DEVELOPMENT OF CENTRAL IMPACT AREA FATE-AND-TRANSPORT SUB-REGIONAL MODEL(S)

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Presented at the 2/5/02 IAGWSP Modeling meeting to the USEPA, MADEP, USACE, NGB, USGS, Jacobs Eng, and AEC (IAGWSP Contact Dave Hill 508-968-5621).

MODELING PRIMARY OBJECTIVES

- Develop sub-regional fate-and-transport model(s) for Central Impact Area from AMEC's regional model of western Cape Cod
- Calibrate fate-and-transport model to present conditions for RDX and other COCs
- Conduct sensitivity analysis to quantify the uncertainty in the calibrated model
- Predict fate-and-transport of COCs from present to future for the 'no action scenario'

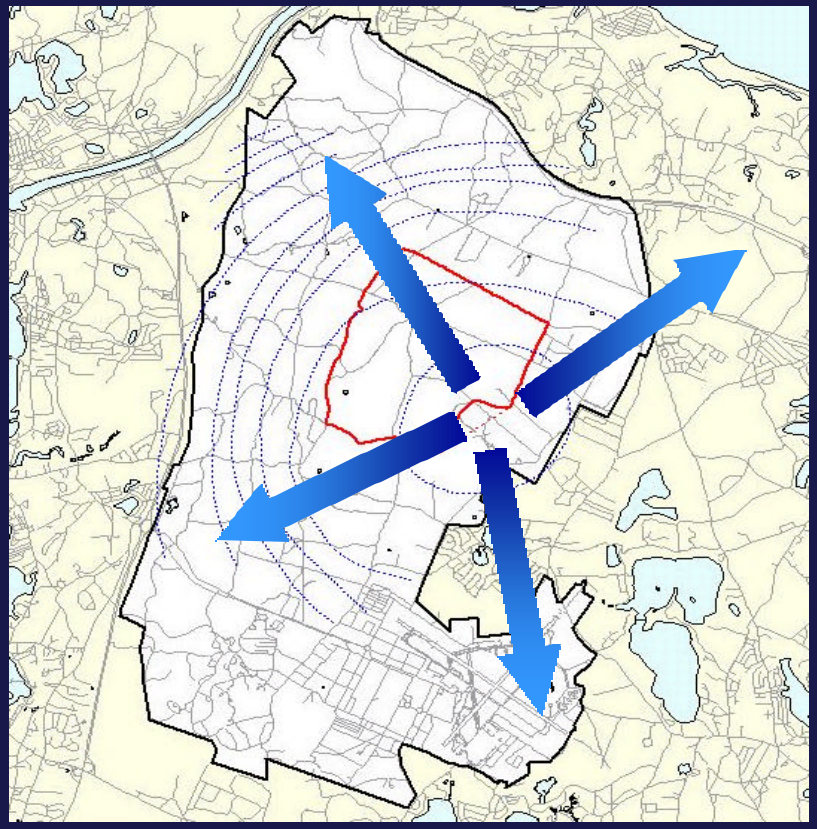
MODELING PRIMARY OBJECTIVES *(Continued)*

- Identify present and potential impacts on the aquifer and water-supply wells
- Utilize fate-and-transport model for assessing various remedial options
- Utilize model for the support of engineering design
- Document Central Impact Area modeling approach, results, and conclusions

SPECIFICS OF CENTRAL IMPACT AREA

- Large area (~ 2,000 acres)
- Thick unsaturated zone (60 – 120 ft)
- Immediately northwest of groundwater mound
- High hydraulic conductivity (K) zone
- Northwest groundwater flow direction
- Horizontal flow is significant
- Scattered and not well defined sources

GROUNDWATER FLOW DIRECTION

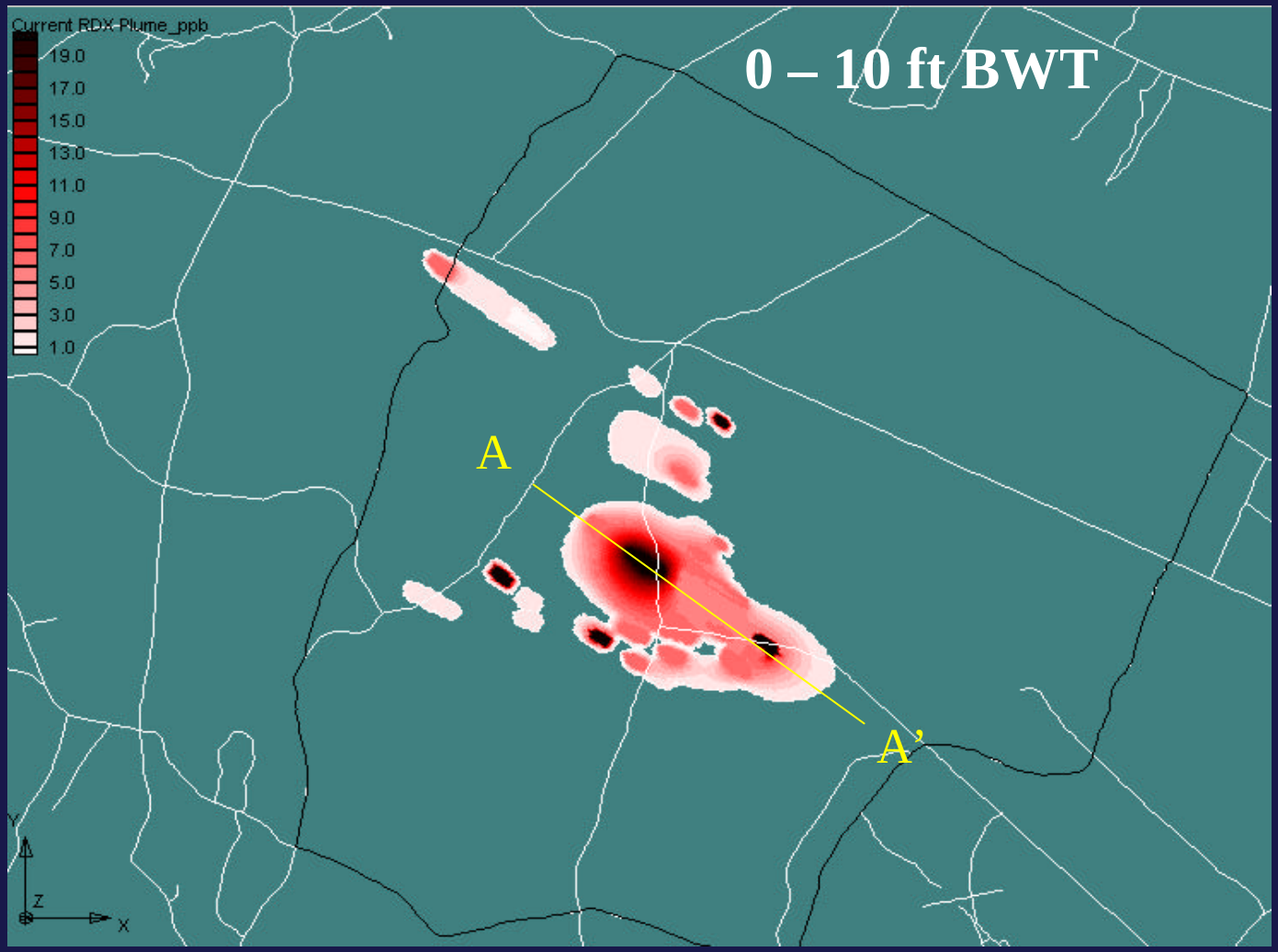


- Groundwater flow is radial with the mound to the southeast of the Impact Area
- Groundwater flow is approximately one foot per day

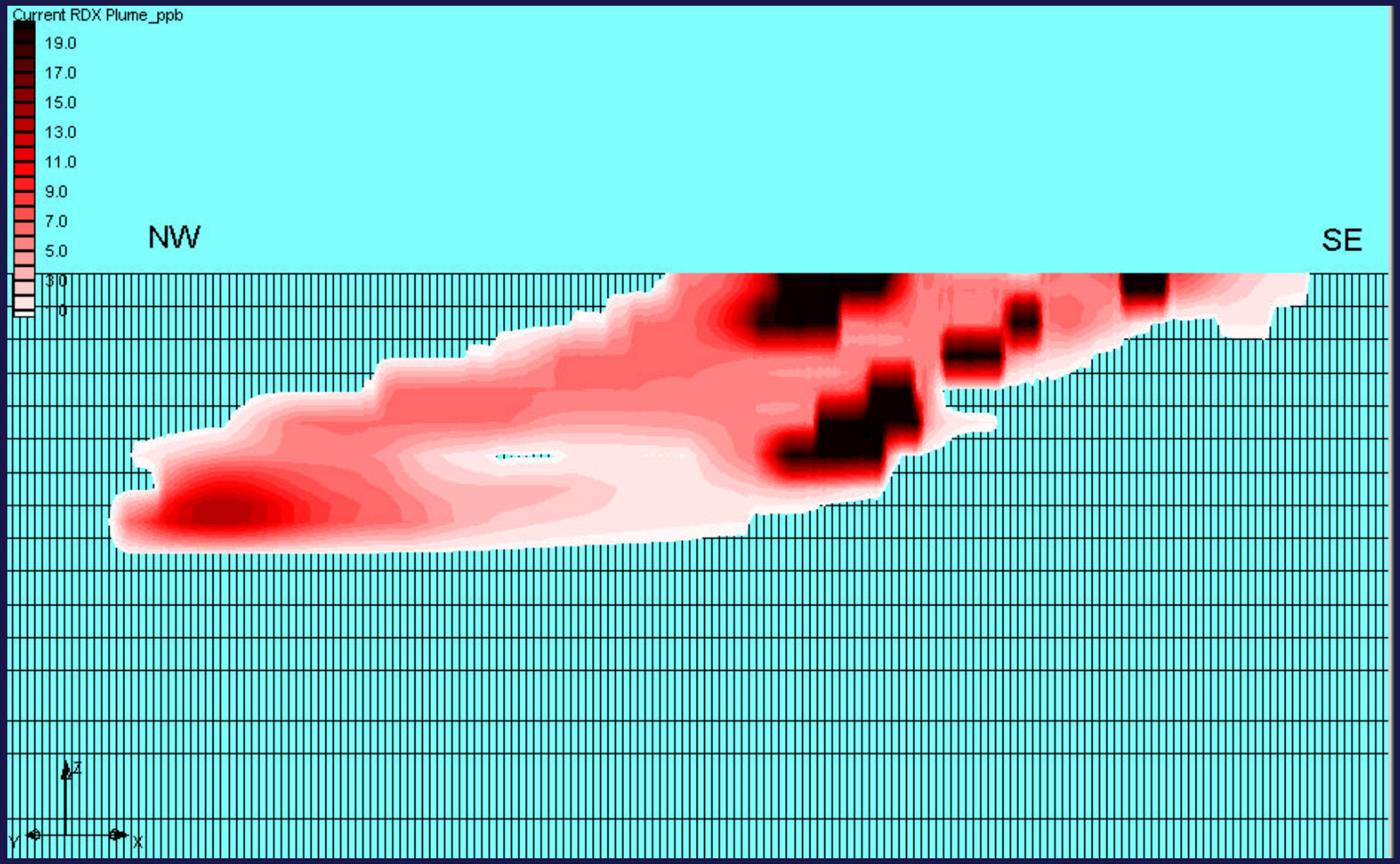
CENTRAL IMPACT AREA GROUNDWATER COCs TO BE MODELED

- RDX
- TNT
- 2A-DNT
- Perchlorate

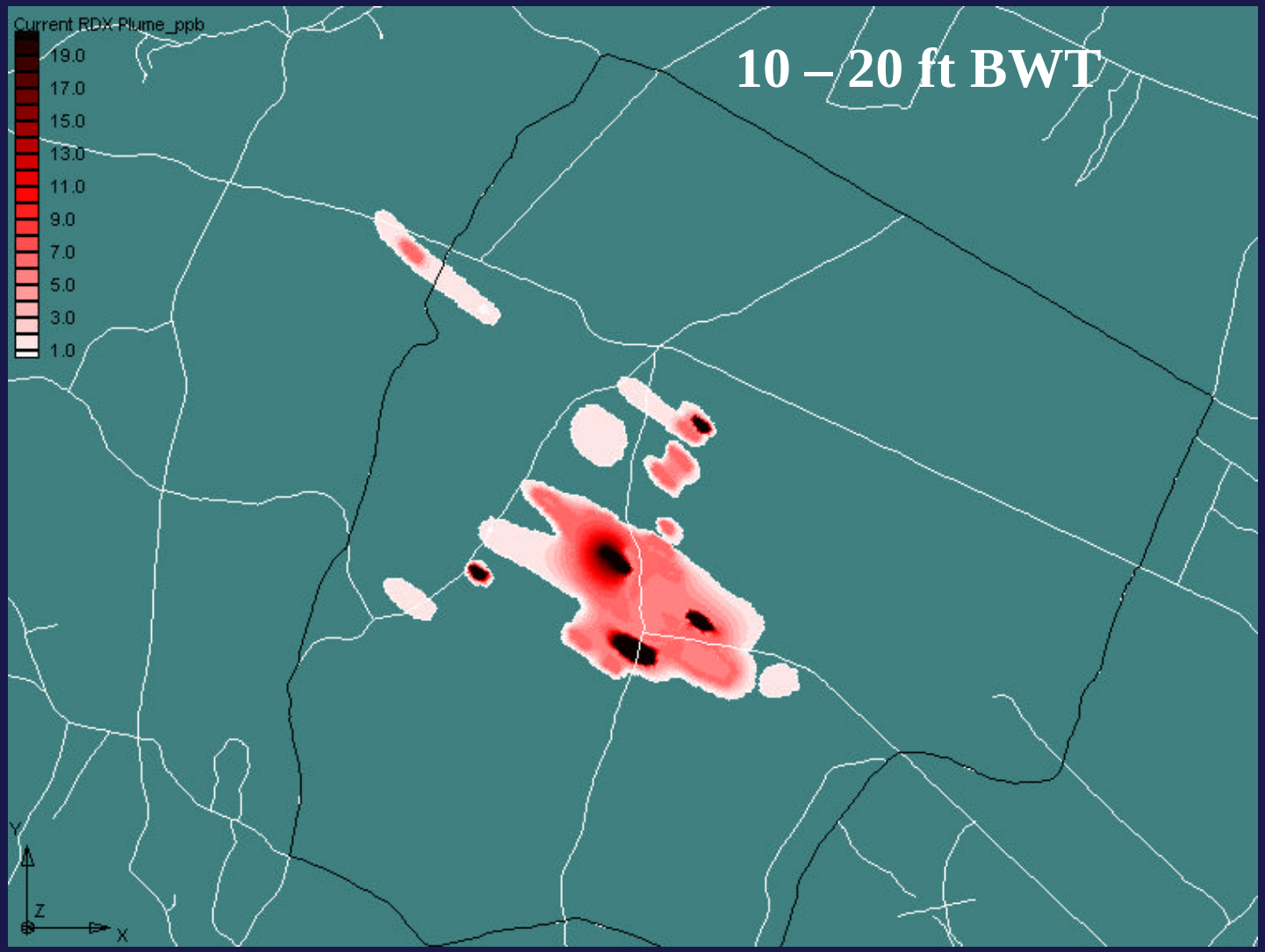
INTERPRETED RDX DISTRIBUTION



CROSS-SECTION A-A’



INTERPRETED RDX DISTRIBUTION



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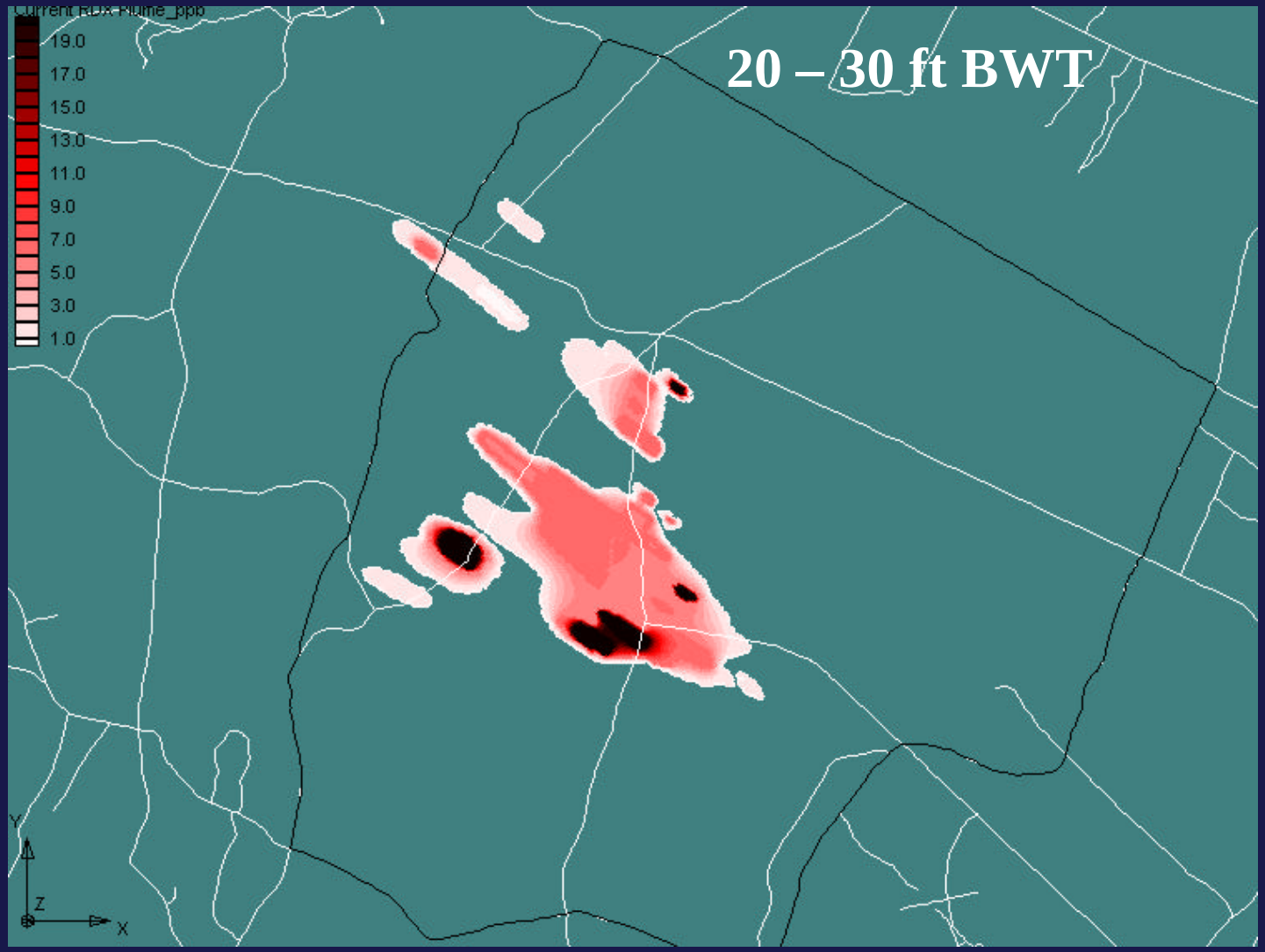

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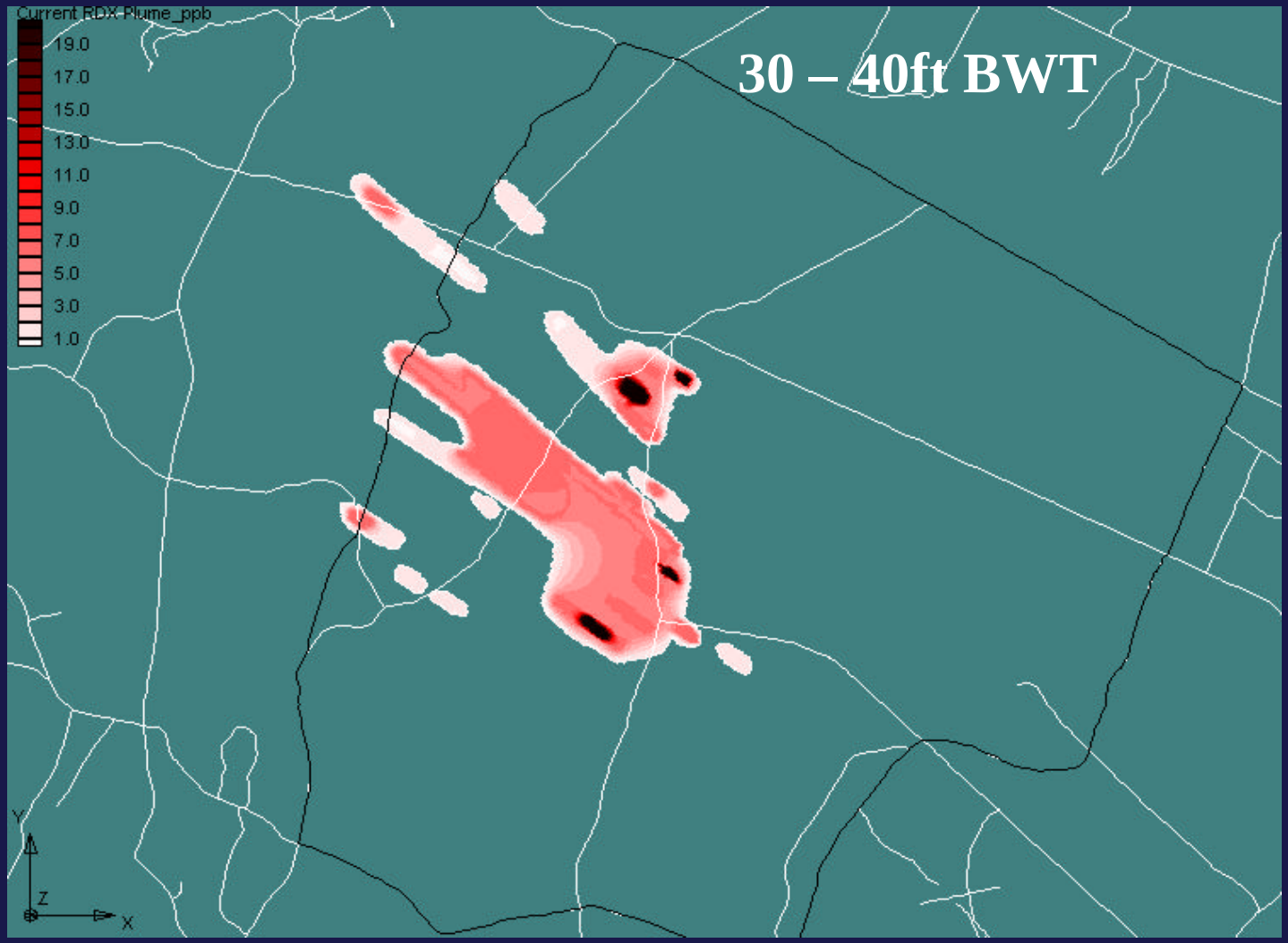

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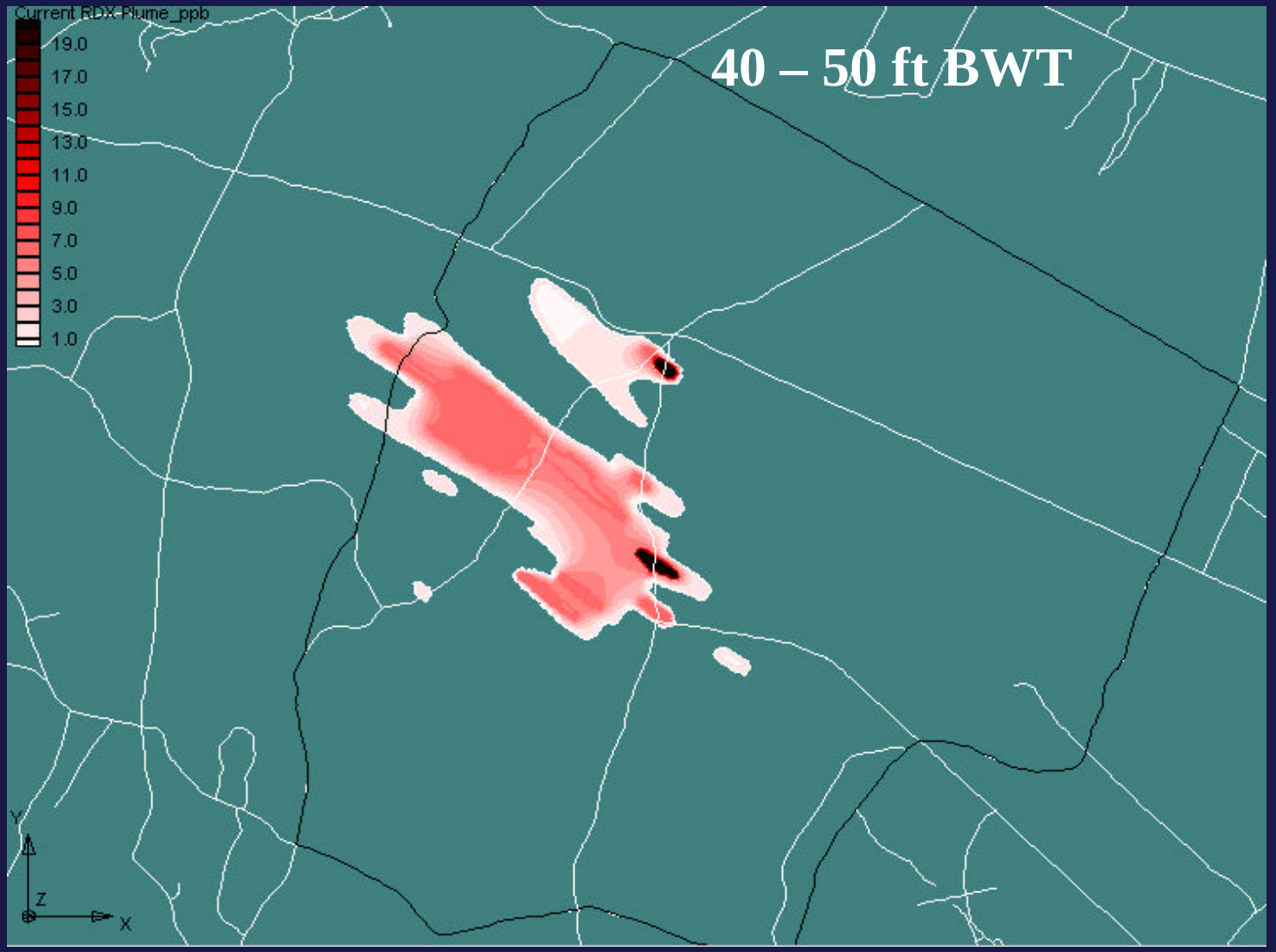

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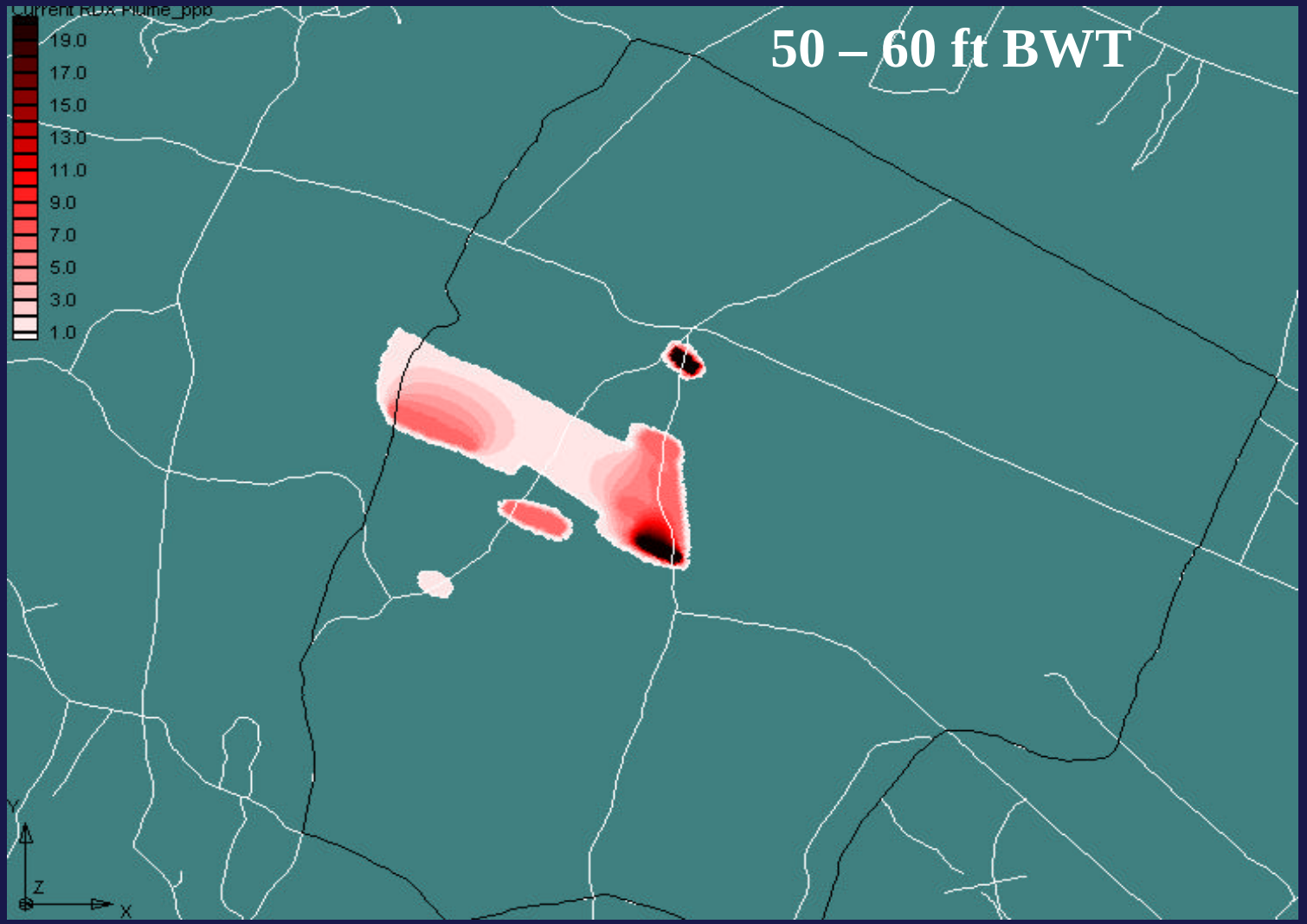

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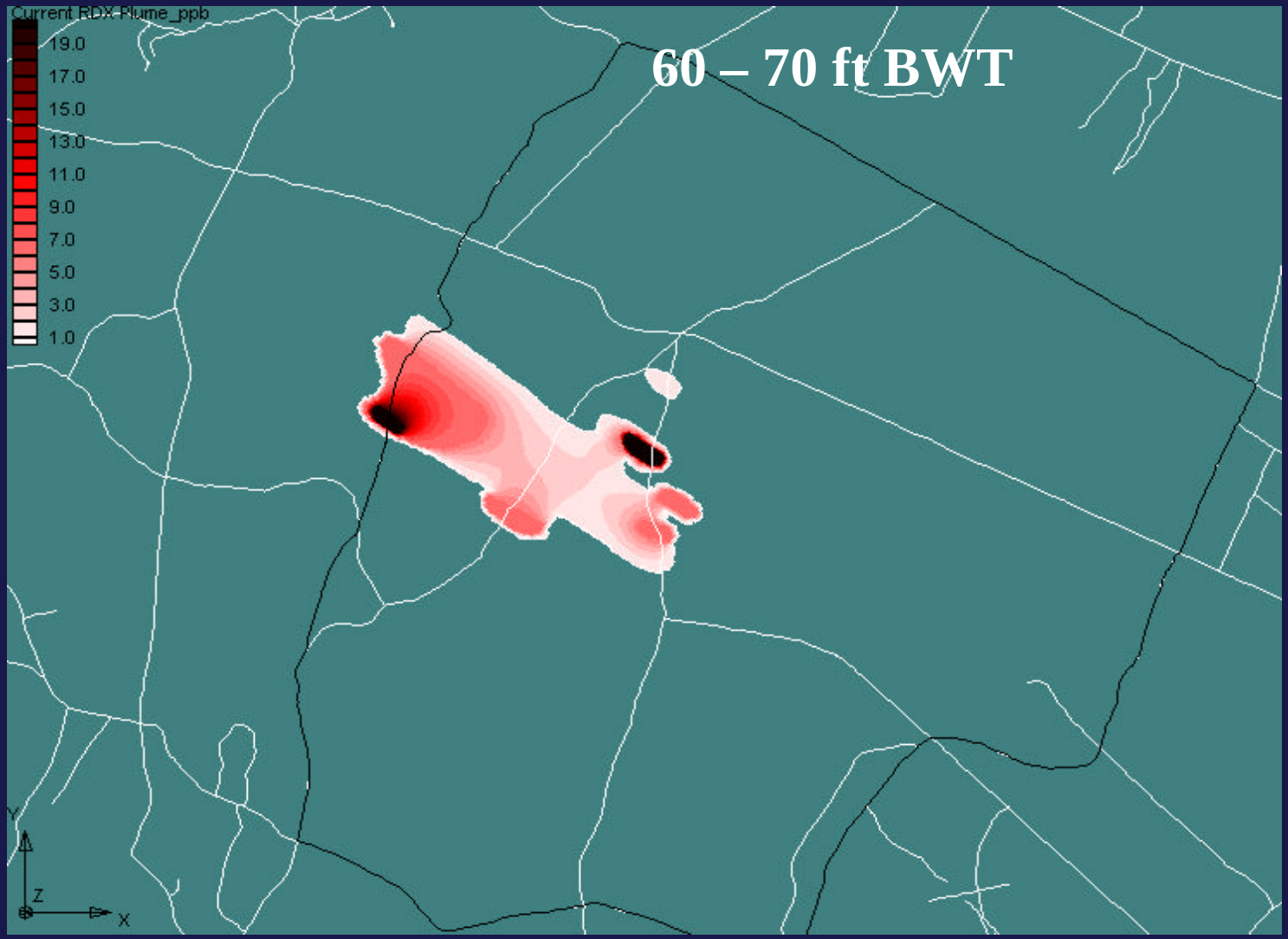

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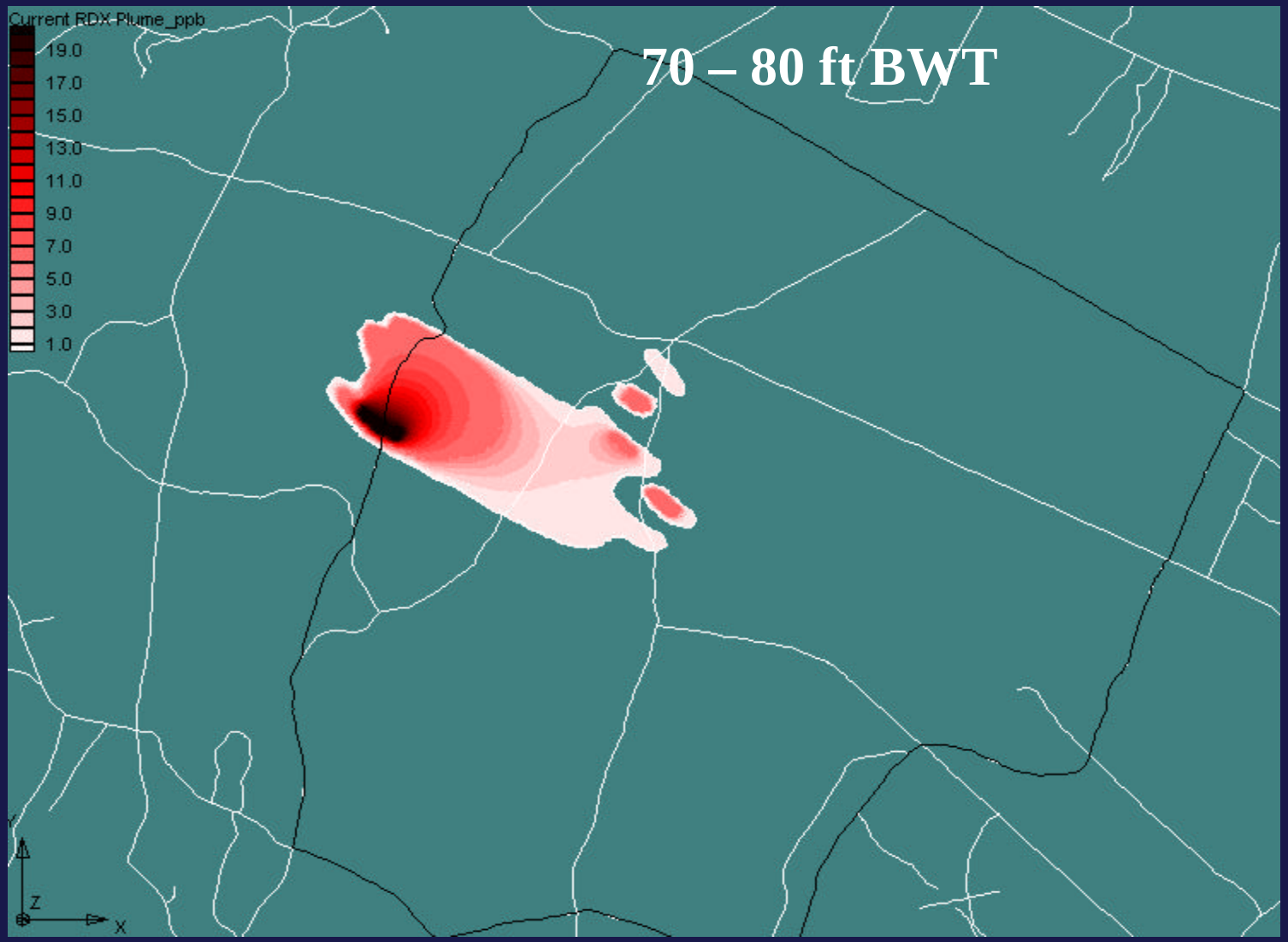

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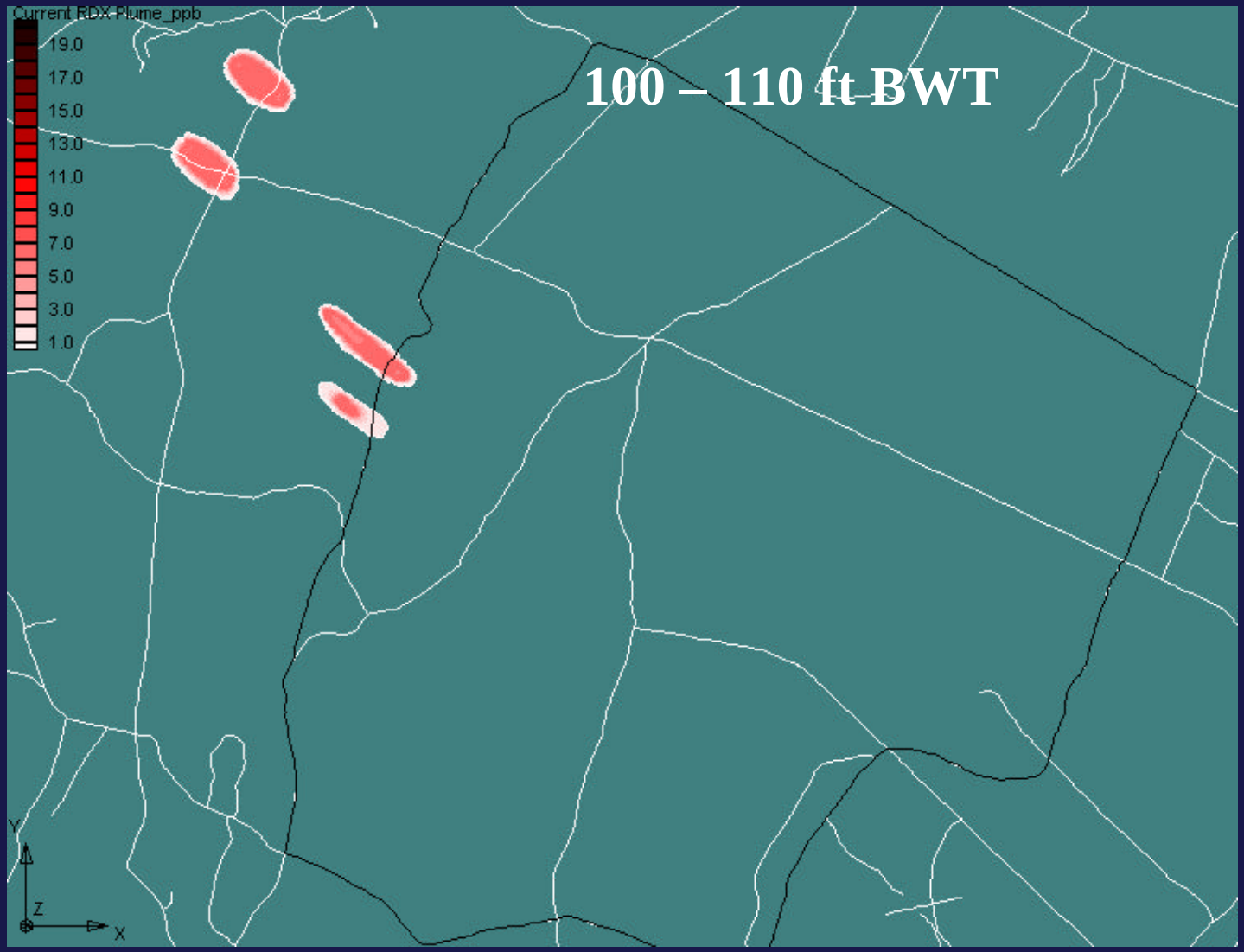
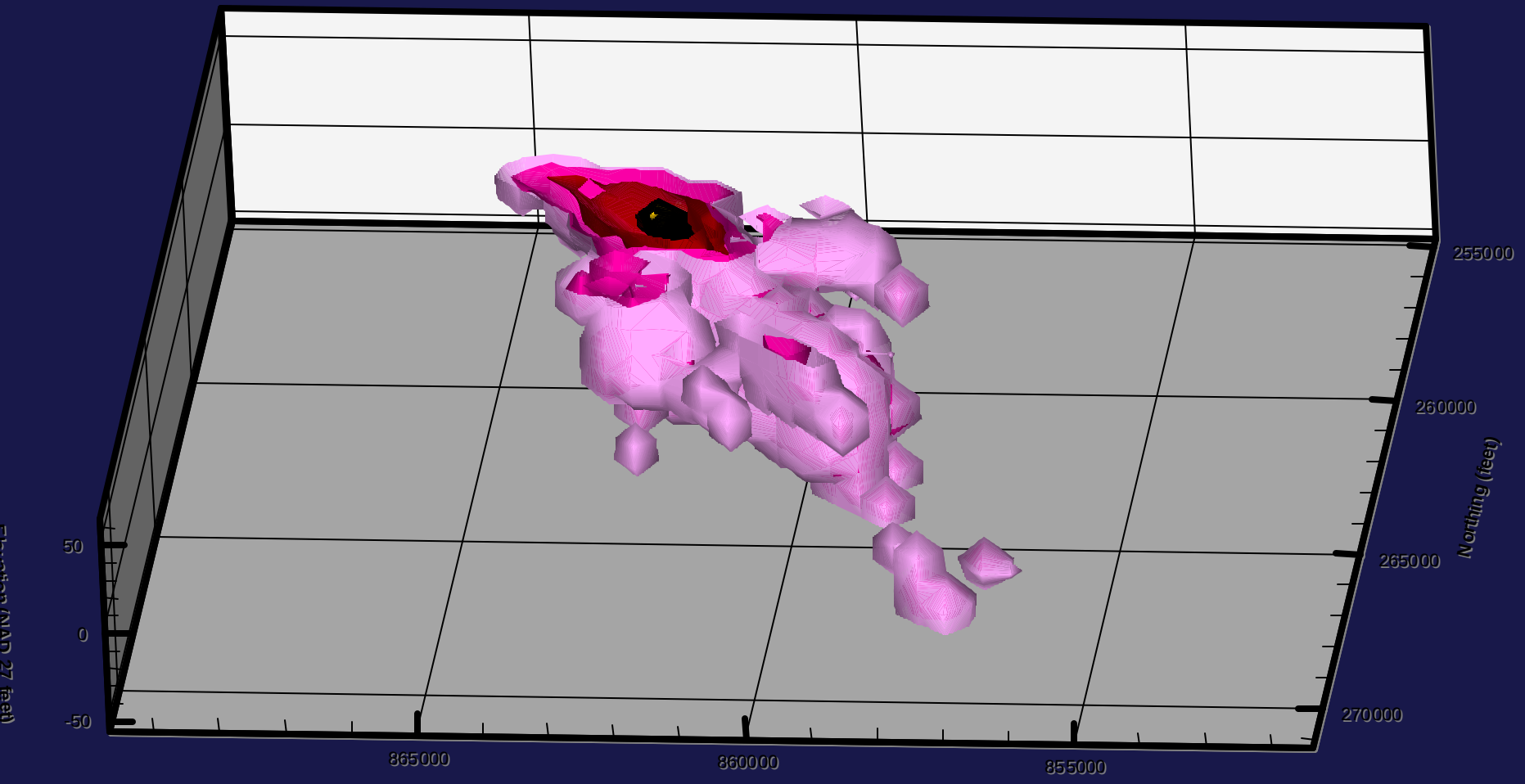
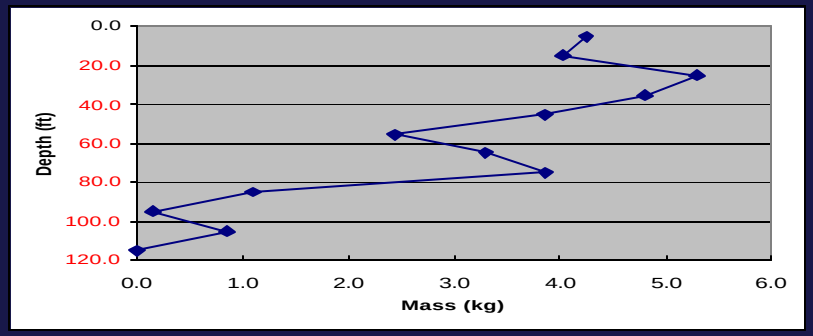


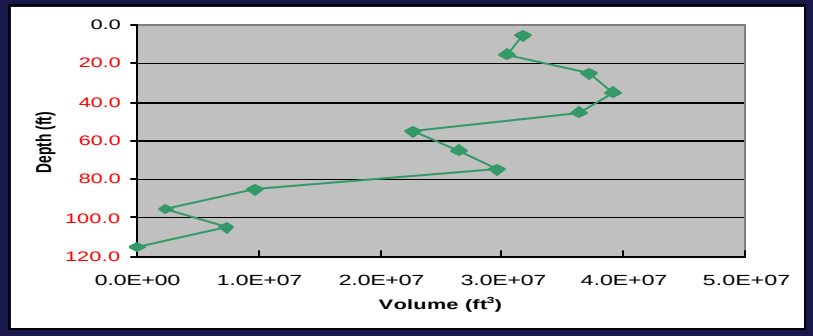
3-D IMAGE OF RDX PLUME

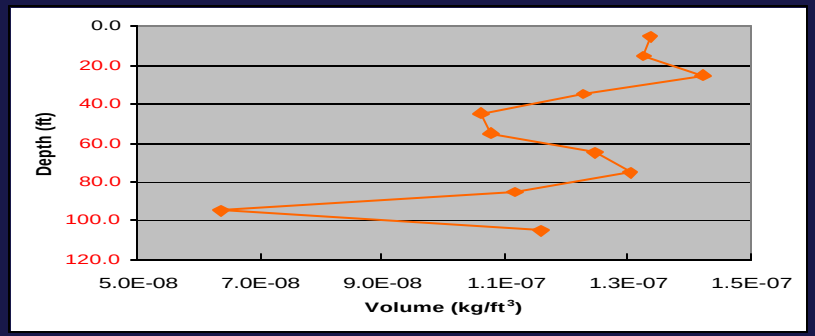
(View from North)



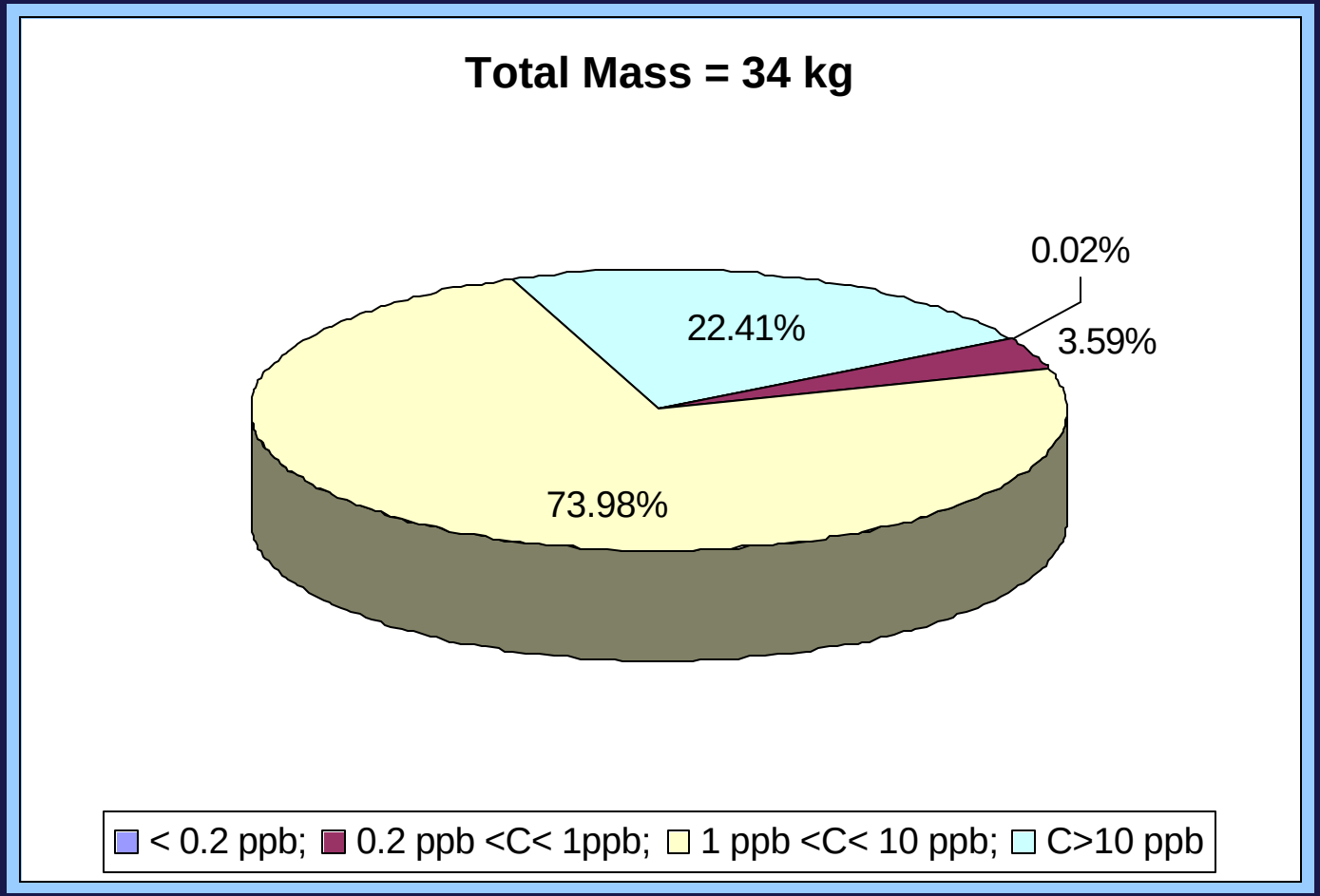
VERTICAL DISTRIBUTION OF RDX BELOW WATER TABLE







DISTRIBUTION OF RDX MASS



MODEL CODES

- MODFLOW (Flow)
- MODPATH (Pathline Analysis)
- MODTMR (Telescopic Mesh Refinement)
- MT3D (Transport)
- GMS (Graphical User Interface - GUI)

PREDICTIVE CAPABILITIES OF MMR-8 FOR CENTRAL IMPACT AREA

- Delineation of source area using particle tracking
- Determining age of plume using particle tracking
- Prediction of contaminant migration using particle tracking

INCORPORATING RETARADATION FACTOR INTO MODPATH ANALYSIS

- Velocity of Non-Reactive Solute:

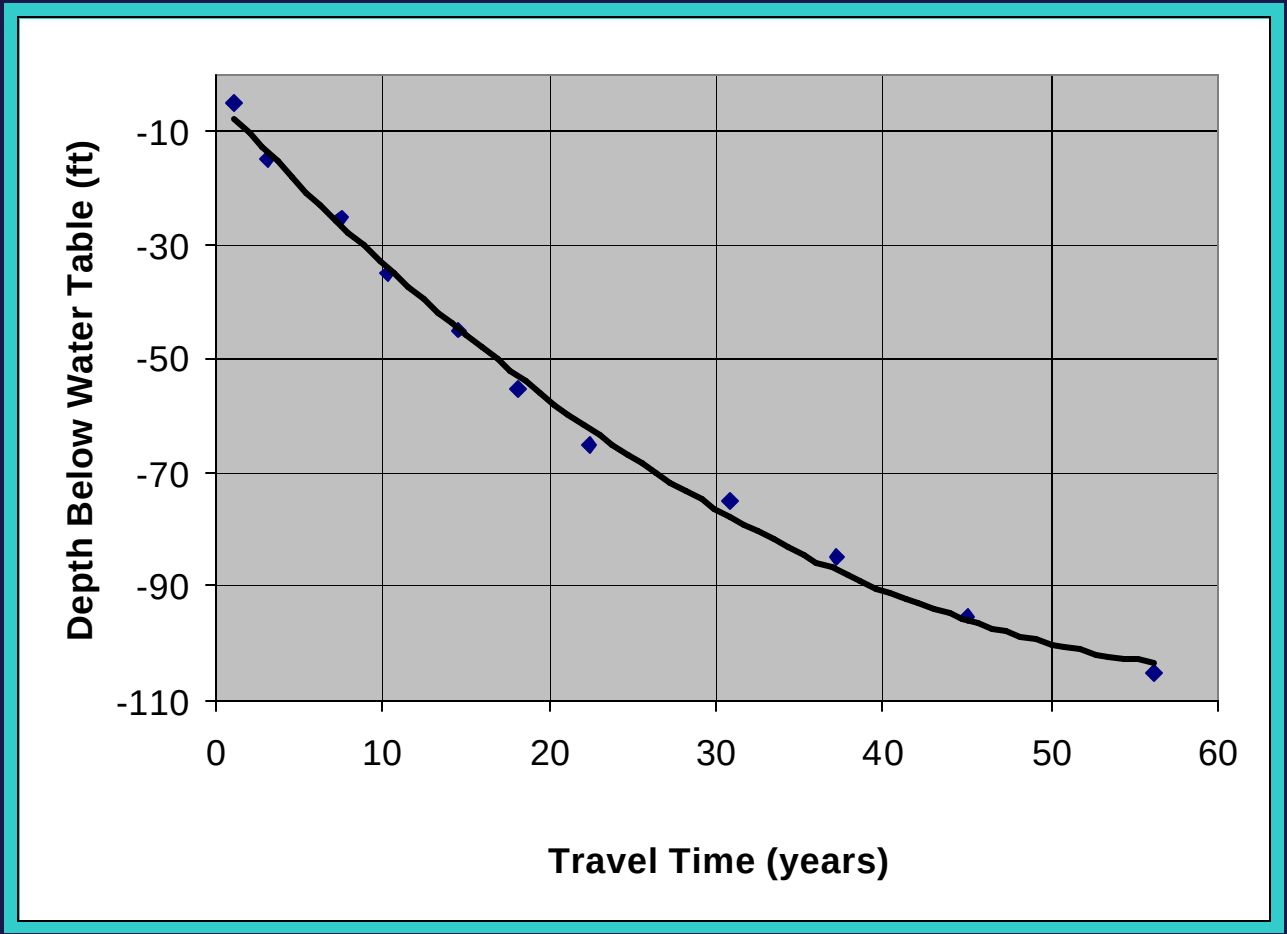
  $V = K*(dh/dl)/n$

- Velocity of Reactive (Sorption) Solute:

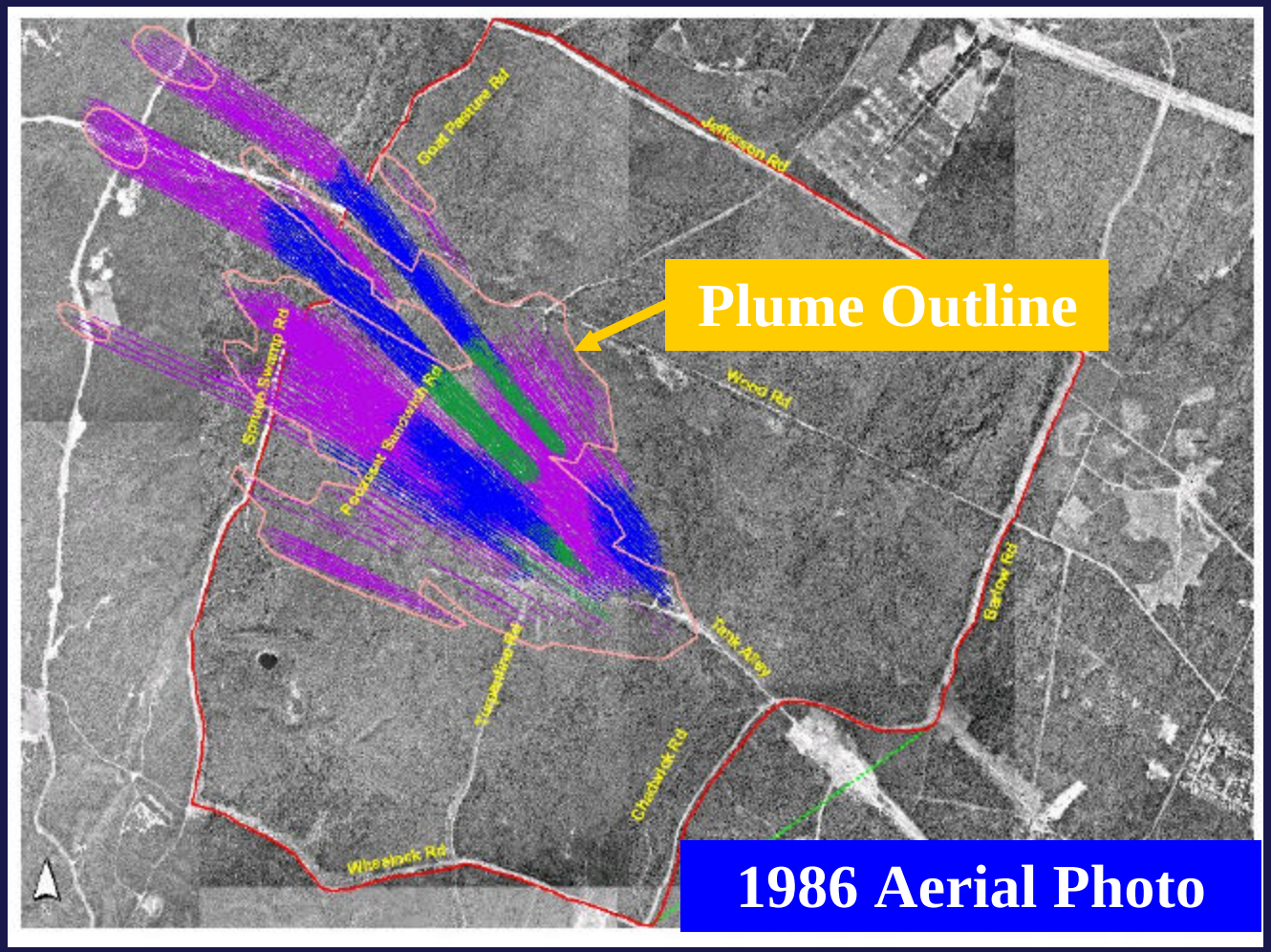
  $V = K*(dh/dl)/(n*Rf)$

⇨ **n’ = n*Rf**

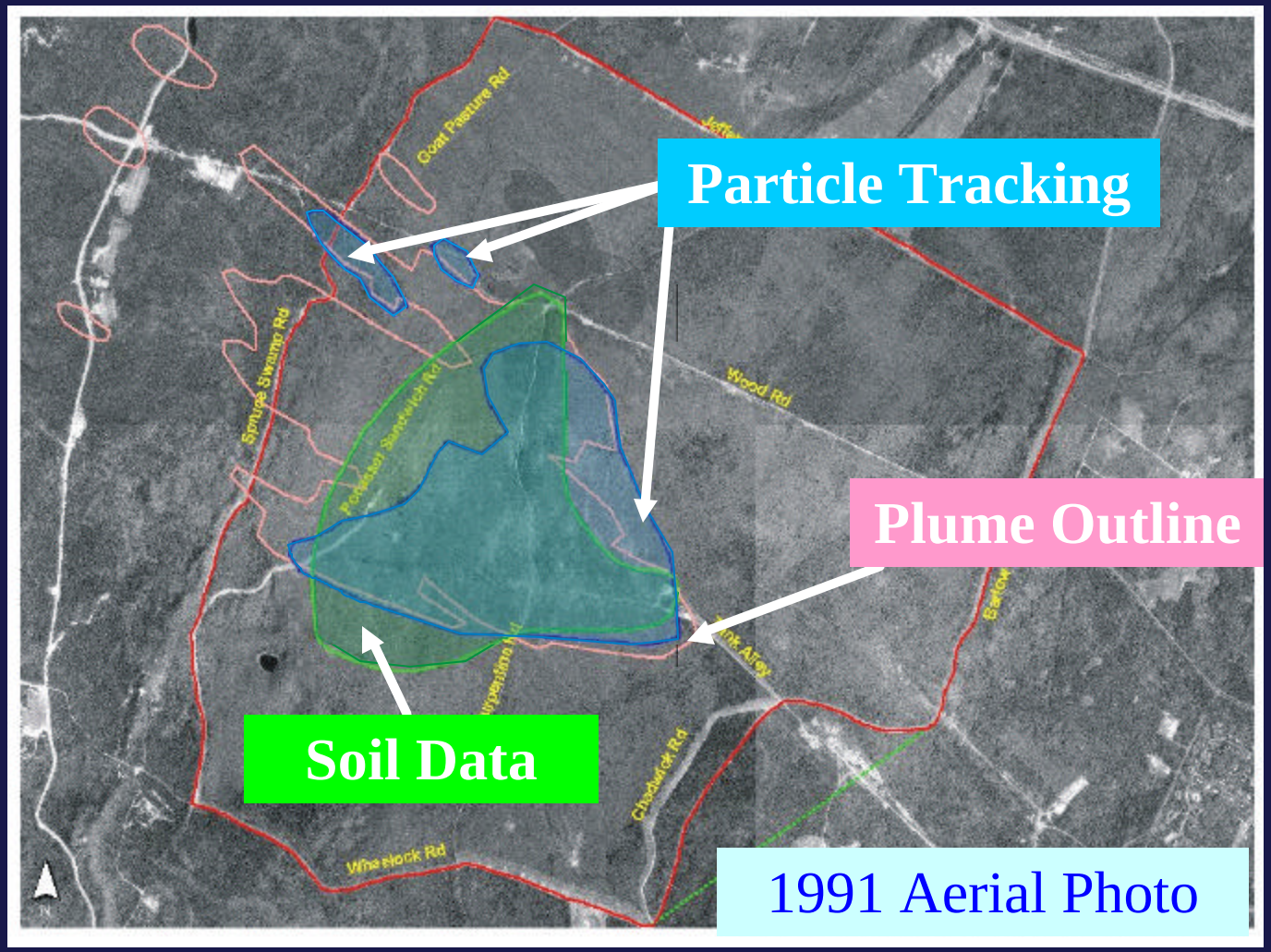
TRAVEL TIME VS DEPTH



MODPATH SIMULATED RDX PLUME VS CURRENT CONFIGURATION



POTENTIAL RDX SOURCES



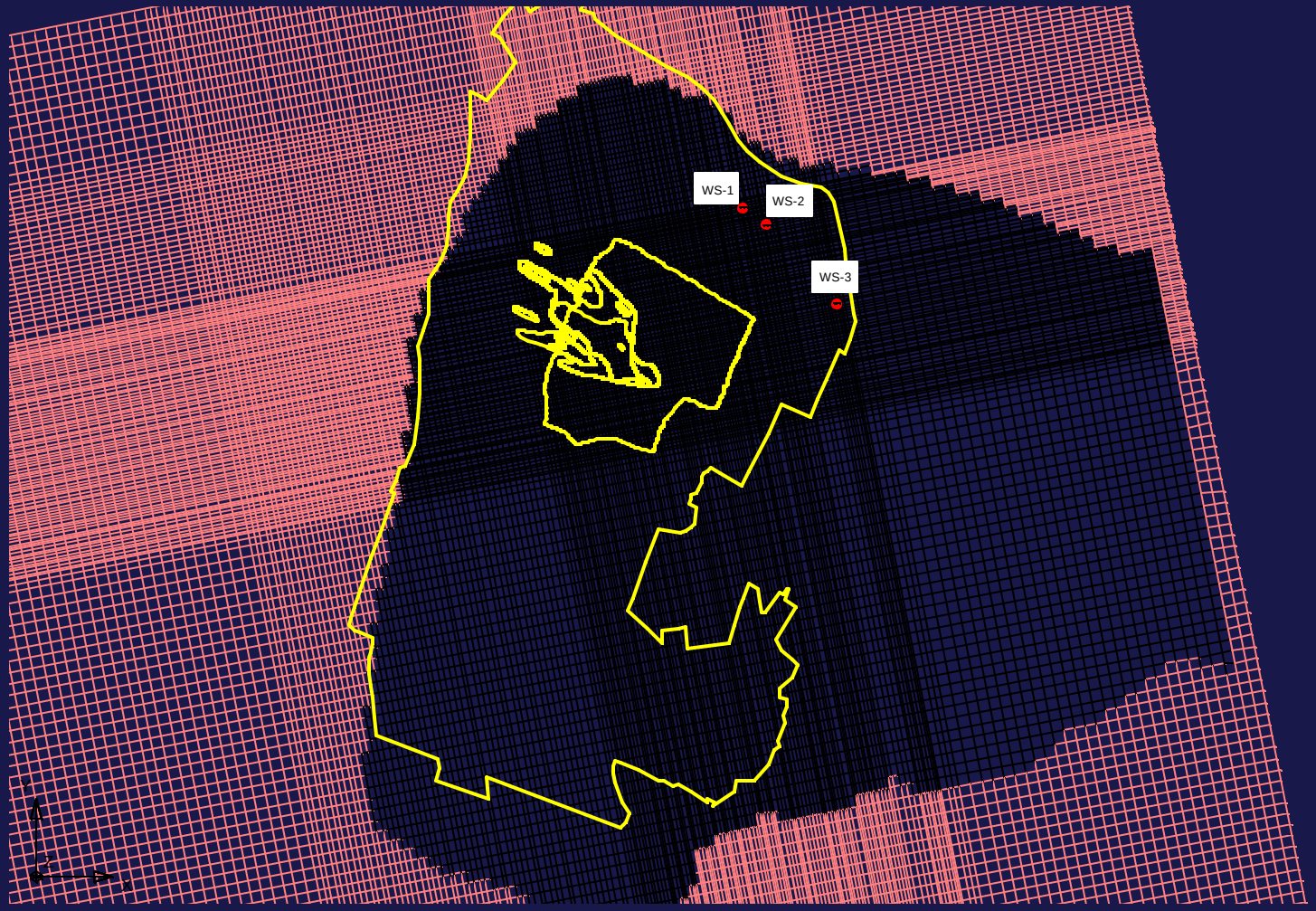
RDX SOURCE AREA DELINEATION SUMMARY

Source Area Delineation Method	Area (acres)
Soil	337
Reverse PTs	298

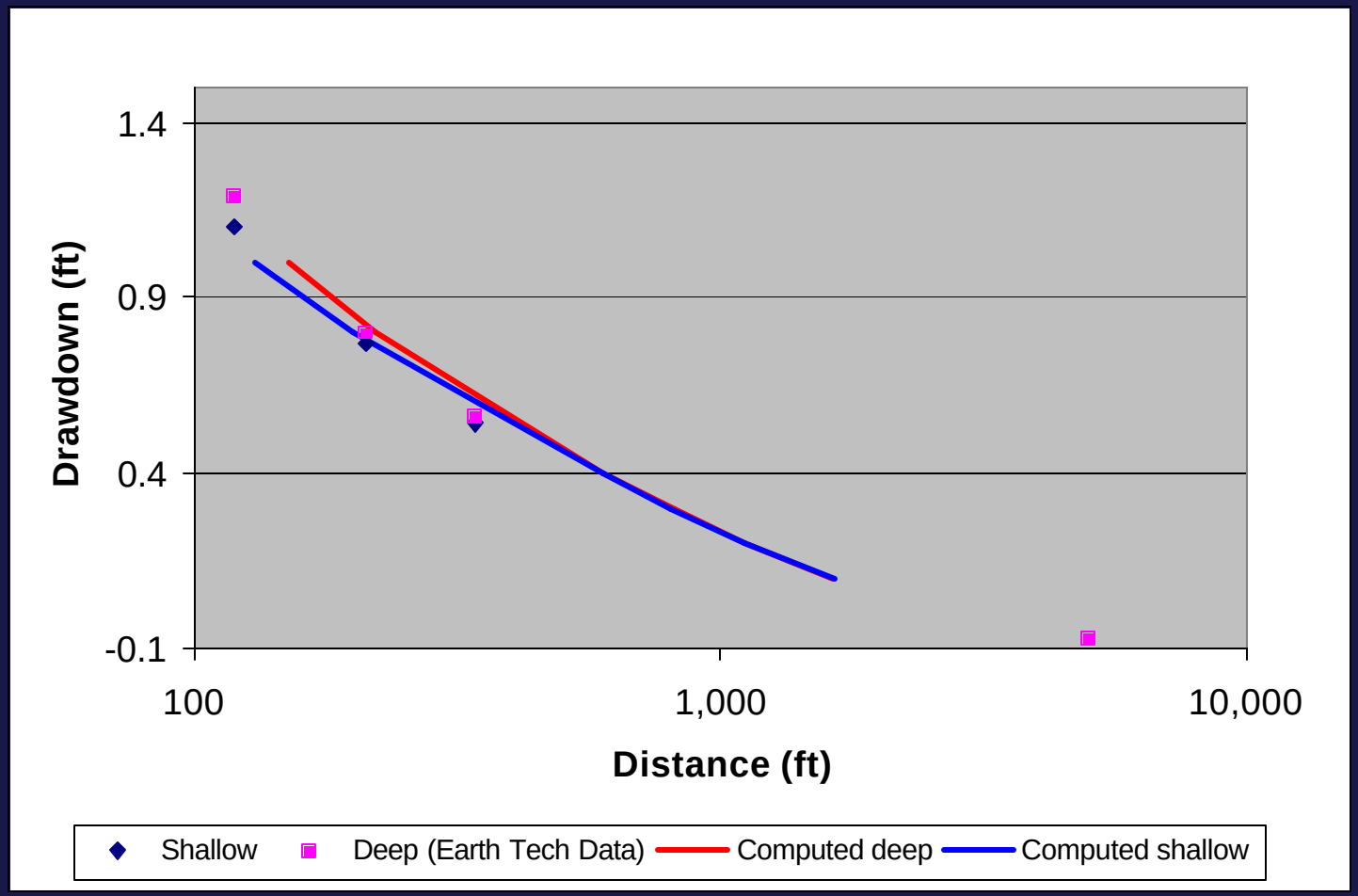
DEVELOPMENT OF CENTRAL IMPACT AREA SUB-REGIONAL MODEL(S)

- Transport Calibration
- Simulation of No-Action Scenario
- Remedial Design Variants

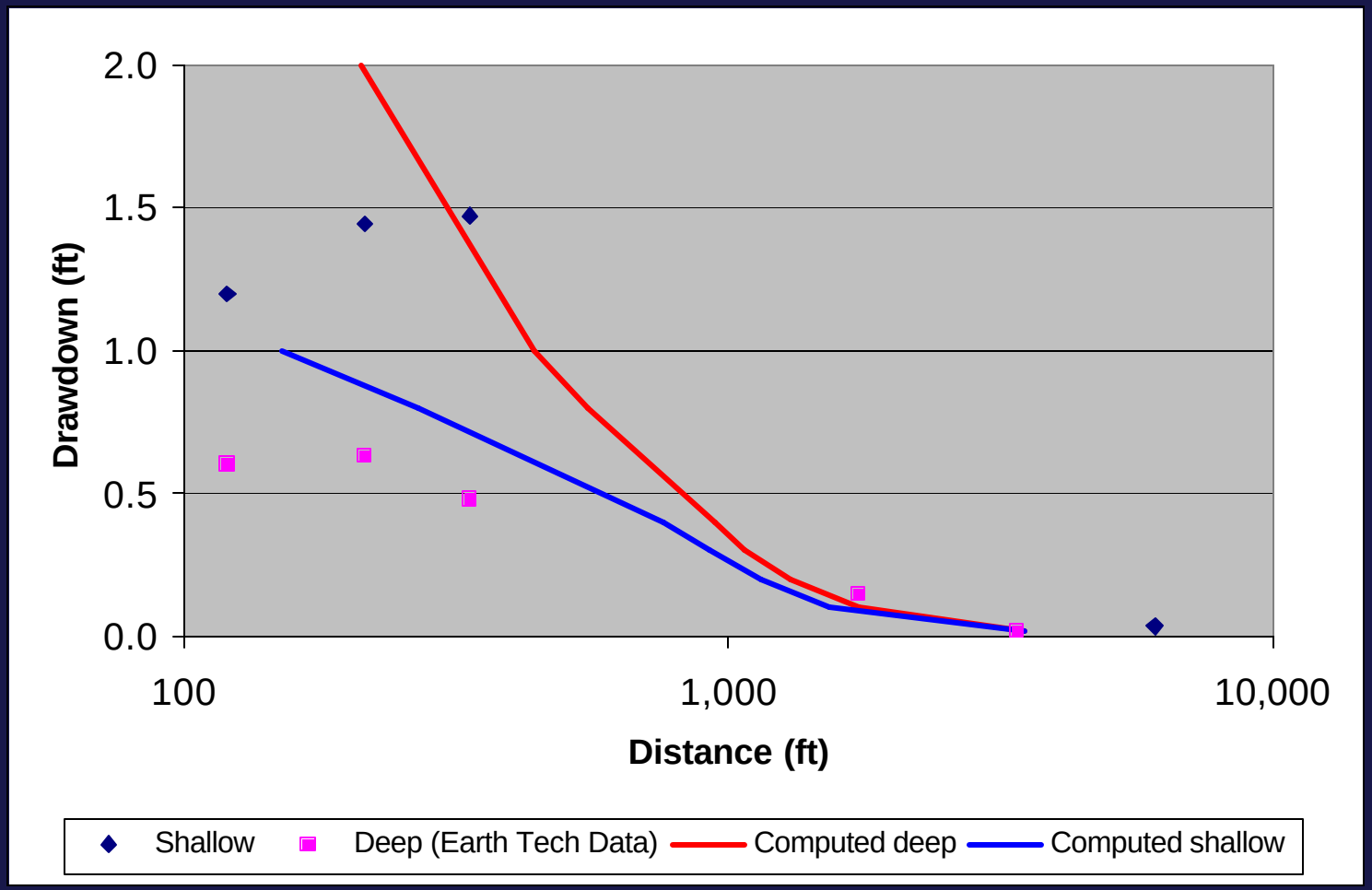
MMR-8 MODEL REFINED IN CENTRAL IMPACT AREA AND WS-1, WS-2, WS-3 SITE



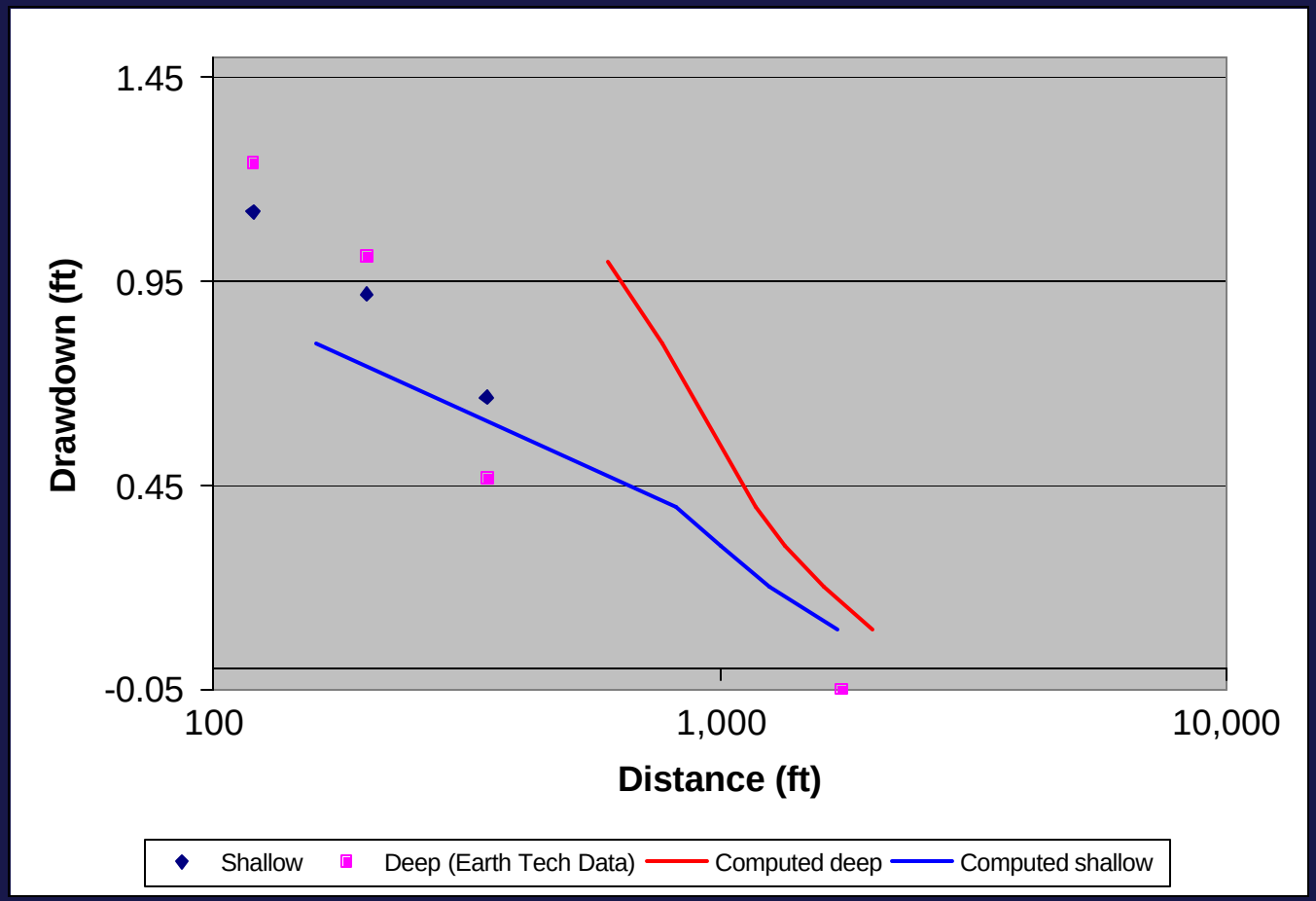
DRAWDOWN VS DISTANCE AT THE END OF 5-DAY WS-1 PUMP TEST



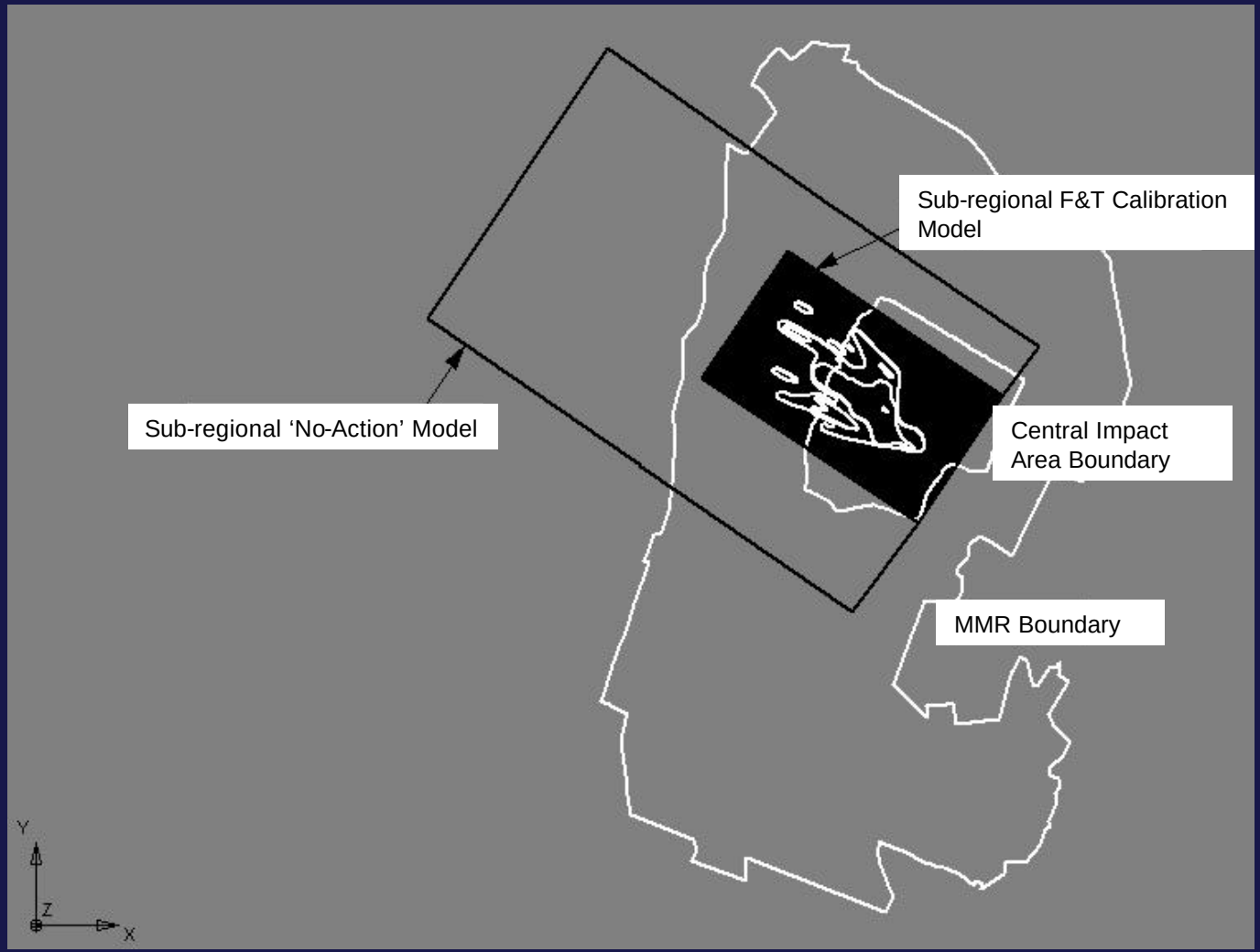
DRAWDOWN VS DISTANCE AT THE END OF 5-DAY WS-2 PUMP TEST



DRAWDOWN VS DISTANCE AT THE END OF 5-DAY WS-3 PUMP TEST



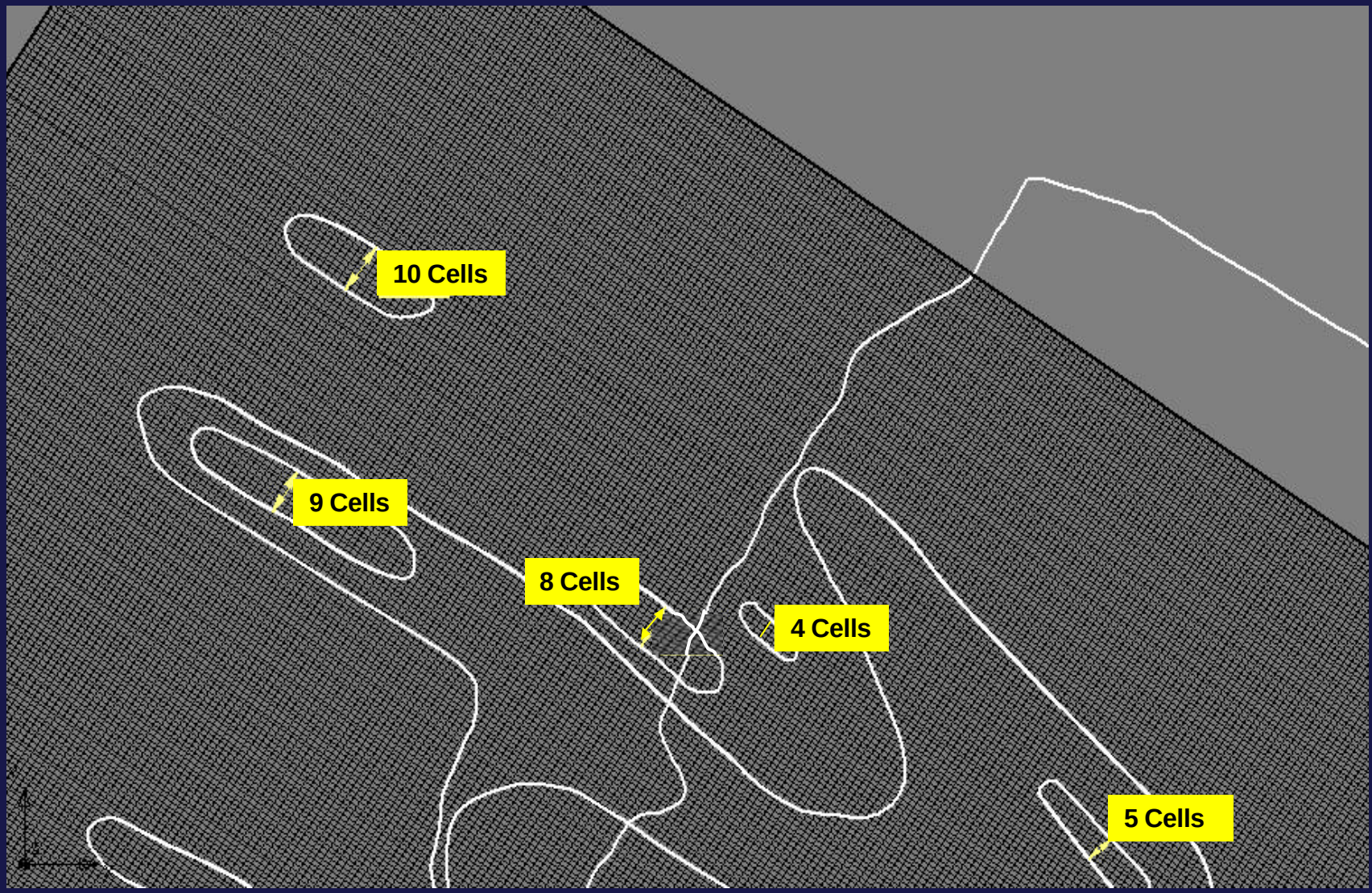
CENTRAL IMPACT AREA SUB-REGIONAL MODEL(S)



CENTRAL IMPACT AREA SUB-REGIONAL MODEL DISCRETIZATION

- Cell Width Along Columns (parallel to flow direction) = 45+ ft
- Cell Width Along Rows (perpendicular to flow direction) = 30+ ft
- Layer Thickness = 10+ ft
- Total Number of Cells for Calibration Model =284x320x17=1,544,960

CENTRAL IMPACT AREA SUB-REGIONAL MODEL GRID



PROPOSED CALIBRATION TARGETS

- Total mass of COC in the aquifer;
- Distribution of COC mass with depth;
- Characteristic width of the COC plume;
- Maximum length/extent of the COC plume;
- Maximum depth of the COC plume; and
- Maximum observed COC concentration.

MAJOR CONCLUSIONS

- Flow direction and gradients are insensitive to seasonal fluctuations in precipitation and aquifer recharge
  - steady-state analysis is justified
- RDX sources are shown to be not more than 60 year old
  - consistent with site history
- Oldest RDX sources are shown to be along northern portion of Turpentine Rd, just south of Wood Rd
  - consistent with 1943 and 1955 Aerial Photographs
- In general, RDX source area identified by reverse particle tracking is in a good agreement with soil data

MAJOR CONCLUSIONS *(continued)*

- Both soil data and particle tracking analysis show RDX source area is about 300 acres
- Total dissolved RDX mass was estimated to be approximately 36 kg
- About 74% of total RDX mass is associated with relatively low concentration values, i.e. between 1 ppb and 10 ppb
- Both RDX mass and plume volume have a general trend of decreasing with depth

MAJOR CONCLUSIONS *(continued)*

- Existing regional ground water flow model is suitable for generating a sub-regional Central Impact Area model used to calibrate current plume configuration and mass
- Existing regional ground water flow model may require some local modifications in the vicinity of WS-3 well in order to be used for the prediction of future stresses.