	± 1.3 m/s
≤ 2 hours	± 1.9 m/s
≤ 3 hours	± 1.4 m/s, 75%
≤ 4 hours	± 1.7 m/s, 75%

4) Based on **WBN 46-m wind speed ≤ 1 hour old**, nowcast the WBN 46-m WS as equal to the last available wind speed. Value is accurate to ± 1.3 m/s .

Observations about Nowcast Aids

The Nowcast Aids do accomplish the goals to be quick, simple, and always available.

- This is achieved by accepting an increasing reduction in accuracy within a few hours or during rapidly changing conditions.
- Use of the Nowcast Aids is limited to the meteorologists participating in the Emergency Preparedness Program, since they are best able to determine the applicability of the Nowcast Aids.

Observations about Nowcast Aids

- Nowcast Aids are also useful for preparing short-term forecasts. The meteorologist simply uses the time-of-day values as the “first-guess” for the applicable hours, and makes adjustments to fine-tune the forecasts.
- Nowcast Aids are useful for filling data gaps for applications (e.g., modeling) that require continuous data.

Conclusion

Nowcast Aids are a tool than can be used in combination with other information to describe the meteorological conditions.