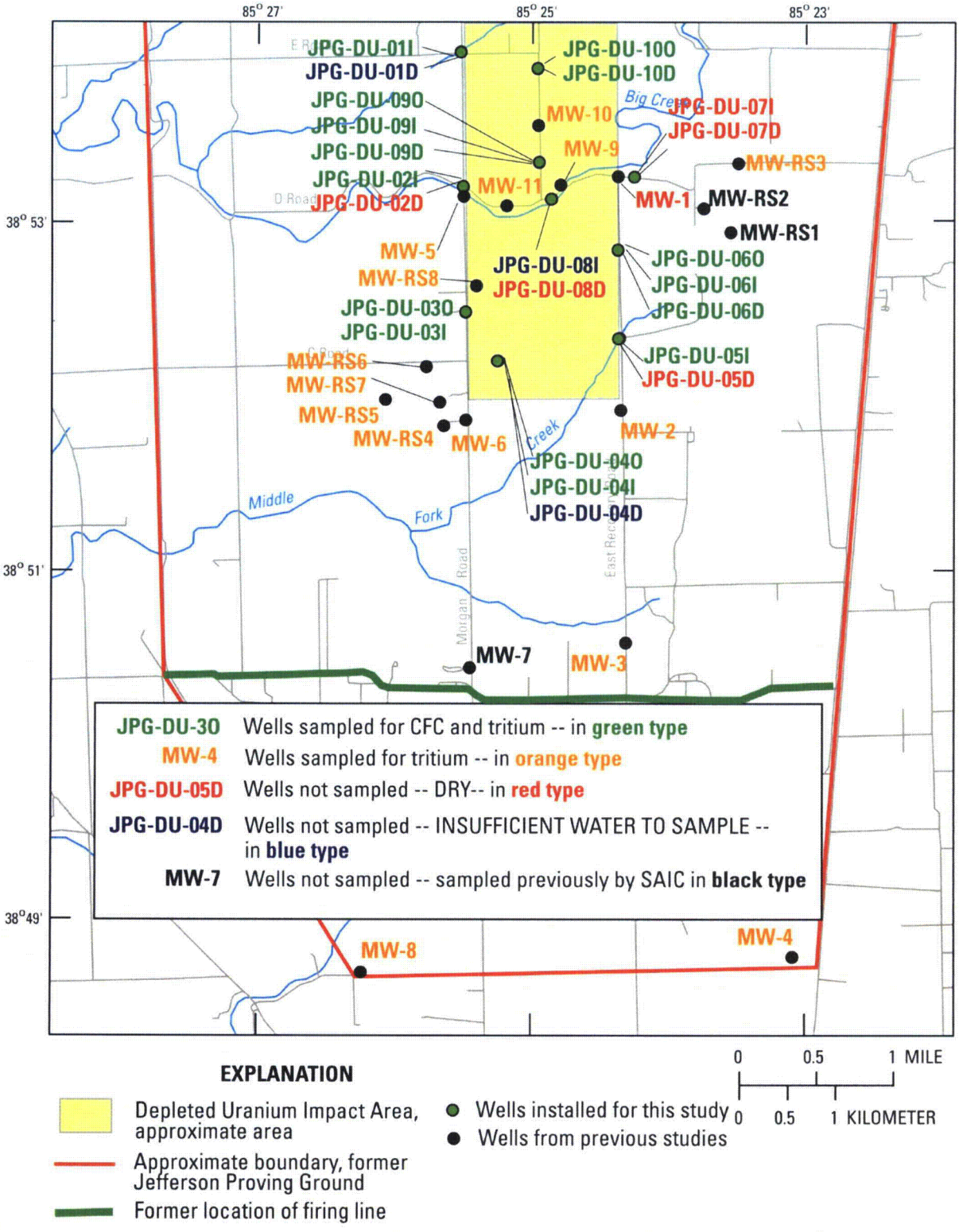
Estimates of groundwater age

- Do wells produce groundwater that recharged before, during, or after test firing of Depleted Uranium penetrators-Post 1984?
- Sampled groundwater from wells in till and carbonate units-4/2008
  - Pre-Wisconsinan till
  - Shallow Carbonate—well screens 1 to 30 ft below bedrock surface
  - Deep Carbonate—well screens 39 feet or more below bedrock surface
- Groundwater from 15 JPG-DU wells analyzed for chlorofluorocarbon compounds, tritium, and dissolved gases; 14 prior study wells for tritium only
- Part of Army/SAIC hydrogeologic framework study

USGS

Wells sampled for age dating



How is groundwater age estimated?

Tritium: decaying isotope; bomb testing, 12.3 year half-life

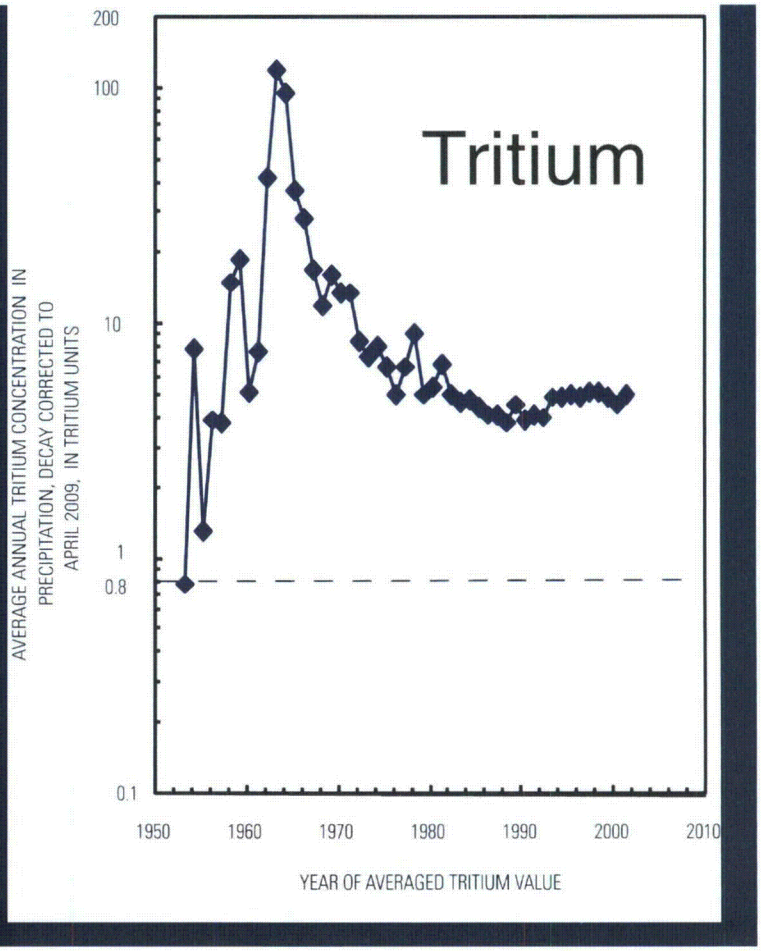
"Chlorofluoro-carbons or CFCs" from refrigerants

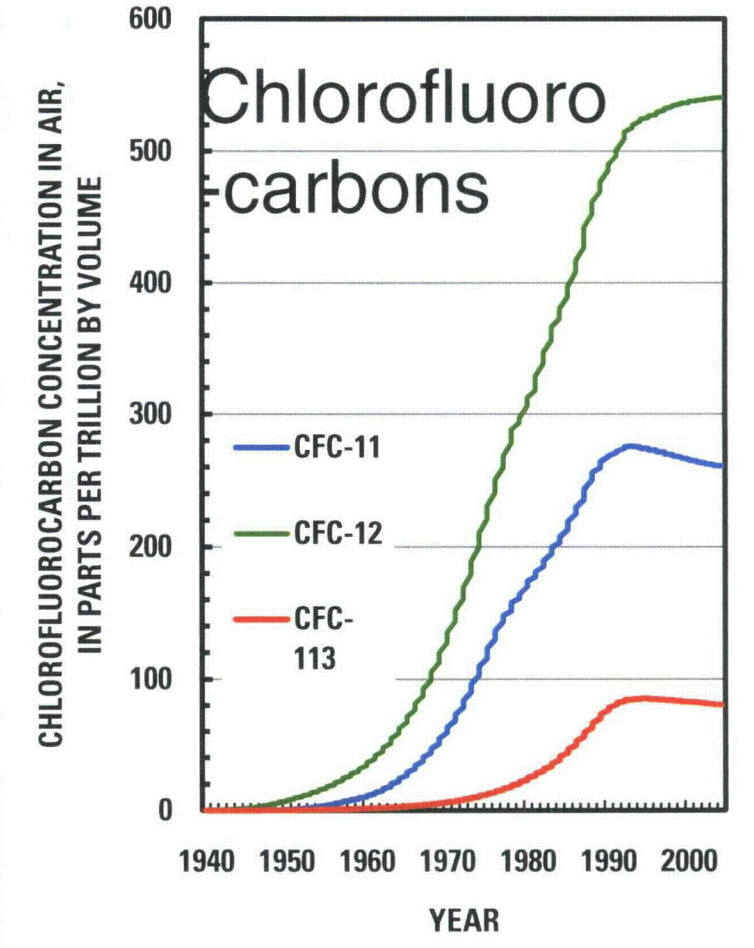
Concentrations in groundwater relate to those in precipitation

Tritium < 0.8 TU; pre-1953 recharge

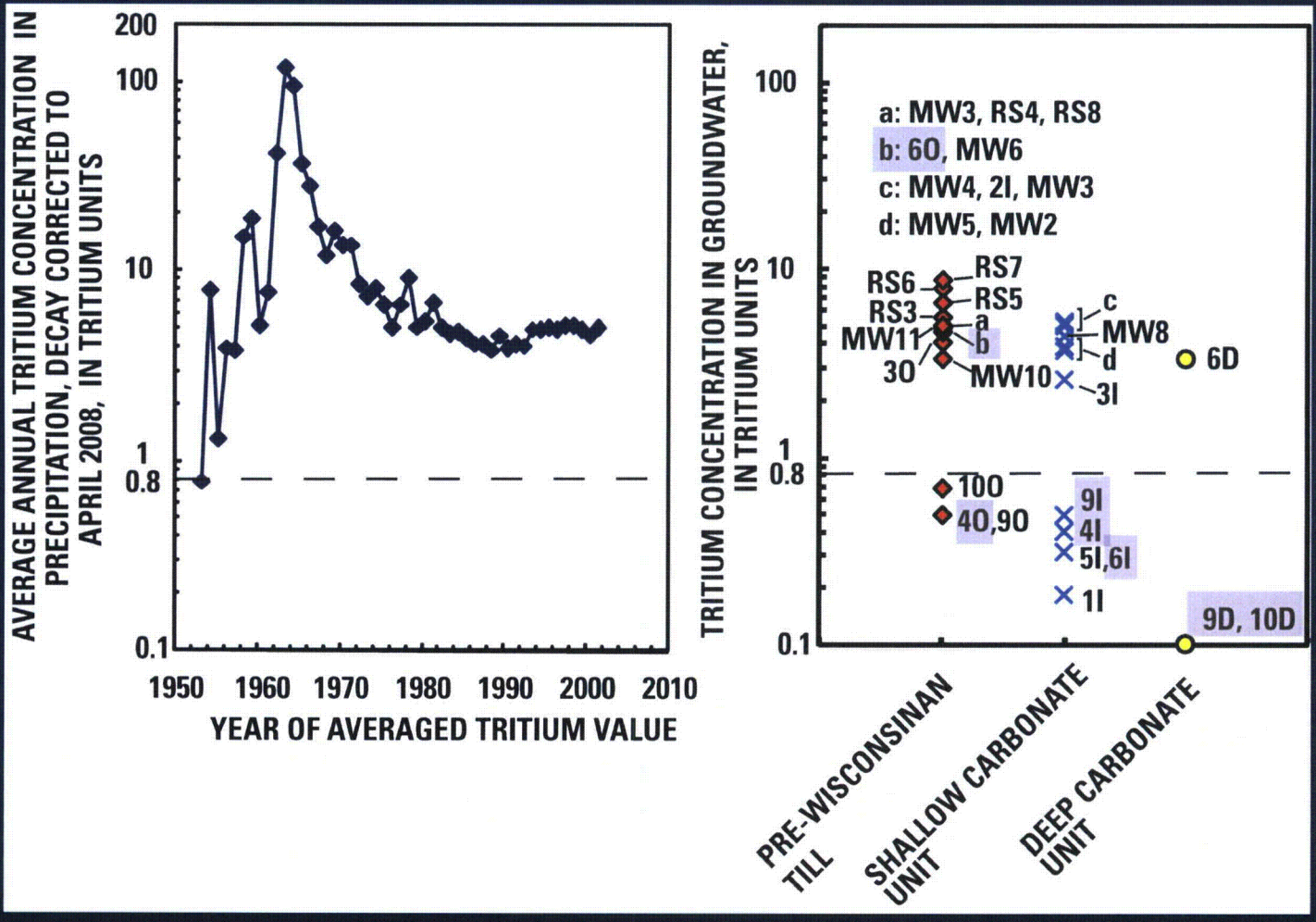
Zero CFCs mean pre-1940 recharge

USGS





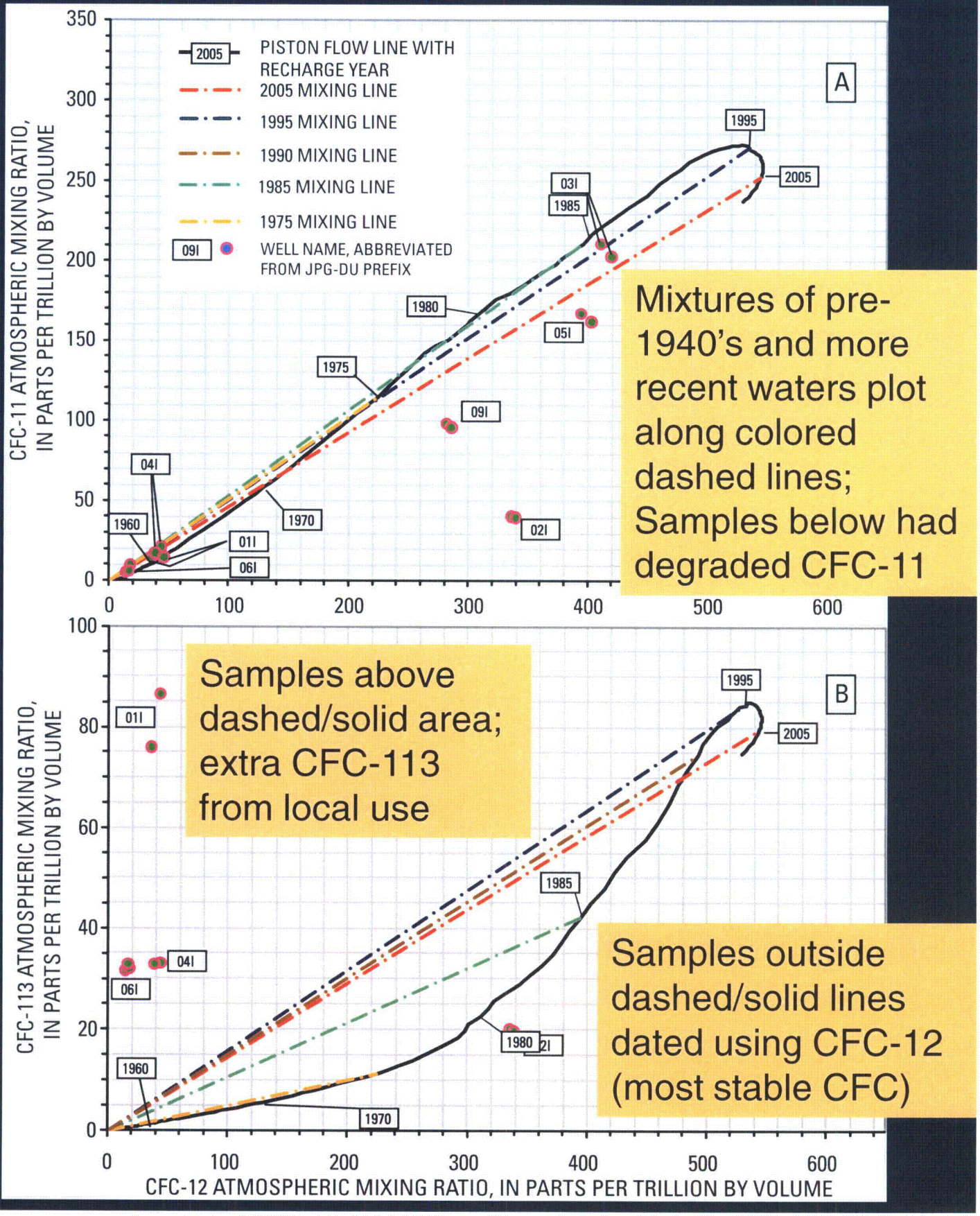
Tritium-based age estimates



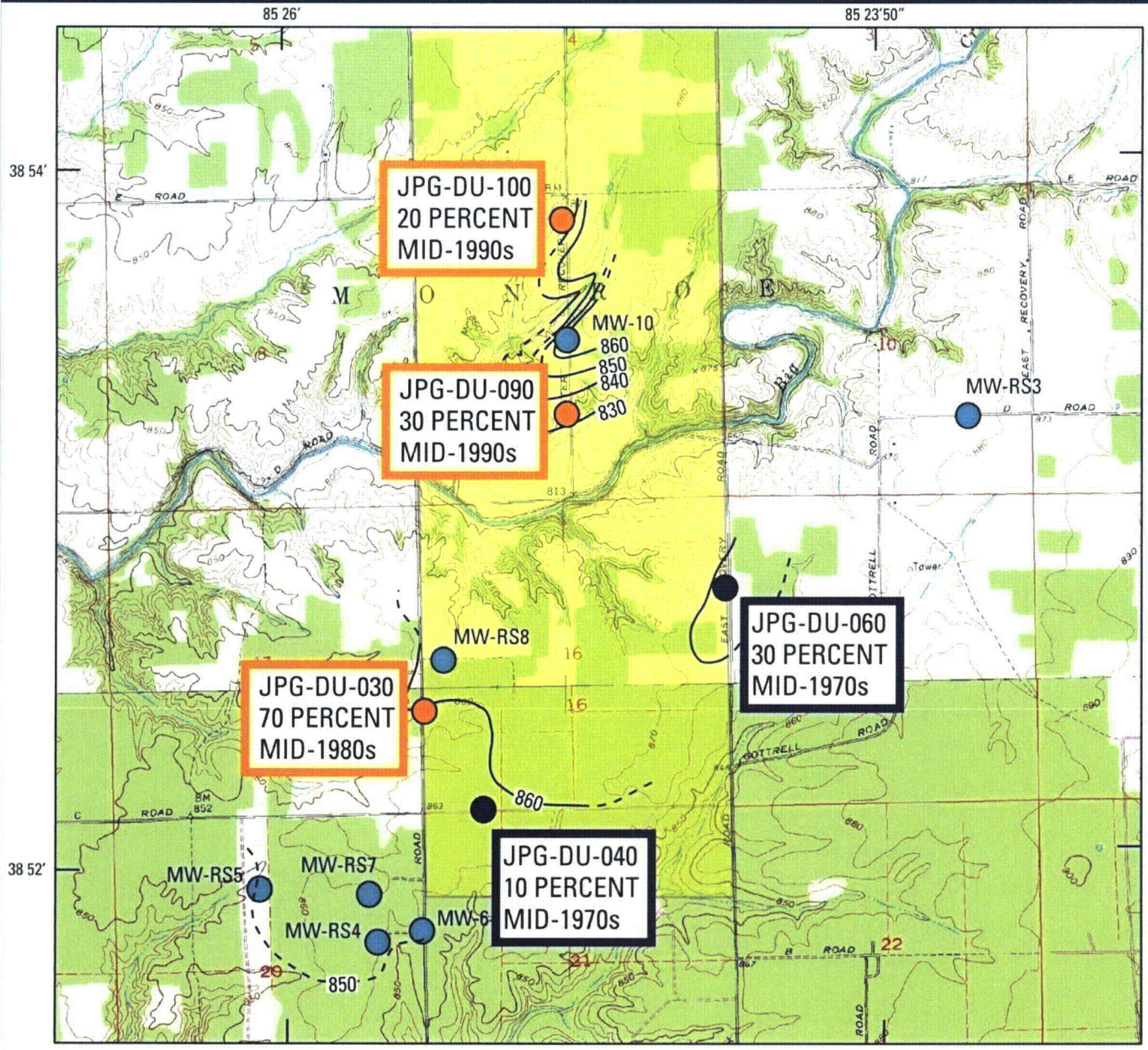
- Groundwater ages in shaded well names predate DU activity
- Some samples with tritium < 0.8 TU were mixtures based on CFC dates; mostly pre-1953 recharge with <= 30 percent post-1984 water

USGS

Chlorofluorocarbon-based ages



Groundwater age dates from Pre-Wisconsinan Till unit



GROUNDWATER AGE-Pre-Wisconsinan Till

DEPLETED URANIUM IMPACT AREA—Approximate extent

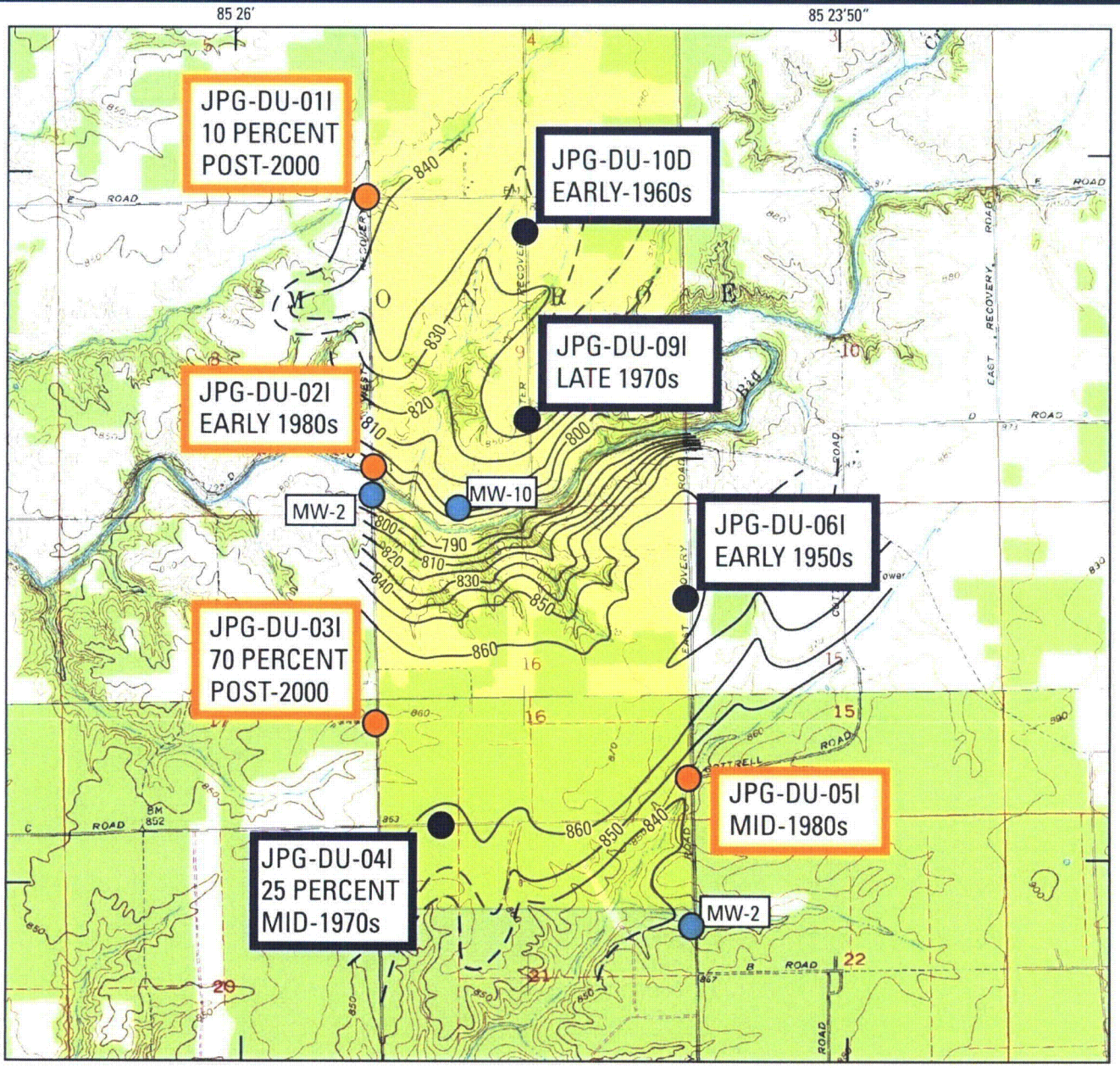
— 860 — WATER-LEVEL CONTOUR—Approximate altitude of the water level April 7, 2008, in feet

PRE-1980 GROUNDWATER AGE; CFC ANALYSIS, with percent modern water

PARTIALLY OR ALL POST-1980 GROUNDWATER AGE; CFC ANALYSIS, with percent modern water

POST-1953 AND POSSIBLY POST-1972 GROUNDWATER AGE; TRITIUM ANALYSIS

Groundwater age dates from Shallow Carbonate unit



0 0.5 1 MILE

0 0.5 1 KILOMETER

GROUNDWATER AGE-Shallow Carbonate Unit

DEPLETED URANIUM IMPACT AREA—Approximate extent

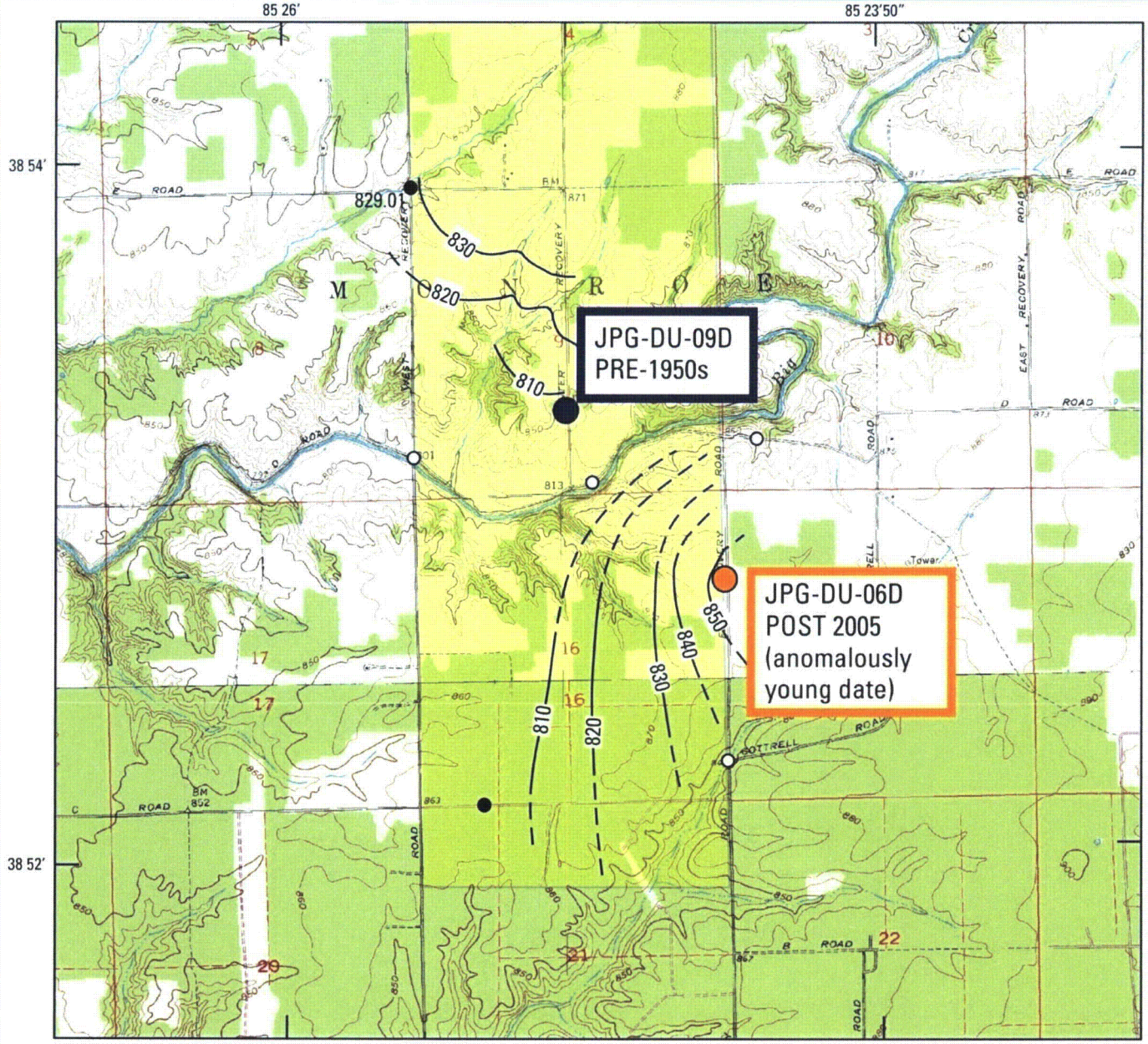
— 860 — WATER-LEVEL CONTOUR—Approximate altitude of the water level April 7, 2008, in feet

PRE-1980 GROUNDWATER AGE; CFC ANALYSIS, with percent modern water

PARTIALLY OR ALL POST-1980 GROUNDWATER AGE; CFC ANALYSIS, with percent modern water

POST-1953 AND POSSIBLY POST-1972 GROUNDWATER AGE; TRITIUM ANALYSIS

Groundwater age dates from Deep Carbonate unit



GROUNDWATER AGE-Deep Carbonate Unit

0 0.5 1 MILE

0 0.5 1 KILOMETER

DEPLETED URANIUM IMPACT AREA—Approximate extent

— 860 — WATER-LEVEL CONTOUR—Approximate altitude of the water level April 7, 2008, in feet

PRE-1980 GROUNDWATER AGE; CFC ANALYSIS, with percent modern water

PARTIALLY OR ALL POST-1980 GROUNDWATER AGE; CFC ANALYSIS, with percent modern water

DRY WELL, at time of sampling

WATER LEVEL IN WELL DID NOT RECOVER FROM PRE-SAMPLING DEVELOPMENT

Age dating conclusions

- Some groundwater predates DU penetrator testing (JPG-DU wells 04O, 04I, 06O, 06I, 09I, 09D, and 10D). Does not currently represent DU transport.

- Groundwater with ages dating from DU testing: JPG-DU wells 02I, 03O, 03I, and 05I. This groundwater best represents potential to detect DU transport.

- Some groundwater (JPG-DU wells 01I, 09O, and 10O) had 30 percent or less of water from DU penetrator testing years. Water ages from these wells are less suitable to detect DU transport.

USGS

Age dating limitations

- Sampling at different times may yield different proportions of pre-1940 and more recent recharge in mixed waters

- Very recent (2005) age water sampled from deep carbonate well JPG-DU-06D. Possible causes could include vertical leakage—natural or along the outer well casing.

USGS age dating summary report in peer review, publication planned by end of January 2010.

USGS

Purpose and Scope: Flowmeter Measurements of Ground-Water-Flow Direction

- Local flow directions in carbonate units may vary from regional directions along water-level gradients.
  - Porosity distribution in carbonate units is not uniform.
  - Groundwater may flow in tortuous paths
  - Longer flow paths can indicate longer groundwater residence time.

- Groundwater-flow measured in well with borehole horizontal flowmeter
- Compared local flow directions to water-level-gradient directions.
- Compared local flow directions to lineament (stream and fracture) orientations.

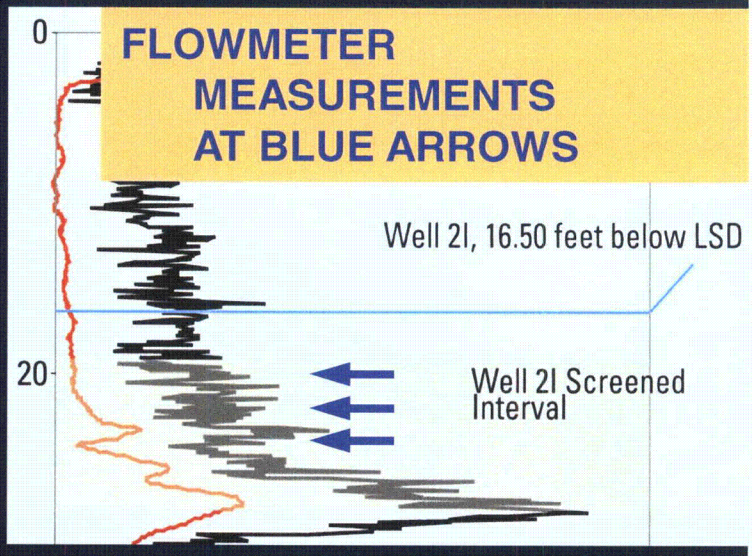
USGS

Flowmeter measurements: 5/08, 8/08

- Tested parts of till and carbonate units with less clay/shale

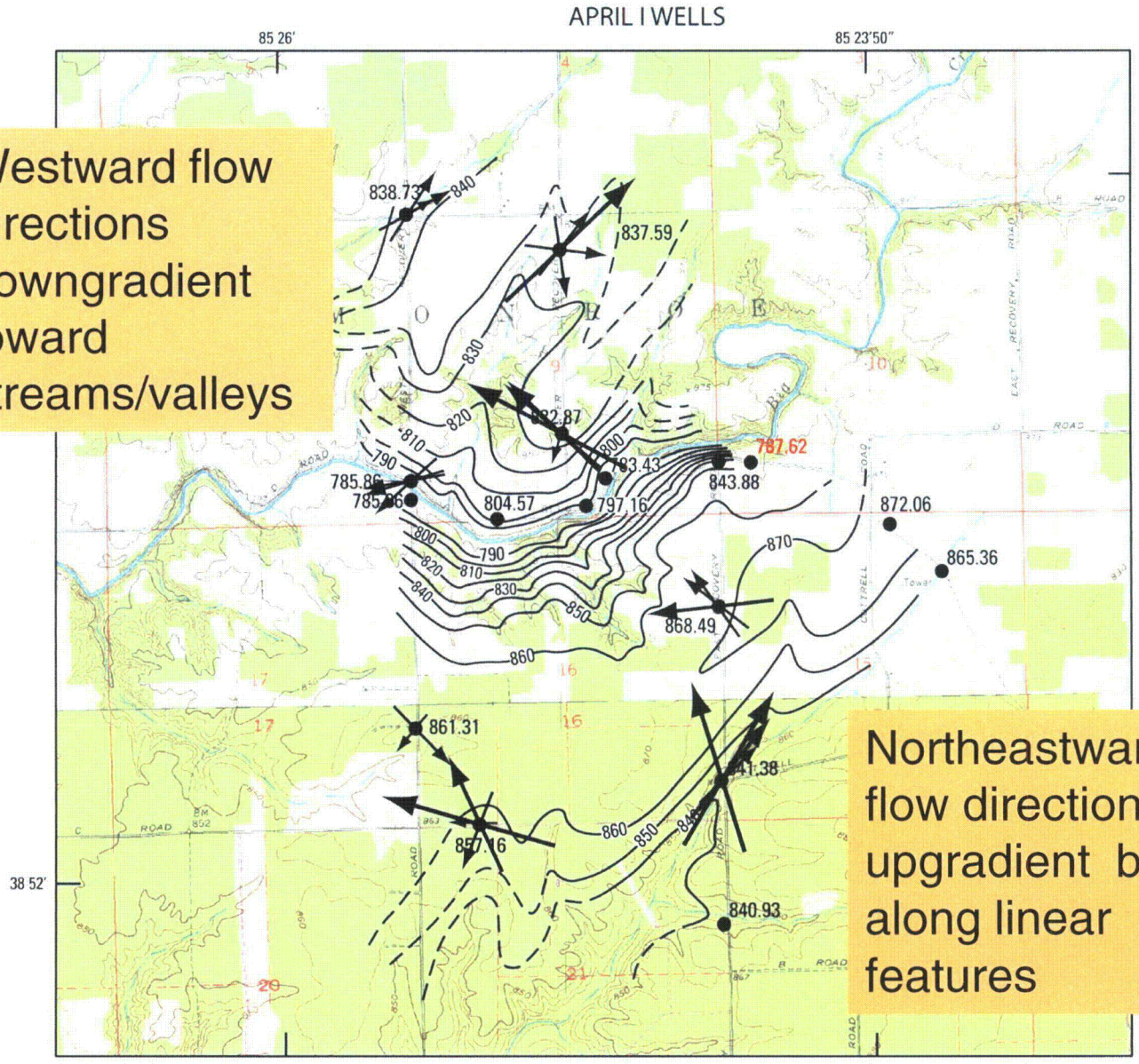
Colloidal Borescope

- Colloids flow past camera, magnified 140 X
- Software matches particles across view field (horizontal flow)
- Software records particles: number, speed, and direction.



USGS

Shallow Carbonate Unit, May 2008



Westward flow directions downgradient toward streams/valleys

Northeastward flow directions upgradient but along linear features

EXPLANATION

— 860 — WATER LEVEL ALTITUDE, IN FEET ABOVE DATUM

857.16 ● GROUNDWATER OBSERVATION WELL WITH WATER-LEVEL ALTITUDE, APRIL, 2008

787.62 ● GROUNDWATER OBSERVATION WELL WITH WATER-LEVEL ALTITUDE, APRIL, 2008 -- DRY

→ FLOW VECTOR WITH A VELOCITY BETWEEN 1 AND 7 FEET PER DAY

→ FLOW VECTOR WITH A VELOCITY BETWEEN 7 AND 30 FEET PER DAY

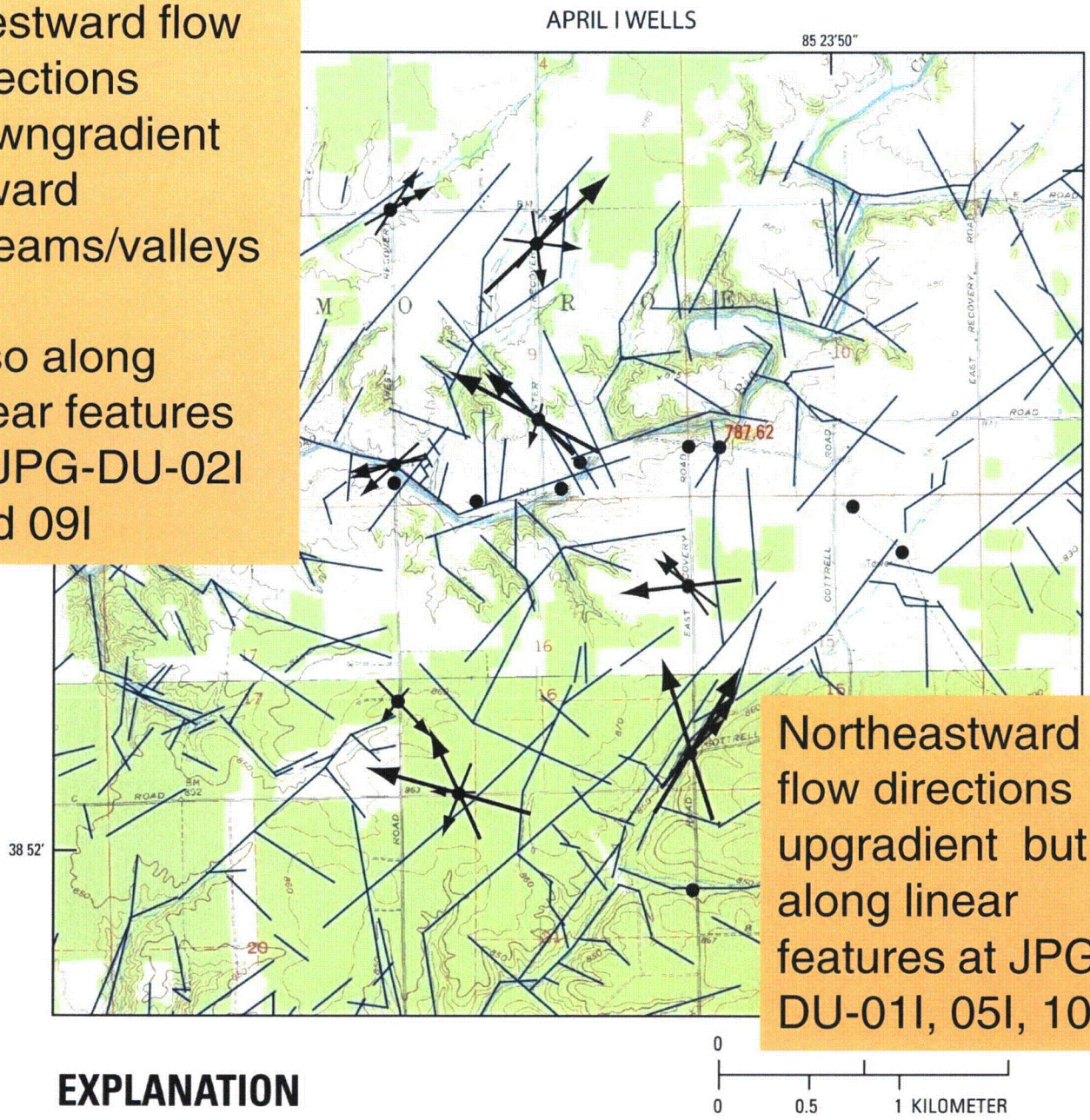
→ FLOW VECTOR WITH A VELOCITY BETWEEN 30 AND 53 FEET PER DAY

→ FLOW VECTOR WITH A VELOCITY GREATER THAN 53 FEET PER DAY

Shallow Carbonate Unit, May 2008

Westward flow directions downgradient toward streams/valleys

Also along linear features at JPG-DU-02I and 09I



Northeastward flow directions upgradient but along linear features at JPG-DU-01I, 05I, 10D

EXPLANATION

MAPPED BEDROCK LINEAMENT (Greeman, 1981)

GROUNDWATER OBSERVATION WELL

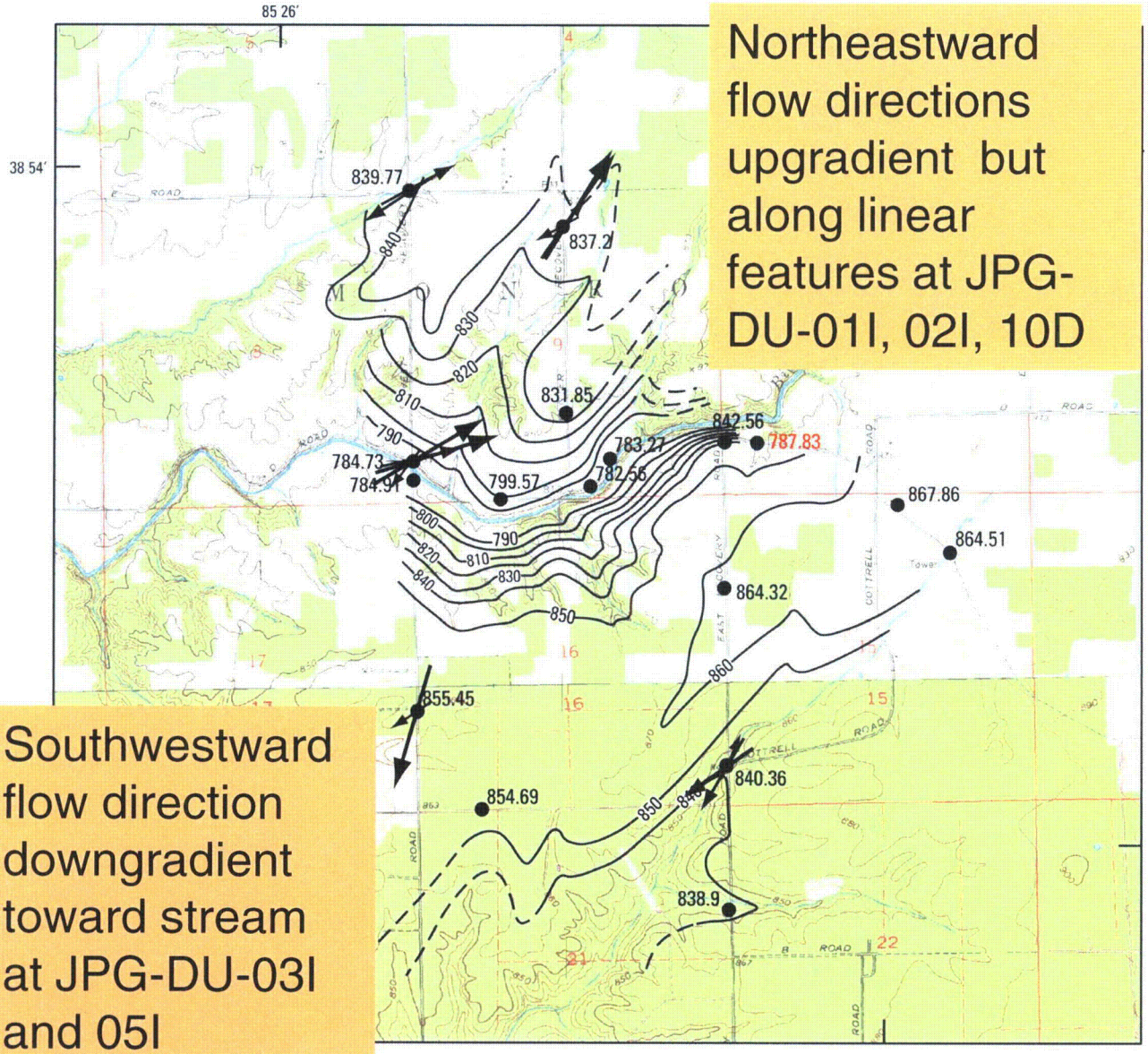
FLOW VECTOR WITH A VELOCITY BETWEEN 1 AND 7 FEET PER DAY

FLOW VECTOR WITH A VELOCITY BETWEEN 7 AND 30 FEET PER DAY

FLOW VECTOR WITH A VELOCITY BETWEEN 30 AND 53 FEET PER DAY

FLOW VECTOR WITH A VELOCITY GREATER THAN 53 FEET PER DAY

Shallow Carbonate Unit, August 2008



Flowmeter conclusions

- Local flow directions near incised streams vary with time (JPG-DU wells 02I, 05I)

- Local flow directions align mostly along linear features where present.

- Local flow directions periodically align with downgradient direction, such as near Big Creek and Middle Fork Creek and along divide between the two.

- Apparent, upgradient directed flow indicates flow along tortuous paths within formation: longer residence time in aquifer than indicated by velocities

Flowmeter report in preparation; peer review draft planned by 10/2009 publication planned by end 3/2010.

USGS

Relation of results to site characterization study

Ground water ages in parts of shallow carbonate unit under till—relatively older—recharge through the till to the shallow carbonate unit is slow; yet

Flow rates in the shallow carbonate unit are rapid

Indicates

- Groundwater flow through shallow carbonate unit is not directly from "point A to point B" along water level gradients
- Groundwater flow is fast at points BUT along long, tortuous, complex paths: slow from "point A to point B"
- Pre-1940's groundwater and some of recent recharge probably from upgradient/upflow sources--off the DU Impact area

USGS

Relation of results to site characterization study

Ground-water ages from JPG-DU-01I, 02I, and 05I near streams and well 03I are relatively younger, and

Flow rates are rapid and directions sometimes reverse

Indicates

- Local recharge to well 03I, possibly from upgradient wetland area and possibility of offsite flow
- At wells 2I and 5I, indicates relatively recent (early-mid-1980's) sources of flow
- Flow paths to well are more direct as GW age gets younger but are still complex—controlled by interconnected porosity in rock.

USGS

Plans for Upcoming Work

- K_d study for existing (loess) soil August/September 2009
- ERM sampling in October 2009
- Stream gauge data downloads in October 2009
- Groundwater level data recorder data downloads in October 2009
- Fate and transport modeling to begin in fall/winter 2009
- Residual radiation dose modeling to begin in fall/winter 2009
- Sampling for till and initiate expanded K_d study
  - Submit Field Sampling Plan Addendum 8 for NRC review in October 2009
  - Collect soil to evaluate uranium partitioning in till (K_d study) in November 2009
  - Initiate laboratory phase of K_d study in December 2009
  - Provide results to NRC when available (spring 2010)
- Revised ERM SOP

Decision Points

Preliminary Recommendations for Site Characterization

- Groundwater
  - No additional site characterization (sampling, monitoring groundwater stages) proposed at this time
  - Modify wells included in ERM sampling based on conclusions of sampling, background comparison, groundwater age-dating, and anion/cation evaluation
  - Review potential need for additional site characterization during completion of fate and transport/dose modeling
- Surface Water/Sediment
  - No additional site characterization (sampling, monitoring surface water stages, manual flow measurements) proposed at this time
  - Modify locations included in ERM sampling based on conclusions of sampling and background comparison
  - Review potential need for additional site characterization during completion of fate and transport/dose modeling
- Soil
  - Only additional site characterization (sampling) proposed at this time is collecting soil to evaluate uranium partitioning in till (K_d study)
  - Review potential need for additional site characterization after completion of corrosion study, leachability testing, K_d study, and during completion of fate and transport/dose modeling

Decision Points

Preliminary Recommendations for Revised ERM SOP

August 2009

Seek NRC input during meeting

September 2009

SAIC to formulate general concepts to develop initial revisions

November 2009

Review initial revisions with Army

November/December 2009

Discuss initial revisions with NRC technical staff

January/February 2010

Submit written ERM SOP revisions for Army review

February/March 2010

Submit proposed ERM SOP revisions for NRC review

Army/NRC Actions

- Army/NRC: Meeting on 29 October 2009 in Rockville, MD
- NRC: Determine if collecting soil for evaluating uranium partitioning in till (K_d study) is necessary
- Army: Coordinate revisions of ERM SOP with NRC staff during periodic teleconferences
- Army: Coordinate initial modeling runs with NRC staff during periodic teleconferences
- NRC: Provide input on Army recommendations regarding site characterization

Questions

- Questions from Public
- Other NRC Questions or Concerns?