# Summary of Key Results

Presented by:
Matthew Pajerowski, USGS

co-authors:
Phillip Goodling
Marina Metes

August 4, 2022

**≋USGS**

Assessment of Contaminant Trends in Plumes and Wells and Monitoring Network Optimization at the Badger Army Ammunition Plant, Sauk County, Wisconsin



Scientific Investigations Report 2020–5106

# Presentation Outline

- Study background

- Summary of key results
  - Plume delineations
  - Statistical analysis of trends

- Optimization
  - Sampling frequency
  - Well spacing/location

- Areas where new wells would reduce uncertainty

≋USGS

# Overall Approach

USGS performed an objective re-analysis of existing water-quality data, from 2000 through 2018.

Two complementary approaches were used:

- Delineation of plume boundaries

- Statistical analysis of water quality data

USGS

# Contaminants considered for this study

**Table 1.** Contaminants of concern within the three major plumes at the Badger Army Ammunition Plant.

[X, indicates the contaminant is of concern relevant to the corresponding plume; —, indicates the contaminant is not of concern relevant to the corresponding plume]

| Contaminant of concern | Acronym used in this report | Propellant Burning Ground plume | Central plume | Deterrent Burning Ground plume |
|---|---|:---:|:---:|:---:|
| Total dinitrotoluene | DNT | X | X | X |
| 2,4-dinitrotoluene | 2,4-DNT | X | X | X |
| 2,6-dinitrotoluene | 2,6-DNT | X | X | X |
| Trichloroethene | TCE | X | X | X |
| 1,1,2-trichloroethane | 1,1,2-TCA | — | X | X |
| Carbon tetrachloride | CTET | X | — | — |
| Ethyl ether | EE | X | — | — |

From Table 1 of USGS SIR 2020-5106

# Overall number of wells available at each well depth interval

Number of wells with data

Depth interval

169 wells — A

108 wells — B

— C

108 wells

58 wells — D

46 wells — E

5 wells — F

Includes monitoring wells and residential wells

Wells with non-detects were included



≋USGS
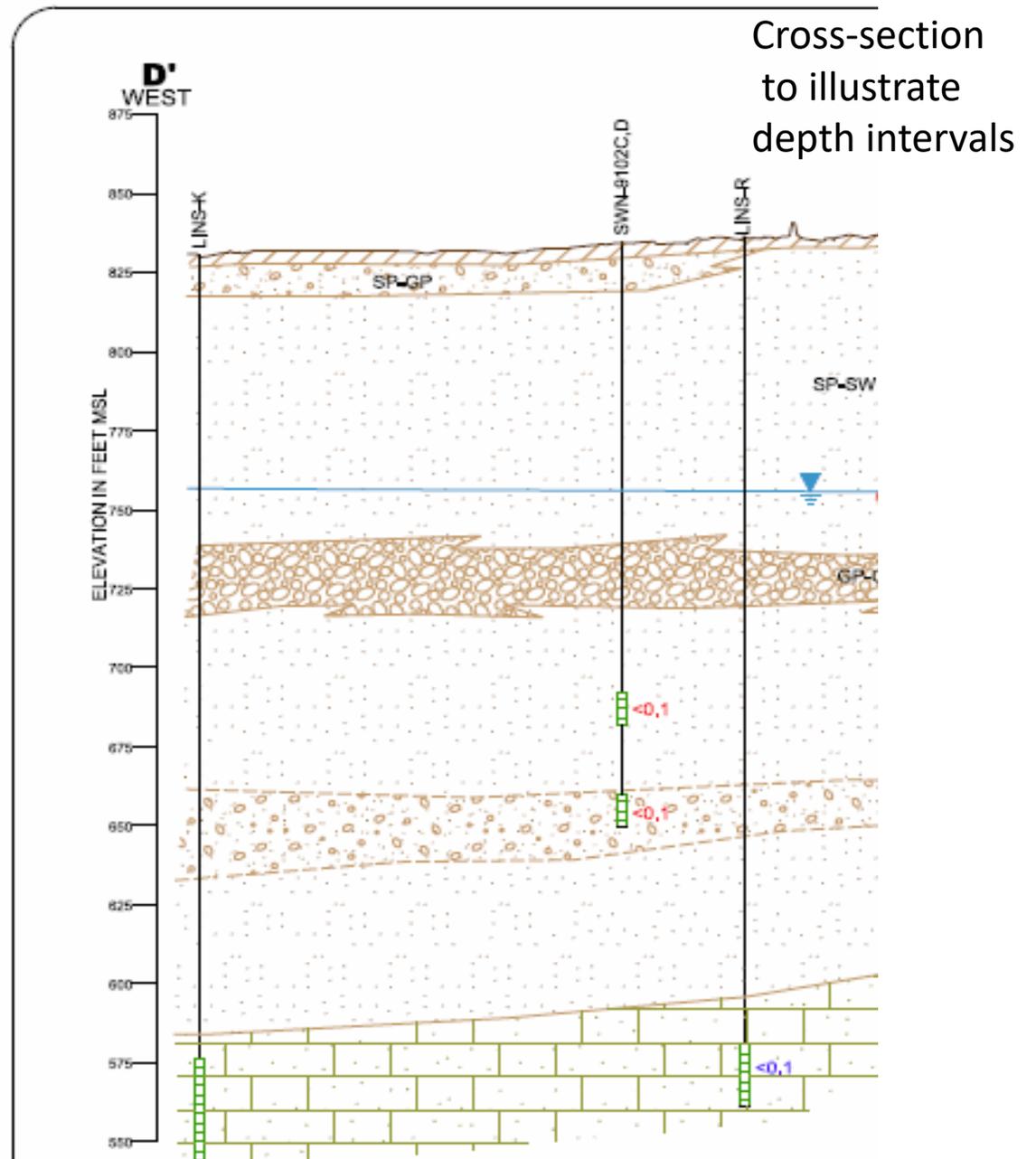
# Key Observations from Plume Delineations

- The plume areas exceeding the ES decrease from the 2000-2002 to 2015-2018 time interval, except for ethyl ether in the PBG, which showed apparent increase.

- Areas were identified where the plume boundaries were uncertain, and could be improved with more data.

≋ USGS

# Statistical Analysis of Trends in Plumes

- Propellant burning ground plume (PBG)
  - In 2000-2012 period, CTET was increasing in mass, only for the D layer.
  - In 2000-2012 period, all other COCs were either stable, decreasing, or no trend detected.
  - In 2013-2018 period, no COCs showed an increasing trend in mass.

- Central plume – insufficient number of detections for plume analysis
- Deterrent burning ground (DBG)
  - In 2000-2012, 2,4-DNT and 2,6-DNT were increasing in mass in the A layer.
  - In 2013-2018 period, no COCs showed an increasing trend in mass.

≋USGS

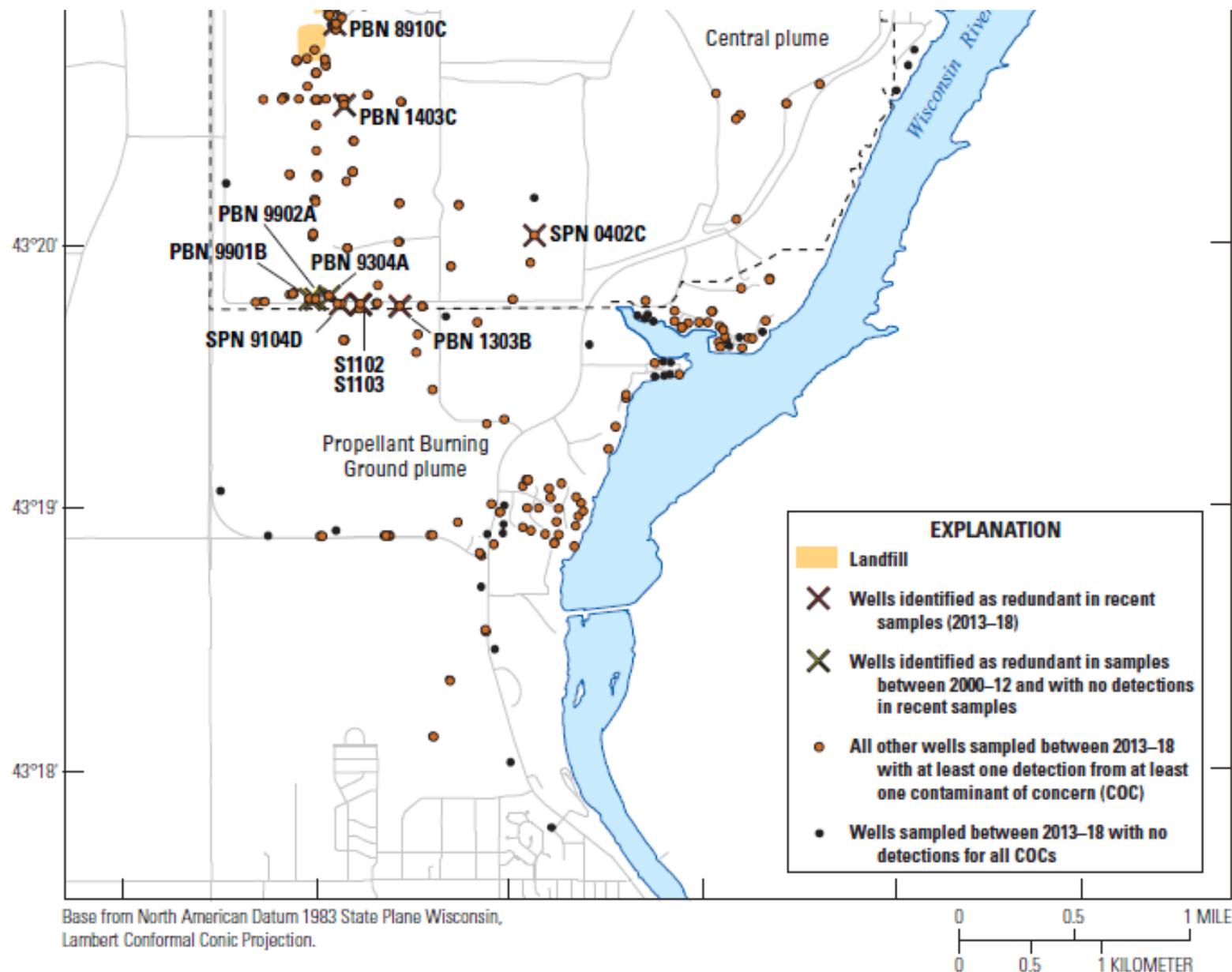# Statistical Analysis of Trends in Individual Wells

- Trends of concentrations in wells varied, and are presented in a series of 14 maps.

- In general, more wells had decreasing trends than had increasing trends for most COCs, with two exceptions.

- In 2013-2018 period, more wells had an increasing trend for 2,6-DNT.

- In 2004-2012 period, more wells had an increasing trend for ethyl ether.

≋USGS

# Optimization results

- Sampling frequency of wells for individual contaminants
  - Sampling frequency for some COCs could be reduced in certain wells.
  - However, no wells had consistent recommended sampling frequencies for all contaminants.

- Spatial optimization of wells
  - Six wells were identified as providing redundant information (figure 20).
  - Statistical analysis did not identify any areas where new wells were needed.
  - Areas were identified where new wells would reduce uncertainty of plume delineations.

# Six wells providing redundant information

- Six wells in the PBG plume were found to be redundant in the 2013-2018 period

- Four additional wells are shown, which were redundant for the 2000-2012 period, but were since dropped

- Removal of these wells would not impact trend analysis or plume delineations, as nearby wells provide similar data

- Not enough data for analysis in CP or DBG plumes



**EXPLANATION**

- Landfill
- X Wells identified as redundant in recent samples (2013–18)
- X Wells identified as redundant in samples between 2000–12 and with no detections in recent samples
- • All other wells sampled between 2013–18 with at least one detection from at least one contaminant of concern (COC)
- • Wells sampled between 2013–18 with no detections for all COCs

Base from North American Datum 1983 State Plane Wisconsin, Lambert Conformal Conic Projection.

**Figure 20.** Map showing location of wells that were identified as redundant and suggested to be considered for removal from the monitoring network
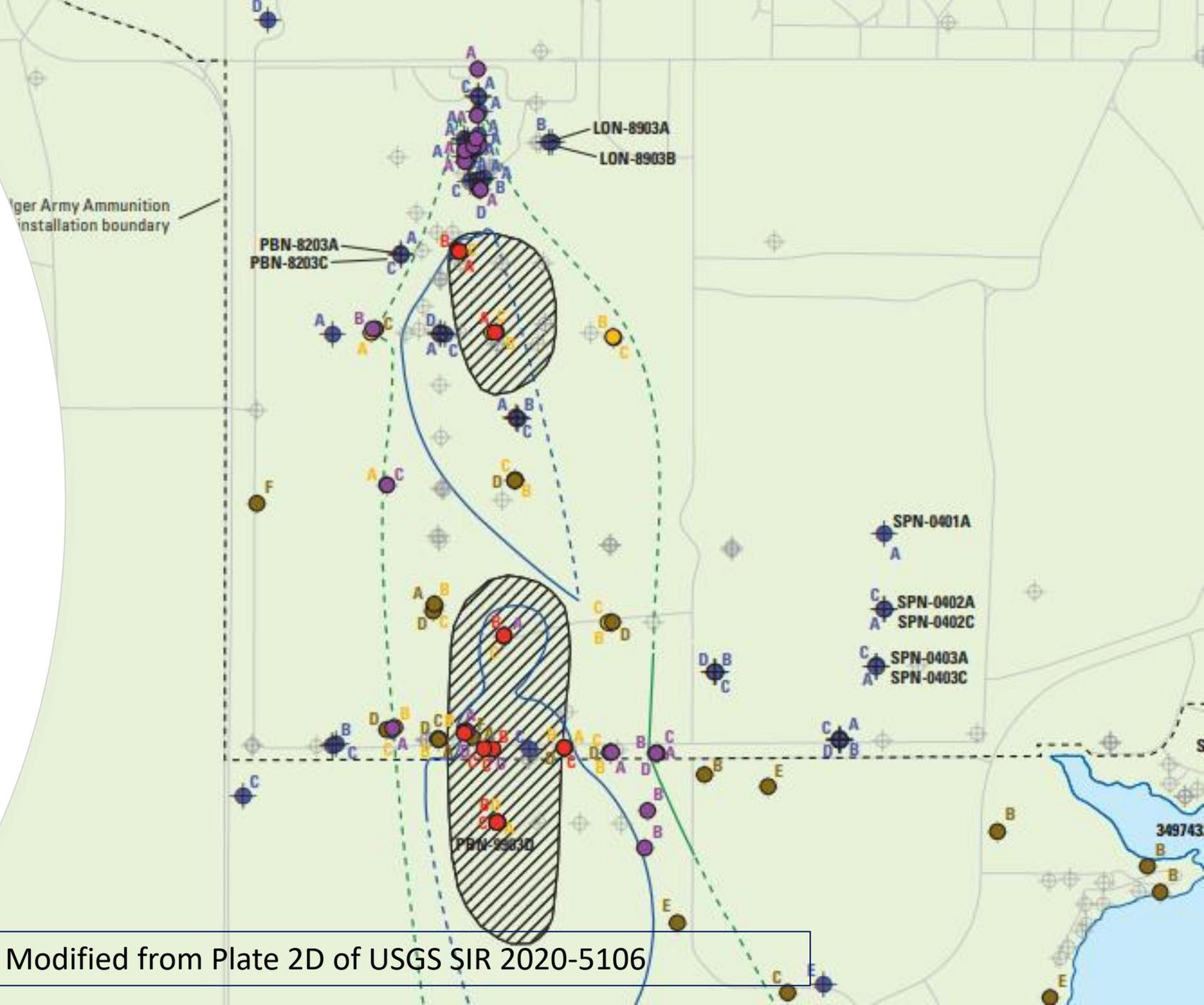
USGS

# Area of plume uncertainty – tail of PBG plume

- Plume tail uncertain downgradient of wells PBN-9101C and PBN-9001D

- True for CTET, TCE, 2,6-DNT and total DNT
  - (TCE plume shown here)

- Based on data from 2015-2018

Modified from Plate 1D of USGS SIR 2020-5106
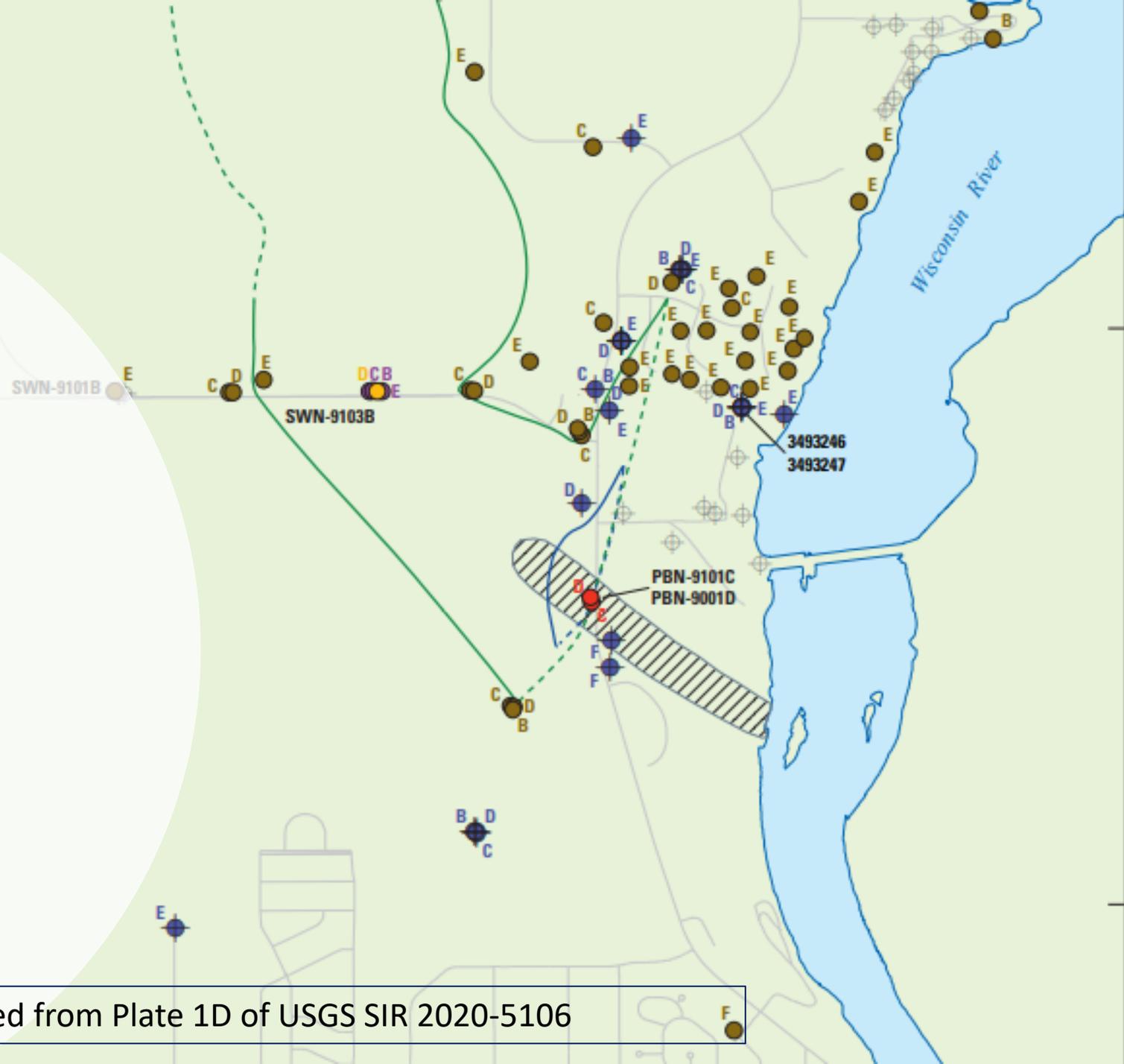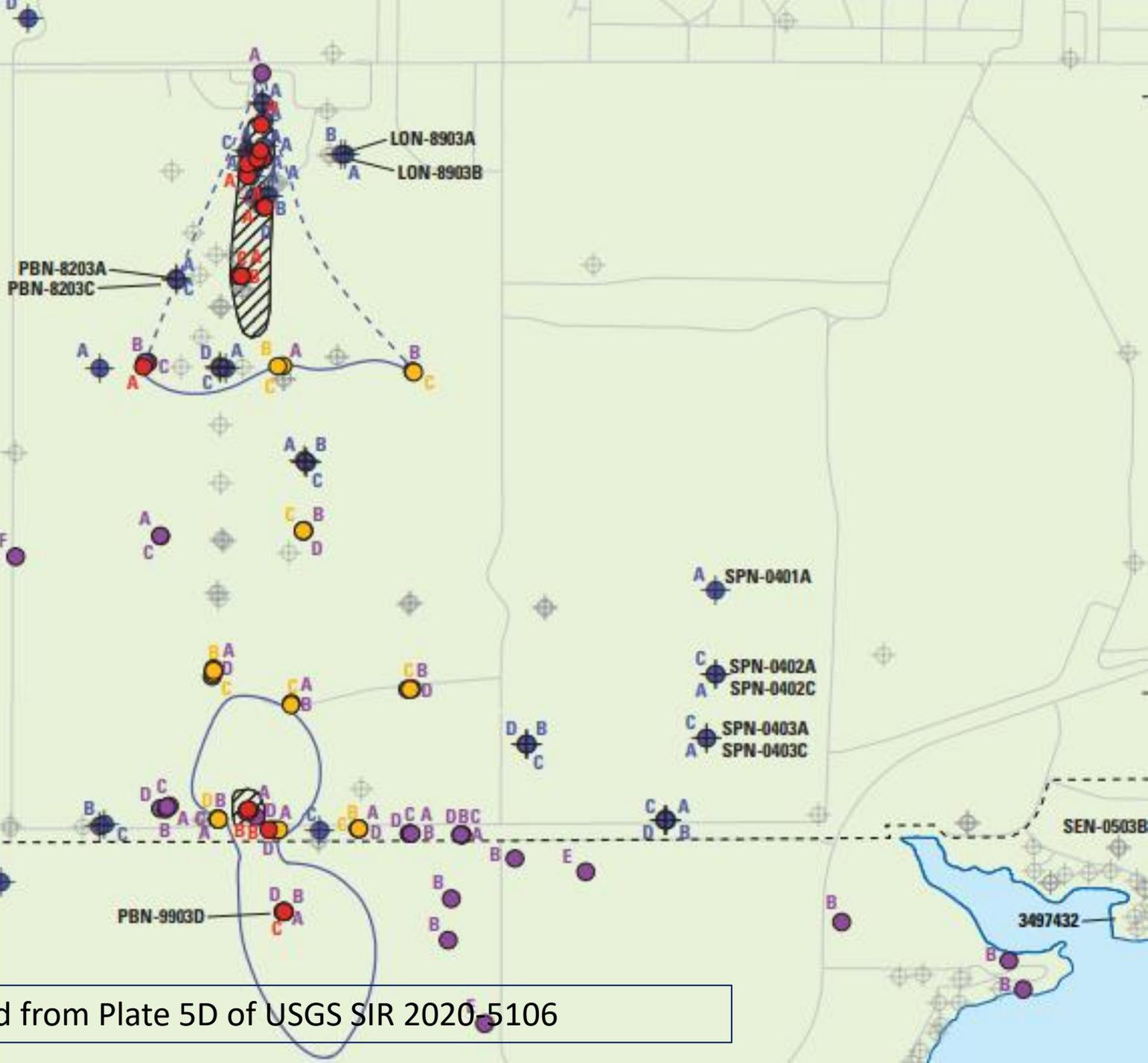
# Area of plume uncertainty – PBG Source area

- Plume delineation uncertain, particularly on the east side of the source area for CTET

- Due to lack of samples from A layer

- Based on data from 2015-2018



Modified from Plate 2D of USGS SIR 2020-5106

ger Army Ammunition installation boundary

LON-8903A
LON-8903B

PBN-8203A
PBN-8203C

SPN-0401A

SPN-0402A
SPN-0402C

SPN-0403A
SPN-0403C

PBN-9503D

USGS

# Area of plume uncertainty – PBG Source area

- Plume delineation uncertain on east and west sides of the source area for all DNT constituents

- (Plume for total DNT shown)

- Due to few nearby wells in the A, B and C layers

- Based on data from 2015-2018

Modified from Plate 5D of USGS SIR 2020-5106

Area of plume uncertainty – southeast corner of PBG plume

- Plume delineation uncertain for CTET due to few wells sampled in D layer

- Based on data from 2015-2018
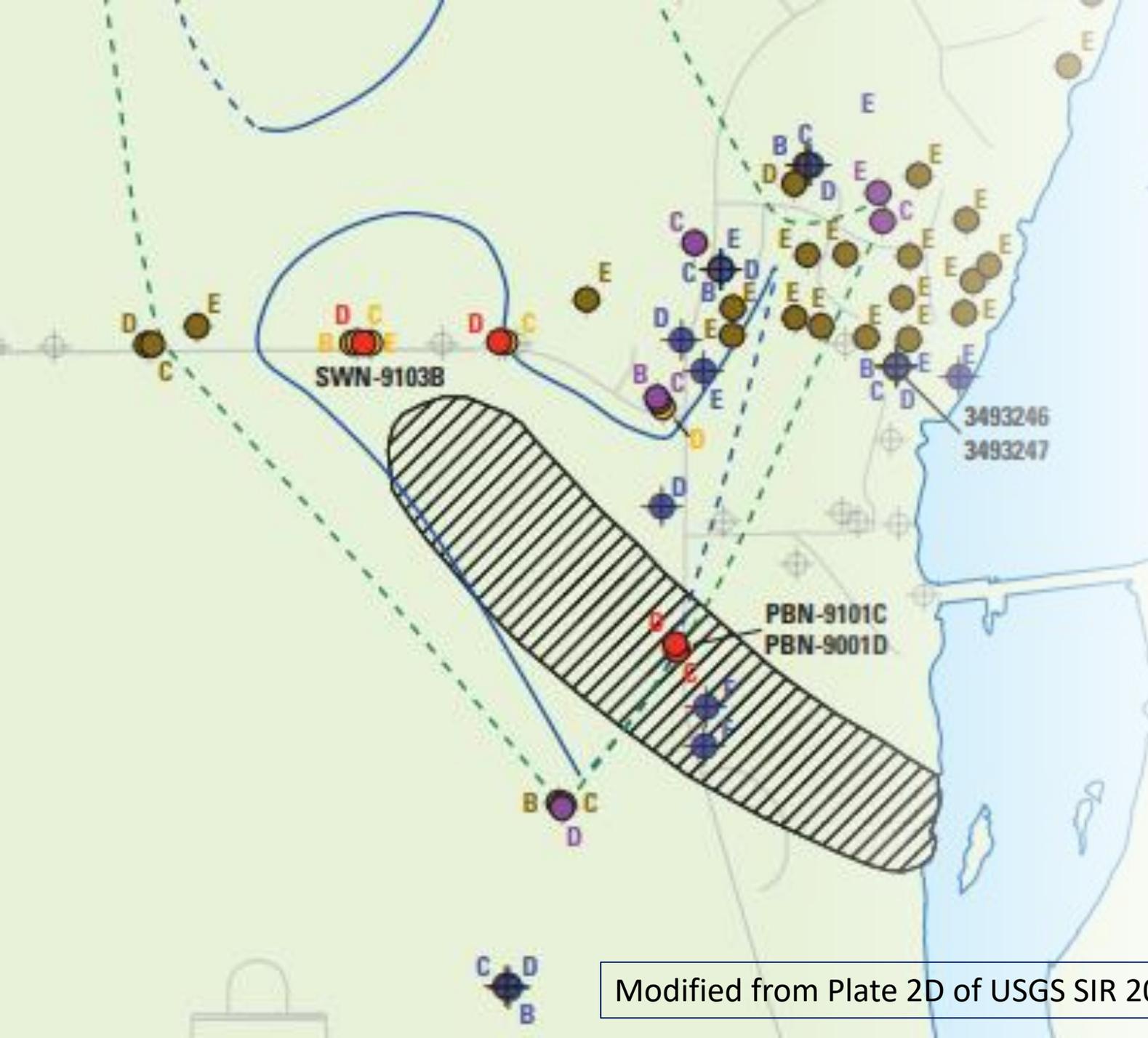
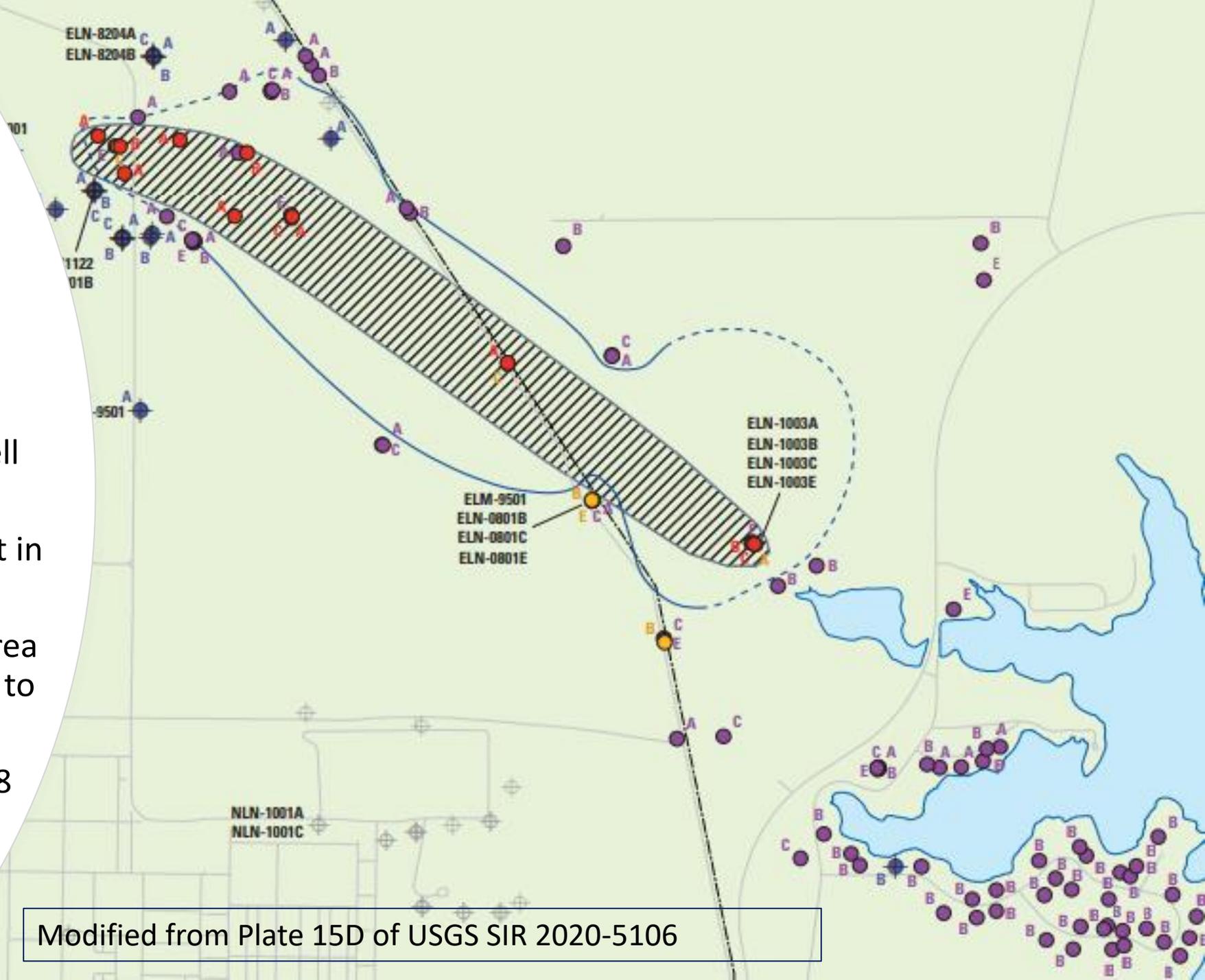Modified from Plate 2D of USGS SIR 2020-5106

# Uncertainty across a great distance – PBG plume south of installation boundary

- Lack of wells requires interpolation across long distance for PAL boundary of ethyl ether

- Additional wells could better constrain the position of the PAL boundary

- Based on data from 2015-2018

Modified from Plate 6D of USGS SIR 2020-5106
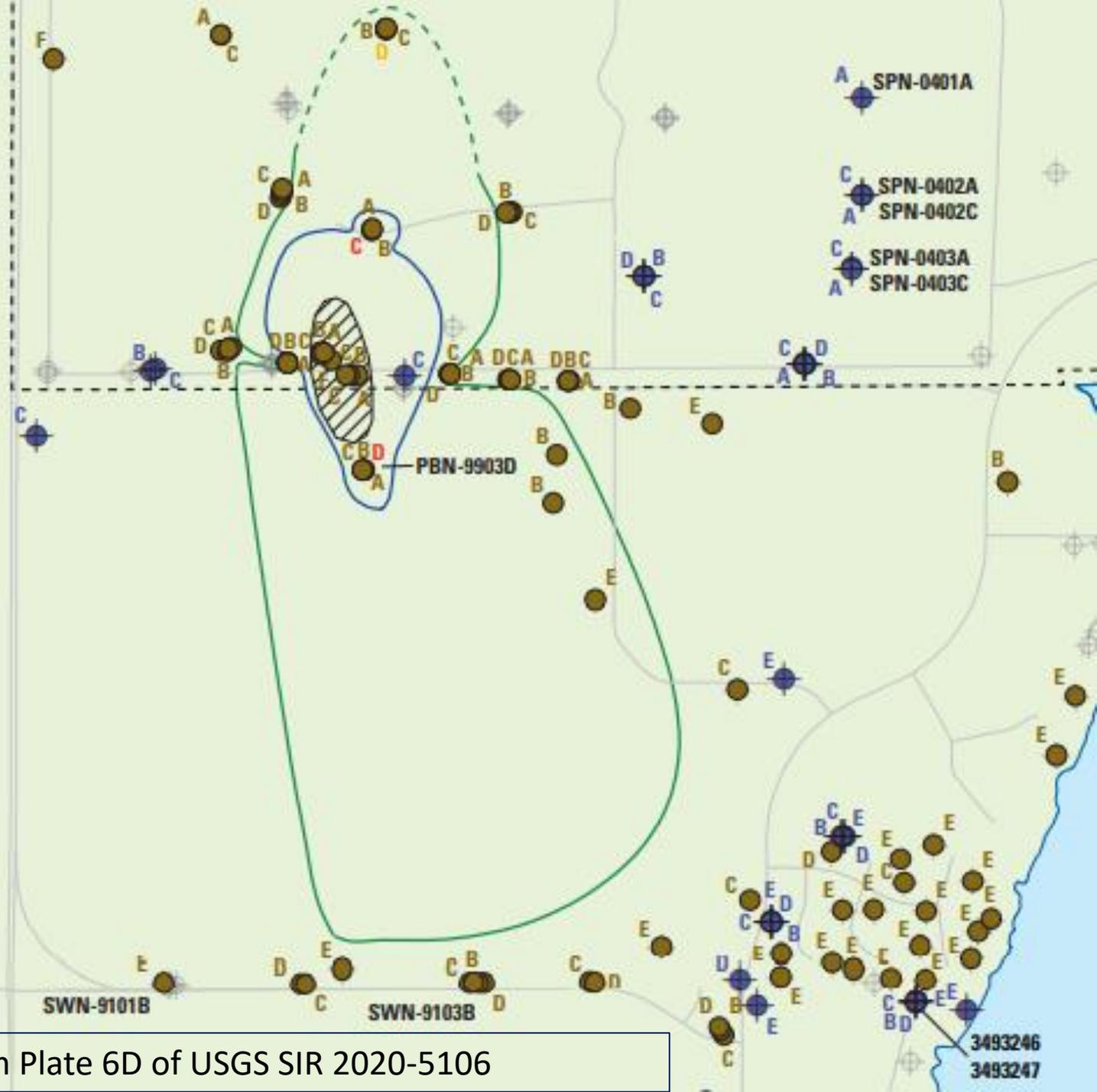
# Areas of uncertainty – tail and source of DBG plume

- Plume tail for total DNT uncertain downgradient of well cluster ELN-1003

- No nearby wells downgradient in C layer

- Plume upgradient of source area is also poorly constrained due to lack of wells with detections

- Based on data from 2015-2018

Modified from Plate 15D of USGS SIR 2020-5106

# Questions?

- Full report and data available at :

  https://pubs.er.usgs.gov/publication/sir20205106

**≋USGS**