Field Investigation of Holocene Faulting Proposed C-746-U Landfill Expansion

Paducah Gaseous Diffusion Plant

Paducah, Kentucky

KRCEE-PGDP Technical Symposium

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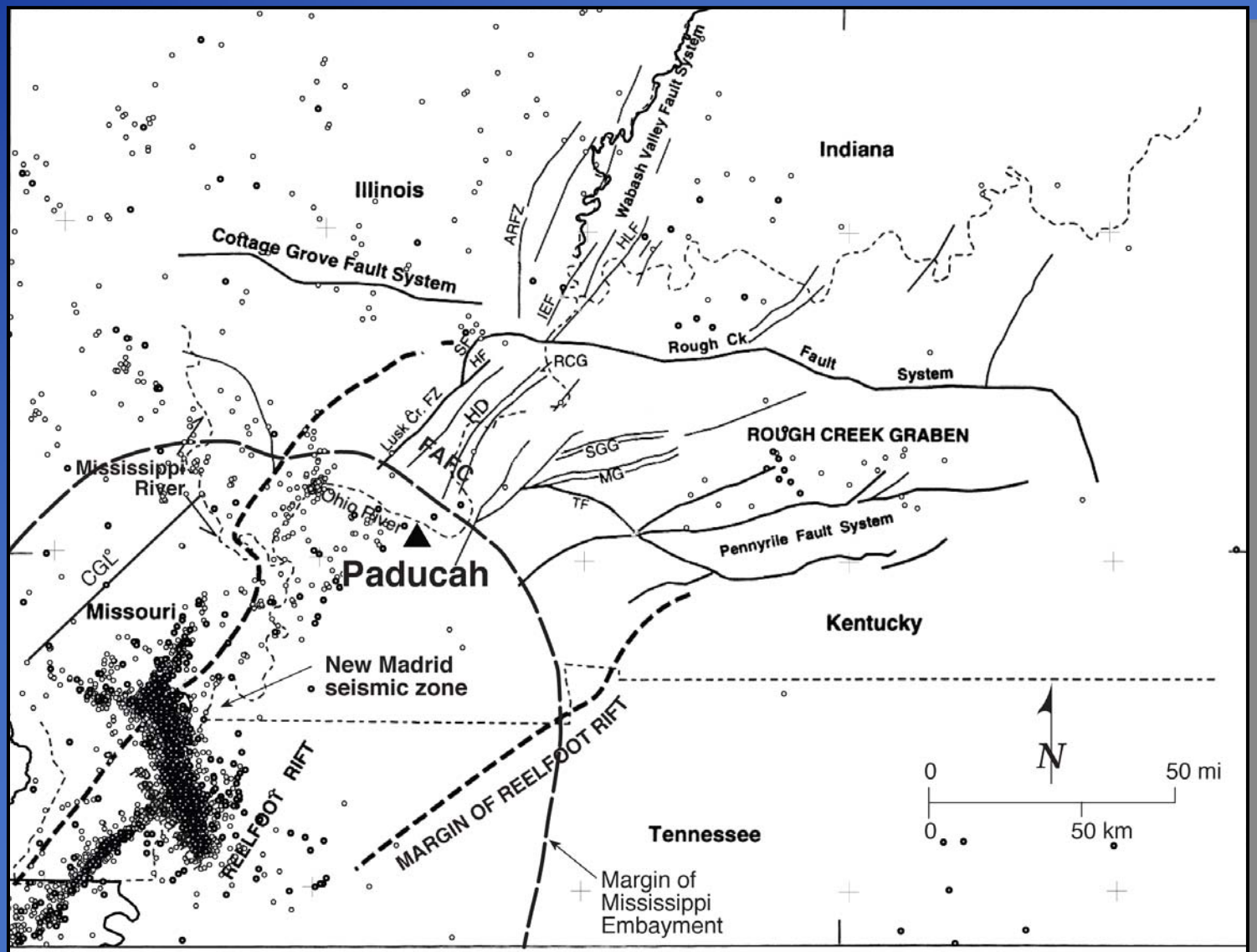
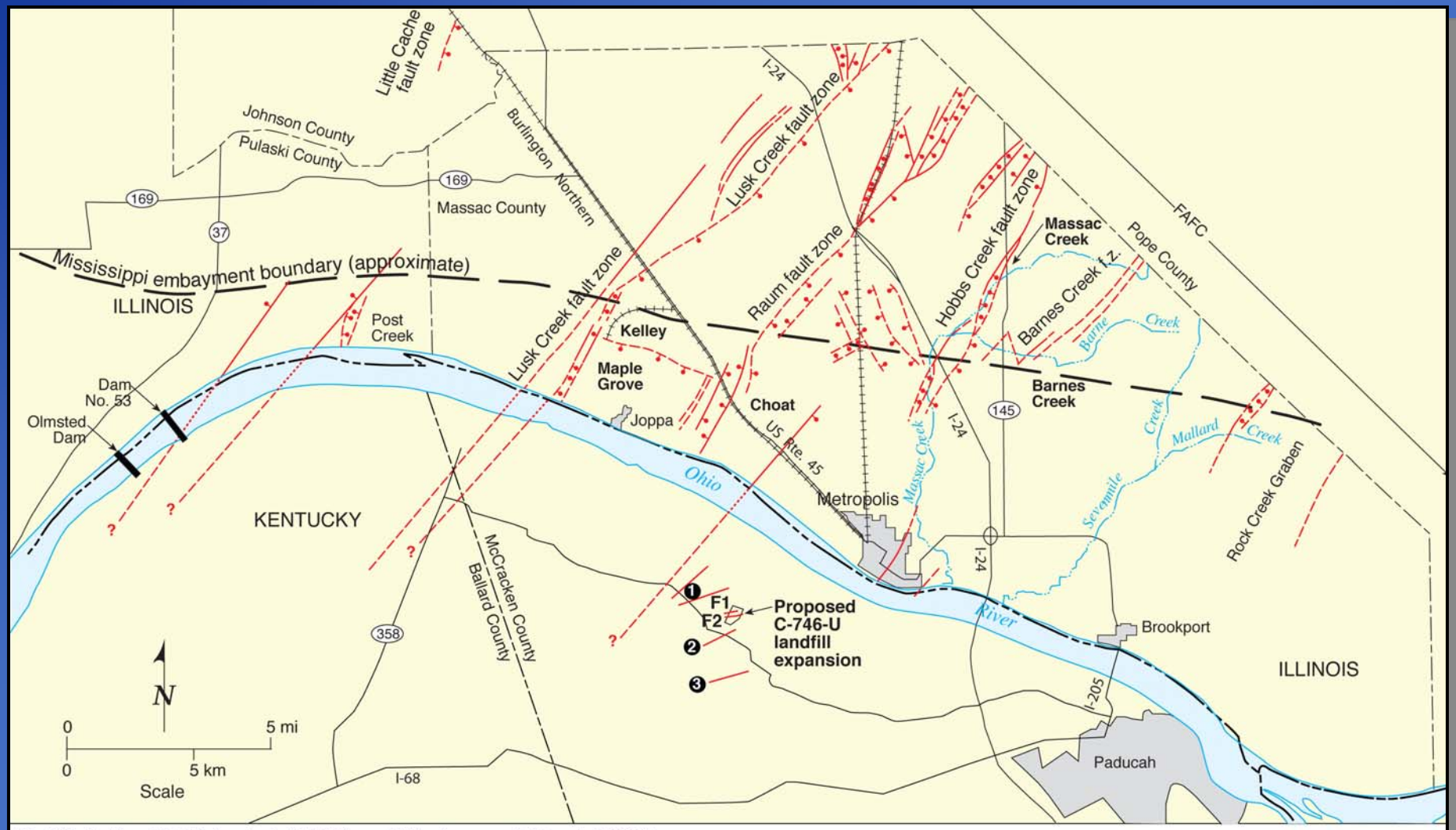
WLA

Seismotectonic Map



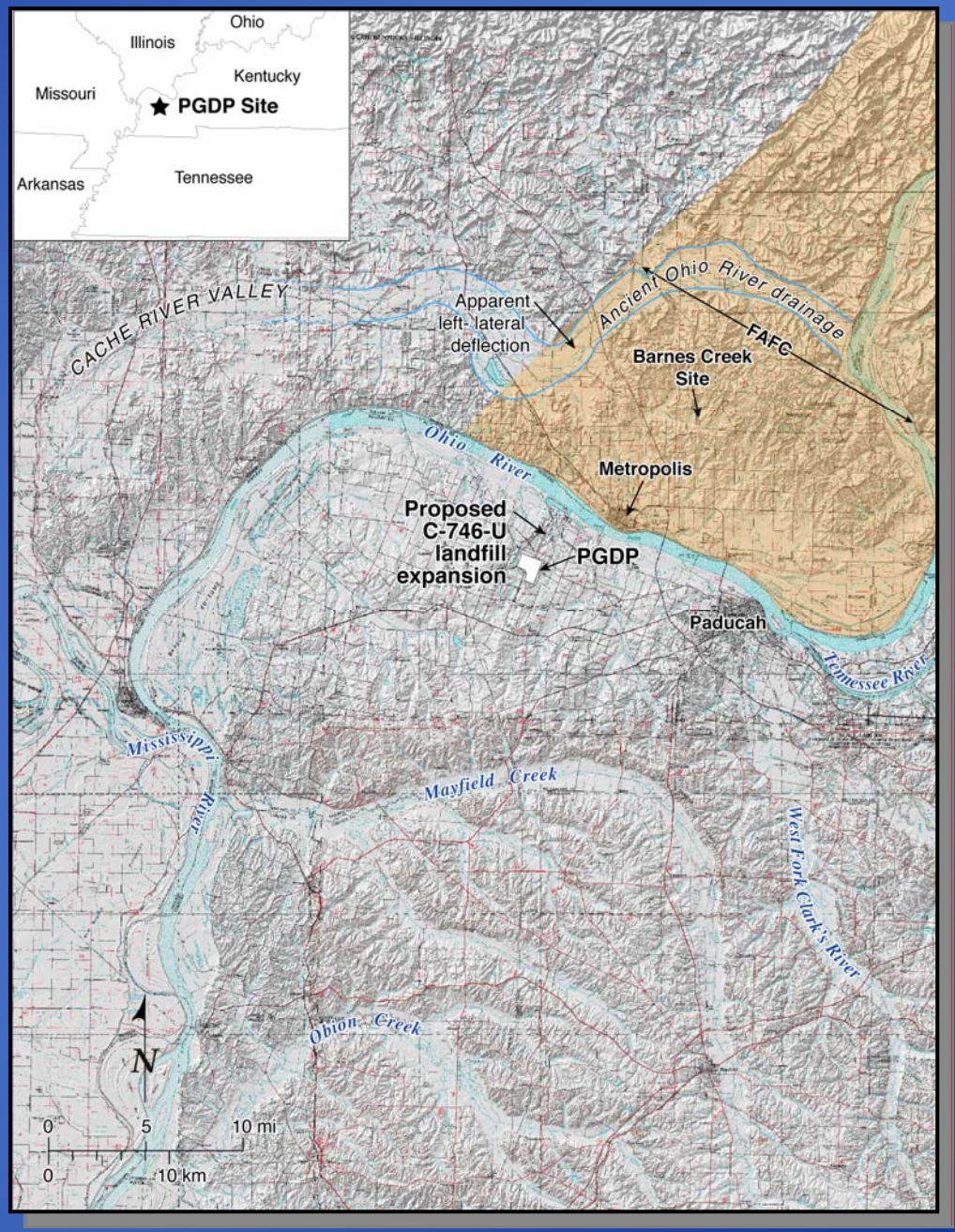
Seismicity from 1974 to 2004 (after Rhea et al., 1995; Johnston and Schweig, 1996; post-1992 seismicity from New Madrid earthquake catalog).

Regional Fault Map

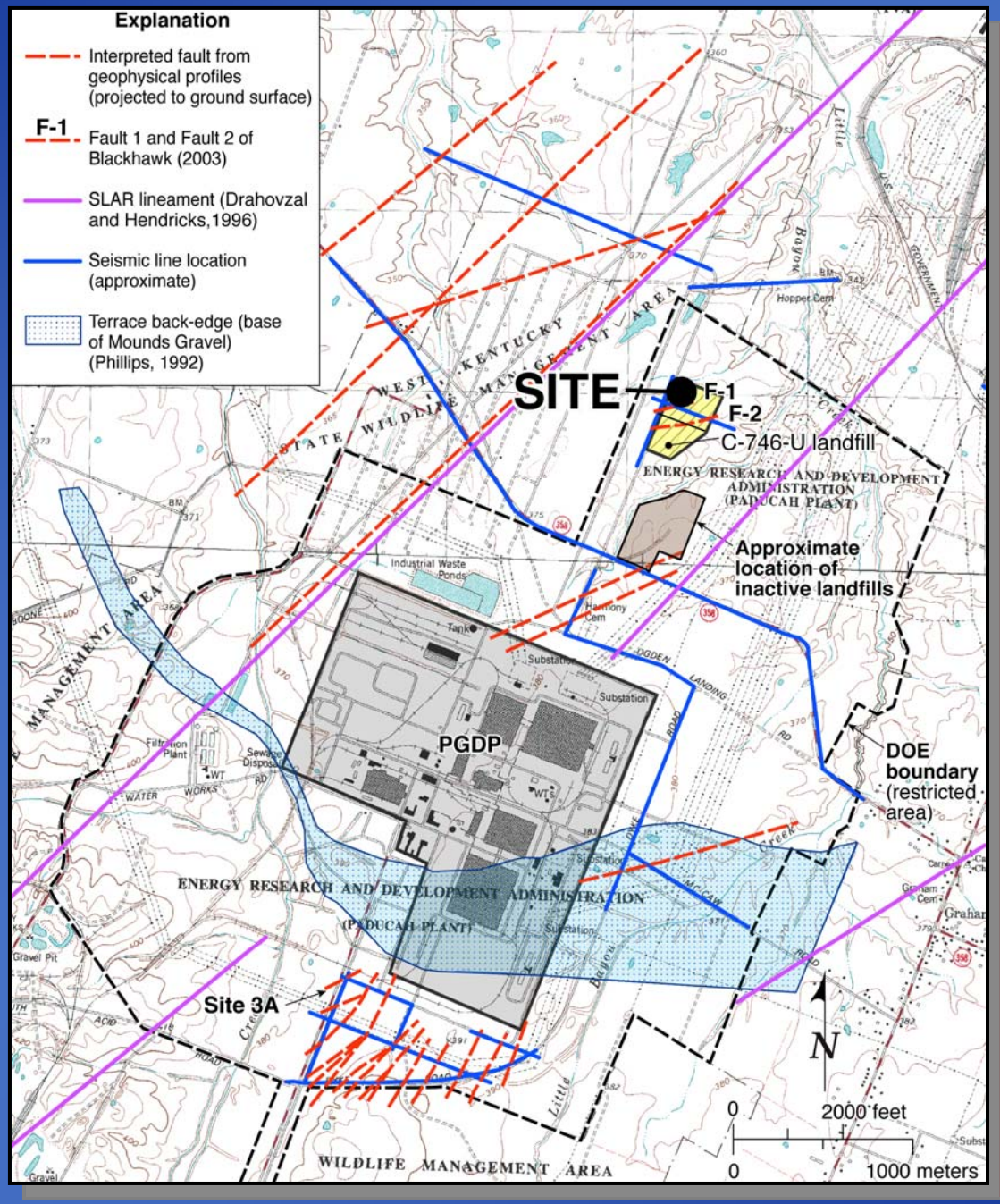


Modified after McBride et al. (2002) and Woolery and Street (2002).

Physiographic Map



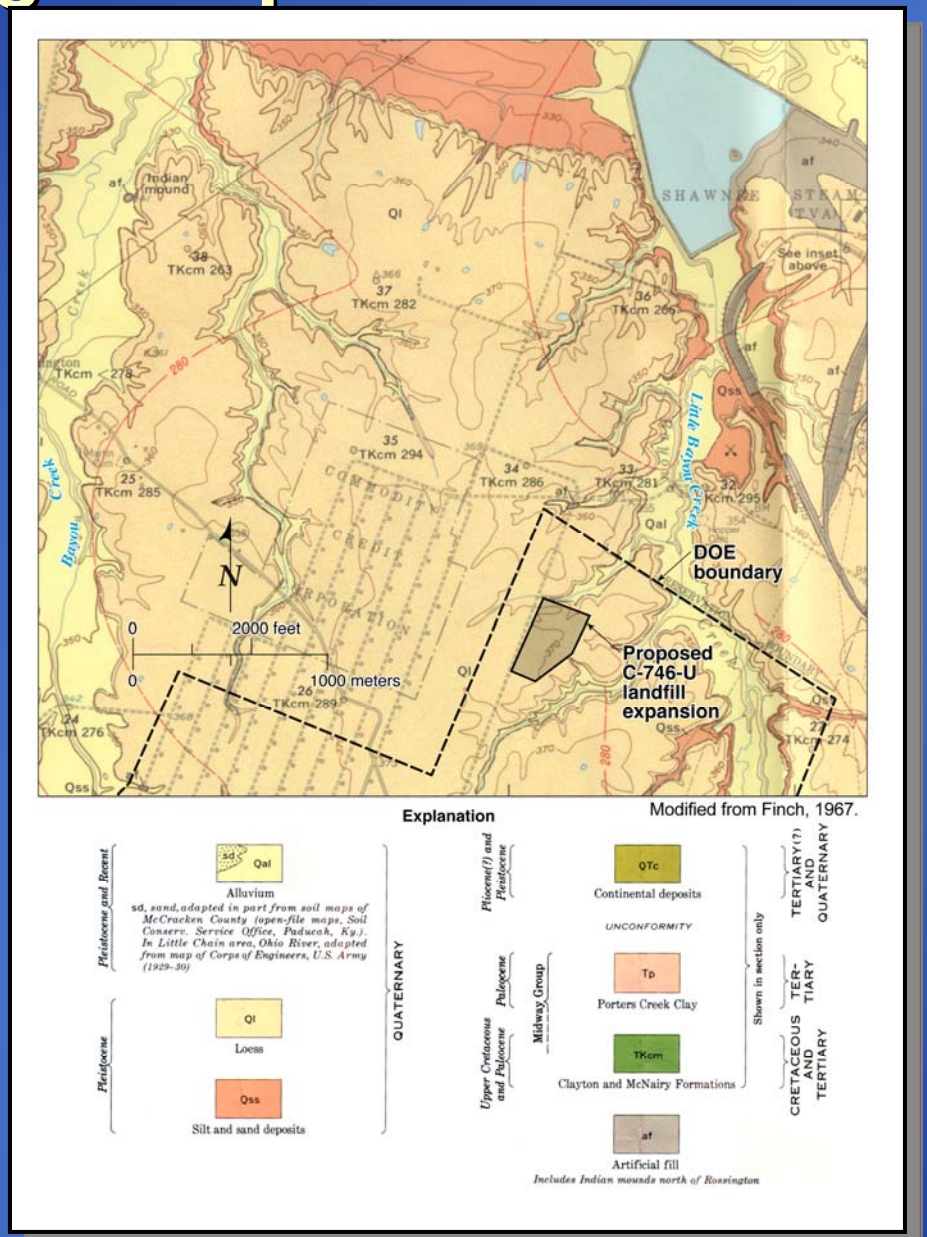
Local Faulting



Purpose of Study

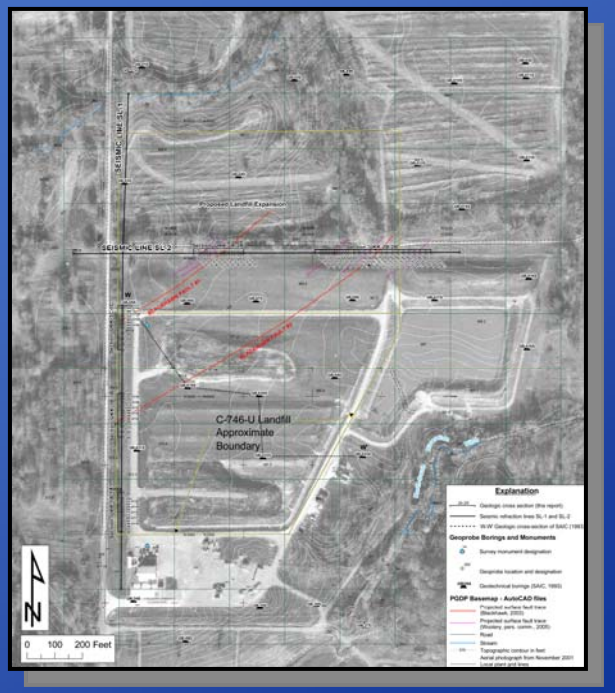
- Seismic reflection profiles (Blackhawk Geosciences, 2003) image at least two faults (Fault 1 and Fault 2) offsetting Quaternary to Tertiary (Mounds Gravel) deposits beneath the project area
- Existence, locations and ages of the inferred faults require confirmation through independent subsurface exploration
- Study based on tectonic model with faulting in So. Illinois extending into western Ky as NE-trending horsts and grabens bounded by both normal and reverse faults within an overall dextral strike-slip fault system
- Compliance with Code of Federal Regulations, Subtitle D, Title 40, Part 258, subpart B (258.13): *New MSWLF (Municipal Solid Waste Landfill Facility) units and lateral expansions shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time (11,000 years)*
- Purpose is to evaluate the absence or presence of Holocene faulting at the proposed C-746-U landfill expansion

Local Geologic Map



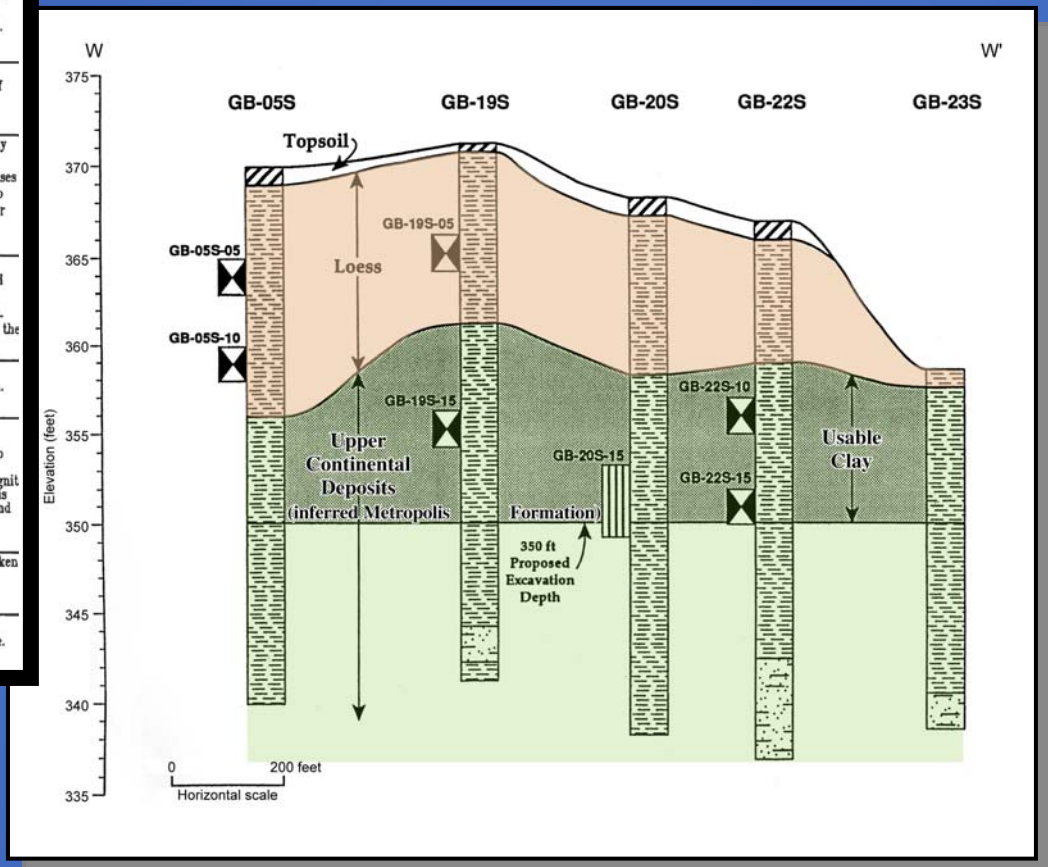
Methodology

- Analyzed aerial photography
- Performed field reconnaissance
- Compiled geologic data
- Interpreted 1 km of seismic reflection data
- Collected and logged 86, 30-ft-long continuous soil cores (2,580 total feet)
- Developed cross sections: lateral continuity, vertical deflections and truncations
- Dated loess deposits by OSL age-dating technique



STRATIGRAPHY

SYSTEM	SERIES	FORMATION	LITHOLOGY	THICKNESS (IN FT)	DESCRIPTION
QUATERNARY	HOLOCENE AND PLEISTOCENE	ALLUVIUM		0-40	Brown or gray sand and silty clay or clayey silt with streaks of sand.
	PLEISTOCENE	PEORIA LOESS ROXANA SILT LOVELAND SILT	Farmdale Geosol Sangamon Geosol	0-43	Brown or yellowish-brown to tan unstratified silty clay.
	PLEISTOCENE	METROPOLIS		3-121	Clay Facies - mottled gray and yellowish brown to brown clayey sil and silty clay, some very fine sand trace of gravel. Often micaceous.
	PLIOCENE-MIOCENE (?)	MOUNDS GRAVEL			Gravel Facies - reddish-brown clayey, silty and sandy chert gravel and beds of gray sand.
TERTIARY	EOCENE	JACKSON, CLAIBORNE, AND WILCOX FORMATIONS		0-200+	Red, brown or white fine to coarse grained sand. Beds of white to dark gray clay are distributed at random.
				0-100+	White to gray sandy clay, clay conglomerates and boulders, scattered clay lenses and lenses of coarse red sand. Black to dark gray lignitic clay, silt or fine grained sand.
	PALEOCENE	PORTERS CREEK CLAY		0-200	Dark gray, slightly to very micaceous clay. Fine grained clayey sand, commonly glauconitic in the upper part. Glauconitic sand and clay at the base.
		CLAYTON FORMATION		Undetermined	Lithologically similar to underlying McNairy Formation.
UPPER CRETACEOUS		McNAIRY FORMATION		200-300	Grayish-white to dark gray micaceous clay, often silty, interbedded with light gray to yellowish-brown very fine to medium grained sand with lignit and pyrite. The upper part is interbedded clay and sand, and and the lower part is sand.
		RUBBLE ZONE		Undetermined	White, semi-rounded and broken chert gravel with clay.
MISSISSIPPIAN		MISSISSIPPIAN CARBONATES		500+	Dark gray limestone and interbedded chert, some shale.



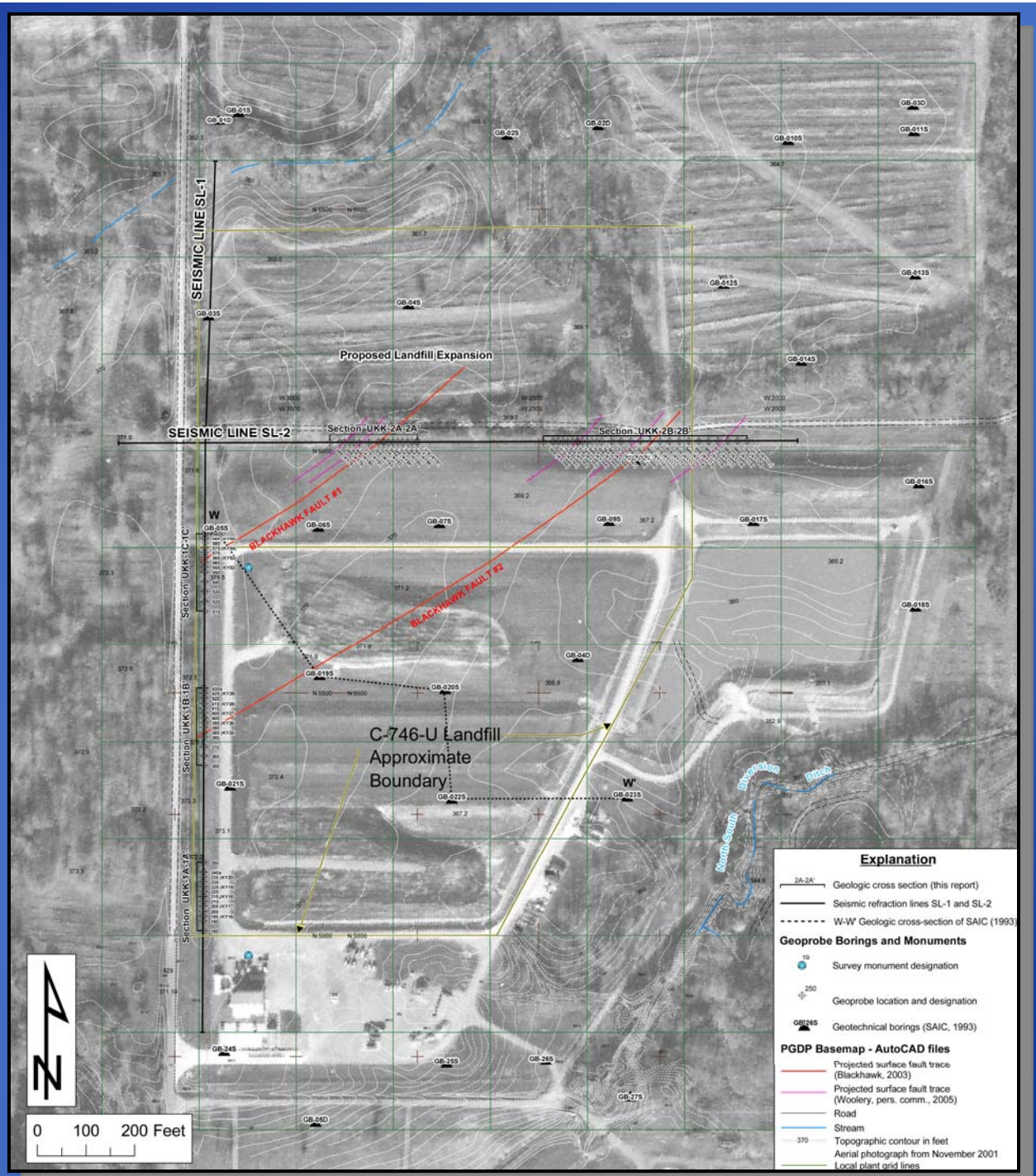
Modified from SAIC (1994)

Geotechnical data indicate upper 30 feet (9 m) of site strata coarsen with depth: upper 15 feet [4.6 m] is a loess overlying silt and clay (approx. 15 to 30 feet [4.6 to 9 m]) with occasional interbeds of silty sand to clayey sand

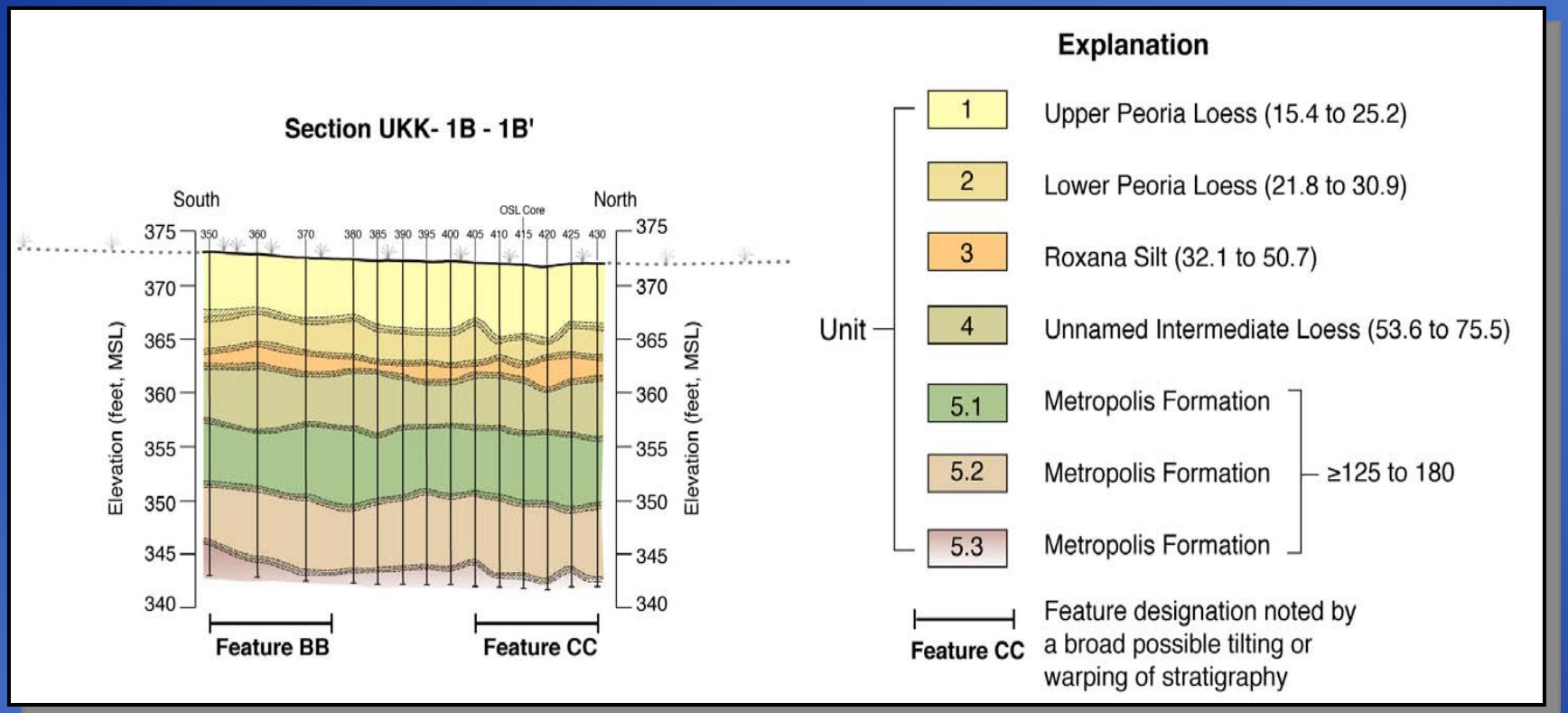
Logging of Sediment Core

- Simultaneous exposure of multiple cores
- Cores arranged with respect to depth and position along transect
- Detailed logging of each core in its entirety
- Strata differentiated based on grain size, sorting color, contact irregularities, soil structure, pedogenic clay or iron-oxide accumulation and age dating
- Peer review by experts in Pleistocene stratigraphy and site geology

Site Map


SEISMIC LINE SL-1
SEISMIC LINE SL-2
Proposed Landfill Expansion
Section UKK-2A-2A'
Section UKK-2B-2B'
BLACKHAWK FAULT #1
BLACKHAWK FAULT #2
C-746-U Landfill
Approximate
Boundary
W
W'
Section UKK-1C-1C'
Section UKK-1B-1B'
Section UKK-1A-1A'
Diversion Ditch
North-South Ditch
0 100 200 Feet
Explanation
Geologic cross section (this report)
Seismic refraction lines SL-1 and SL-2
W-W' Geologic cross-section of SAIC (1993)
Geoprobe Borings and Monuments
Survey monument designation
Geoprobe location and designation
Geotechnical borings (SAIC, 1993)
PGDP Basemap - AutoCAD files
Projected surface fault trace (Blackhawk, 2003)
Projected surface fault trace (Woolery, pers. comm., 2005)
Road
Stream
Topographic contour in feet
Aerial photograph from November 2001
Local plant grid lines

Site Stratigraphy



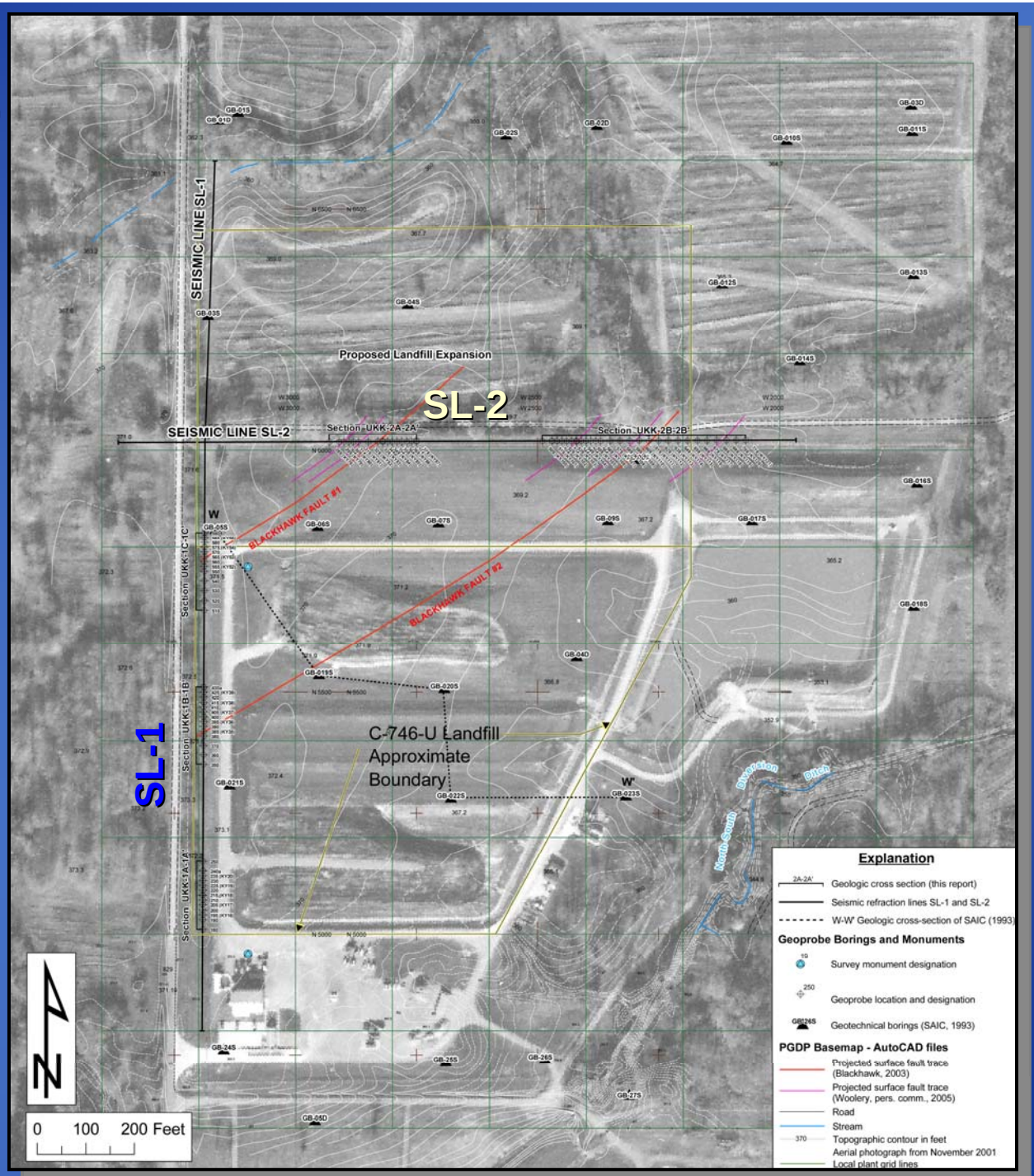
- Upper three loess units generally flat-lying and mantle pre-existing topography
- Lower older units exhibit subtle to abrupt undulations of basal contacts

Average Uncertainty in Contact Correlation by Stratigraphic Unit

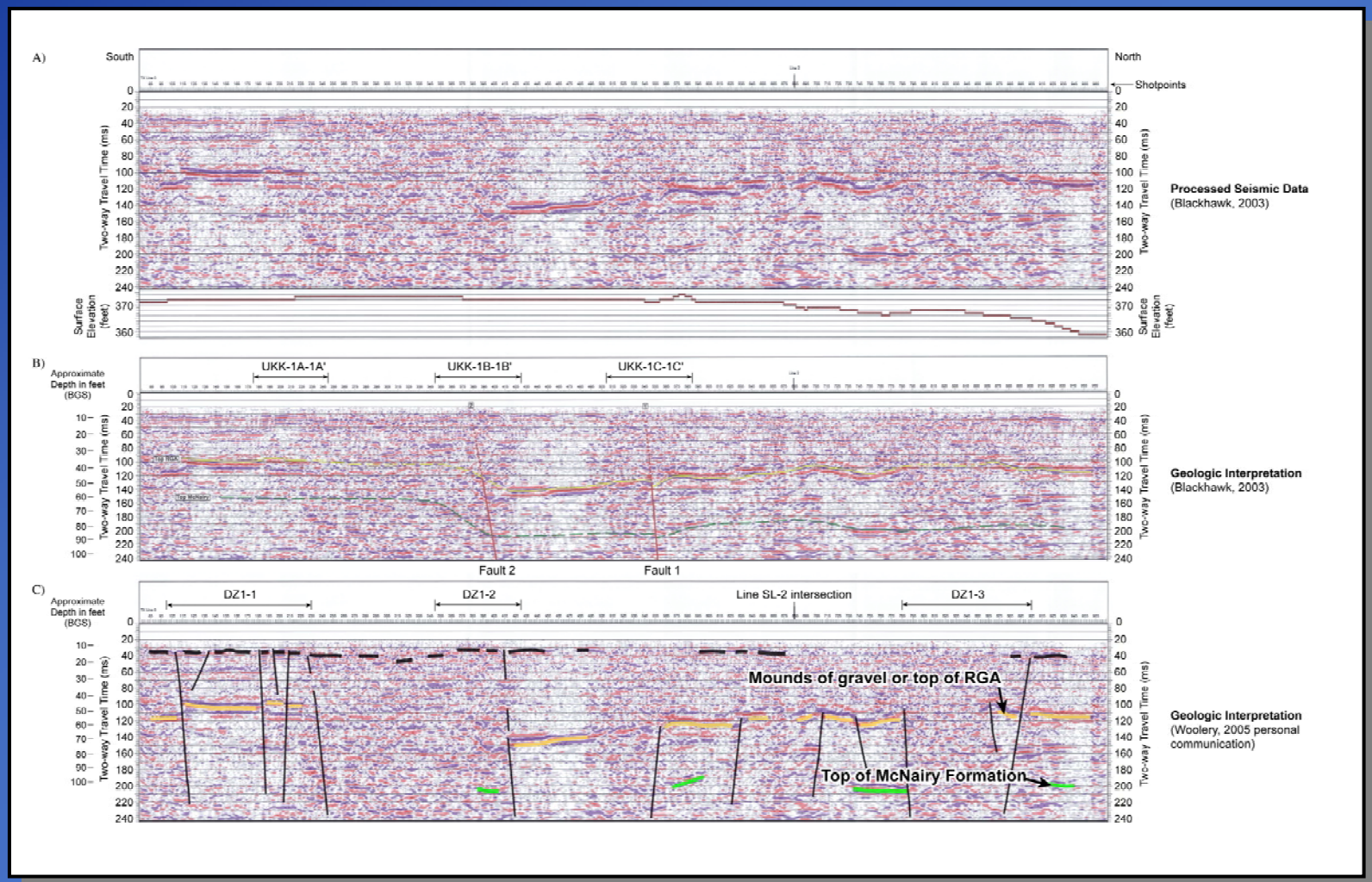
Basal Contact	Uncertainty (feet)
Base of Upper Peoria, unit 1	0.6
Base of Lower Peoria, unit 2	0.4
Base of Roxana Silt, unit 3	0.4
Base of Unnamed Intermediate Loess, unit 4	0.3
Base of Metropolis, unit 5.1	0.5
Base of Metropolis, unit 5.2	0.4

- Core compression and/or recovery
- Contact correlation (distinct vs gradational)
- Inclined basal contacts

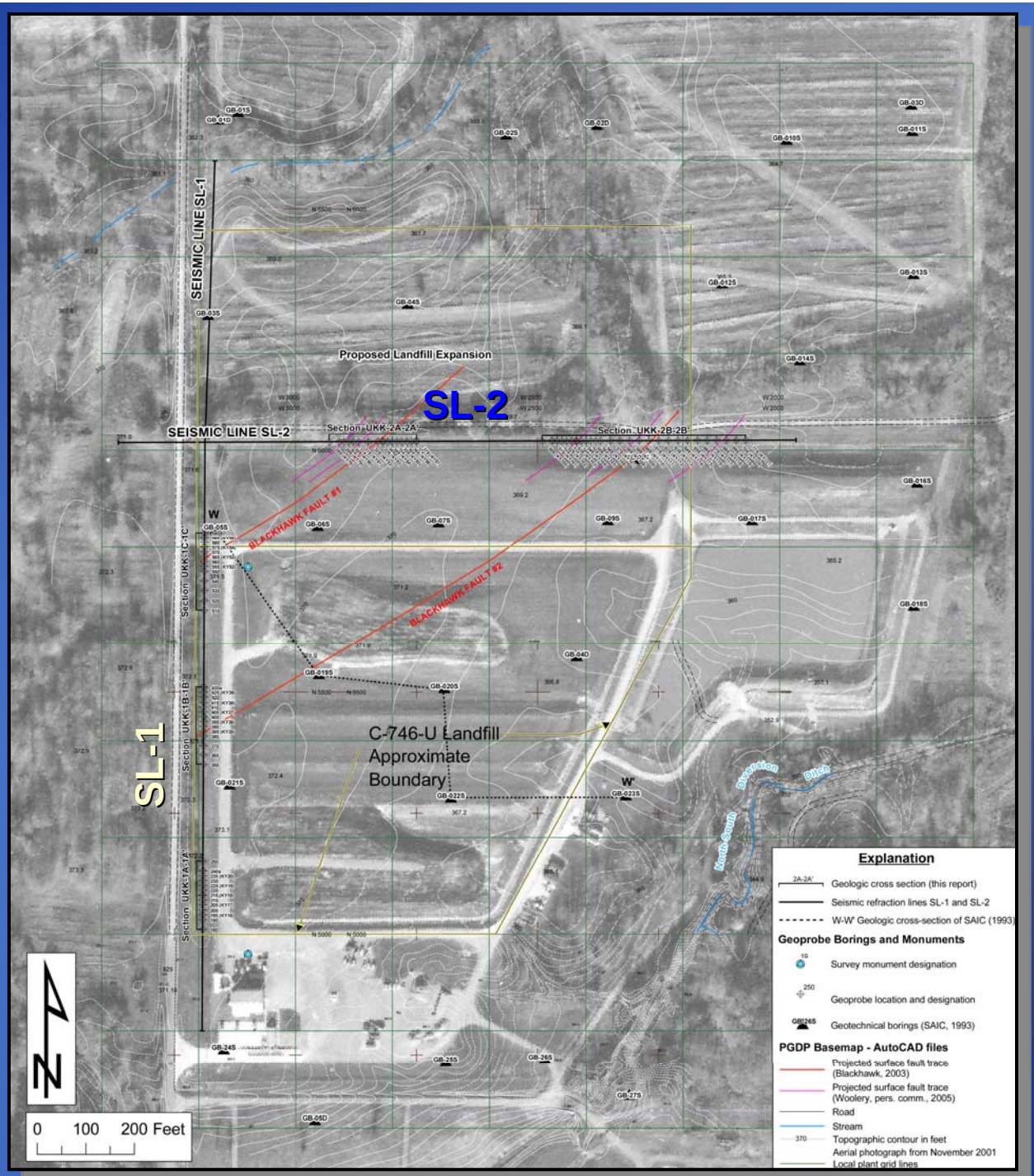
GEOPHYSICAL PROFILE SL-1



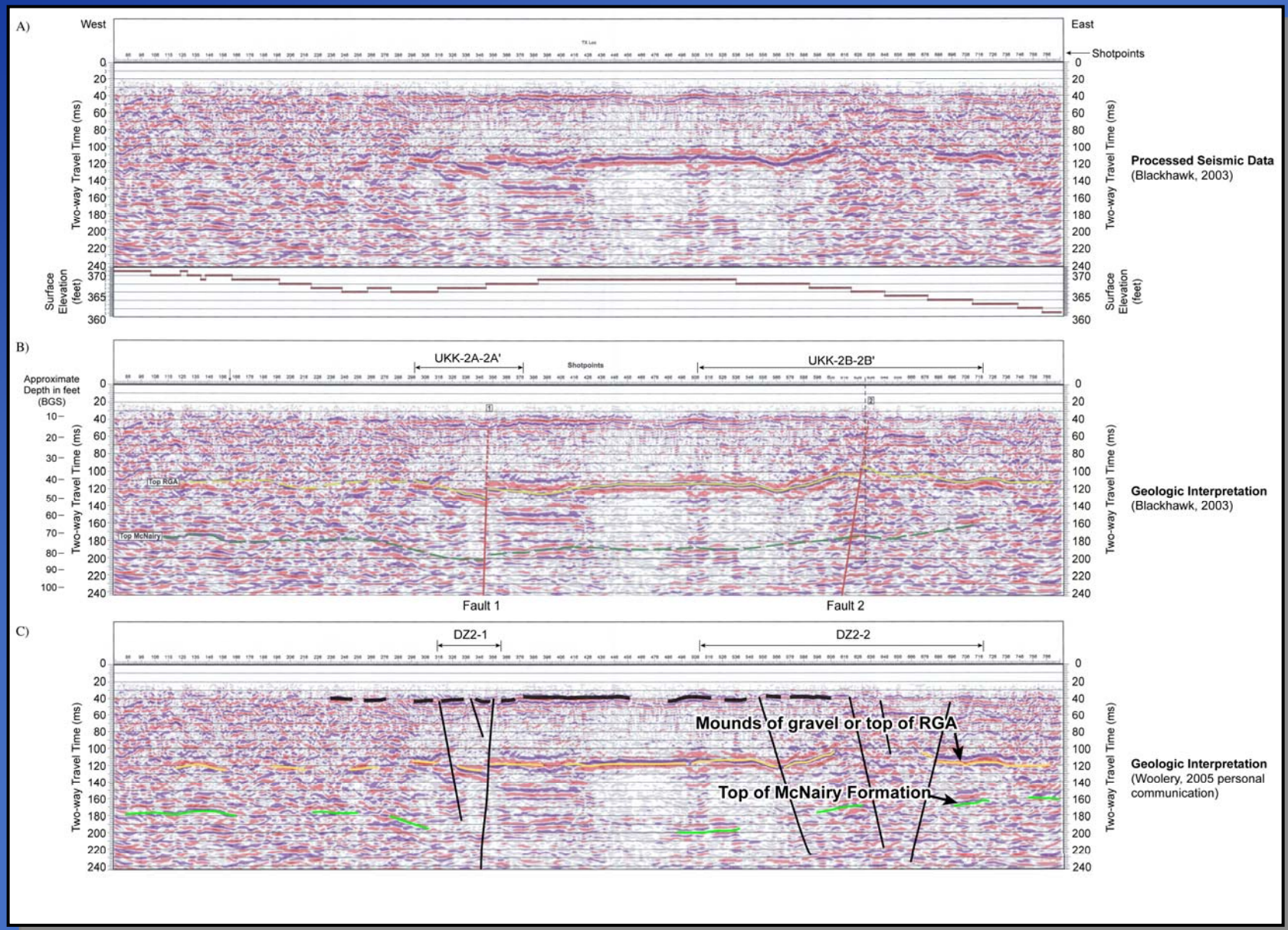
Seismic Reflection Data (SL-1)



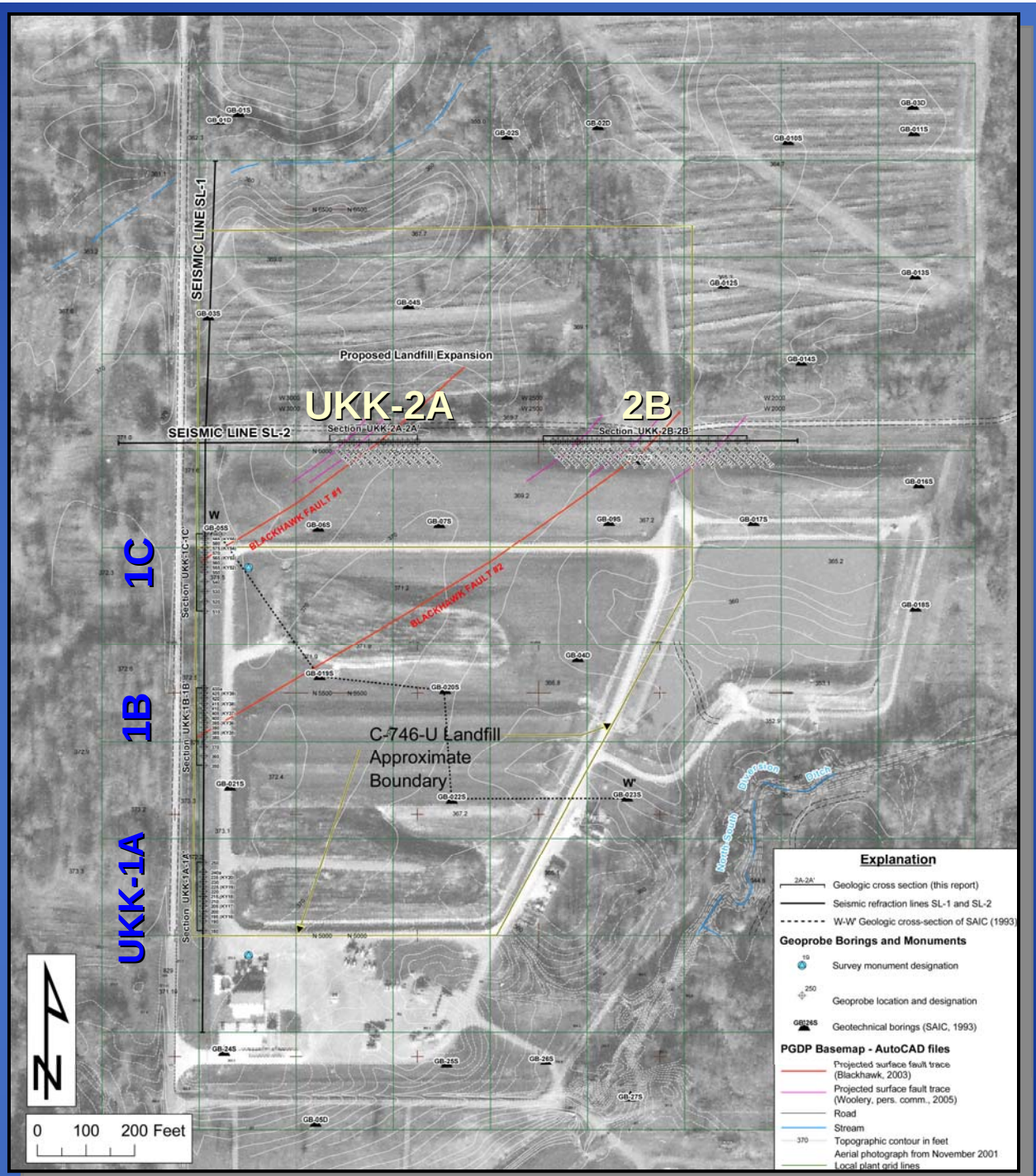
GEOPHYSICAL PROFILE SL-2



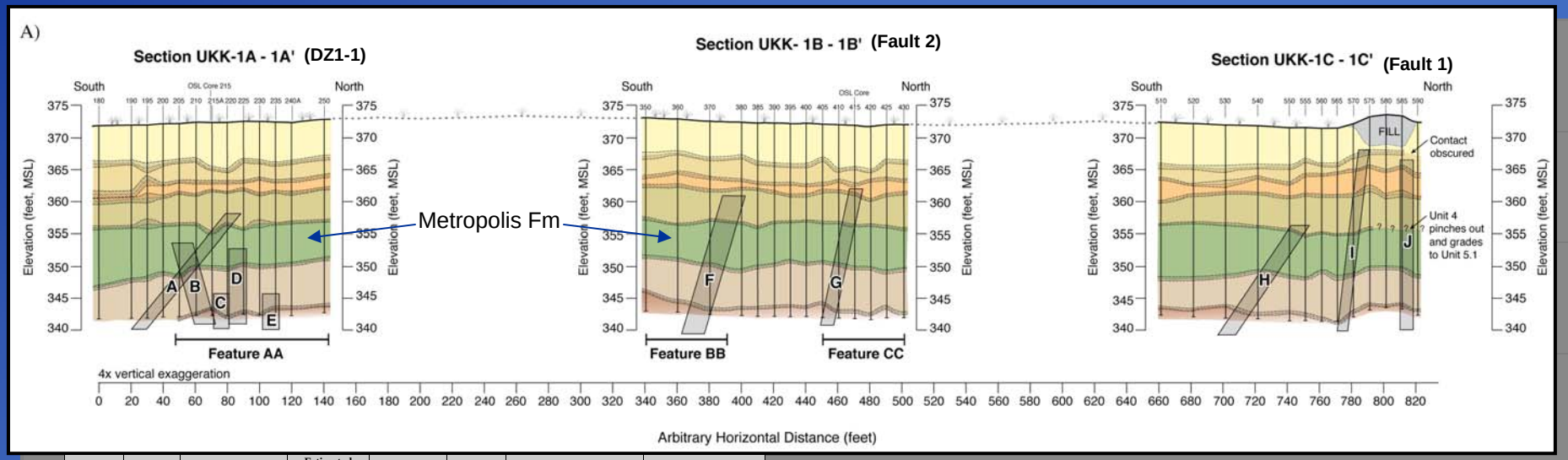
Seismic Reflection Data (SL-2)



GEOLOGIC SECTIONS



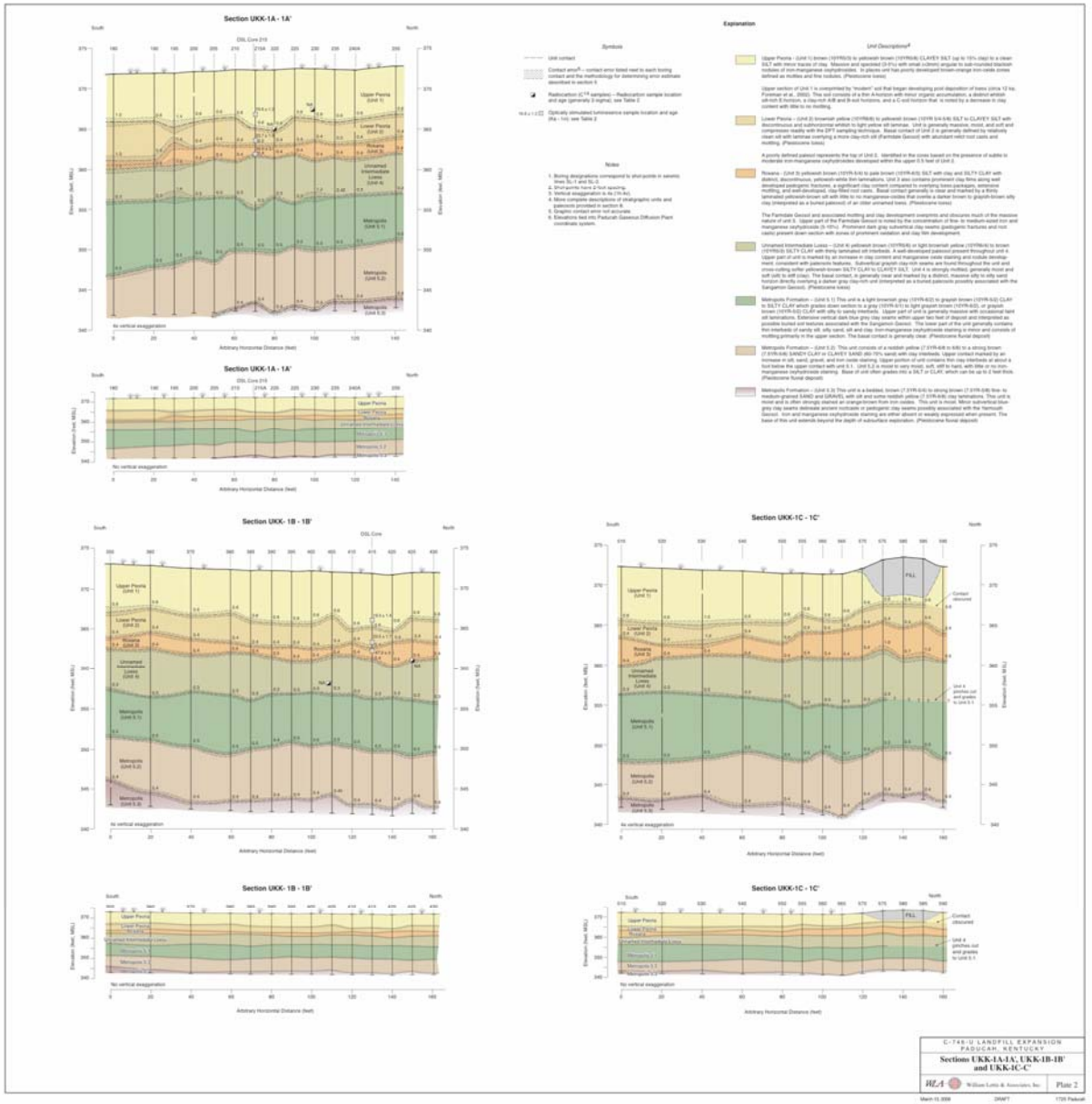
Geologic Cross Section (UKK-1) 4x



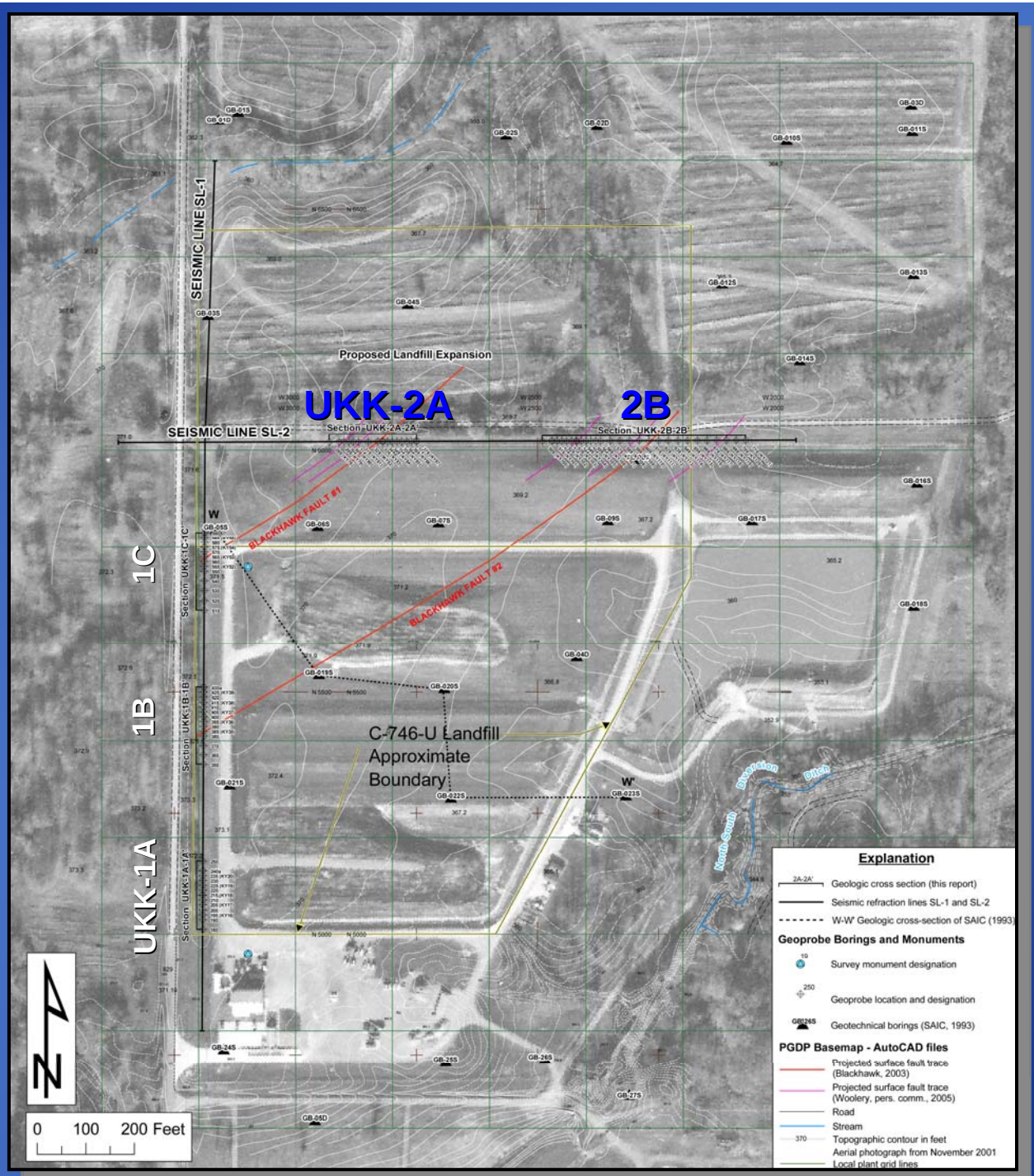
Feature	Cross Section Line (UKK)	Feature Constrained Between Cores	Estimated Amount of Separation Max/Limit of Resolution[A] (ft)	Sense of Vertical Separation (Direction/ Style)[B]	Dip of Feature (H, M, L)[C]	Youngest Unit Boundary Vertically Separated[D]		Estimated Age of Youngest Unit Vertically Separated Ka[E]
A	1A Š 1AÕ	UKK-1-200 to 220	2.0/0.4	S/N	L	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
B	1A Š 1AÕ	UKK-1-205 to 215A	2.0/0.3	N/R	M	Unit 5.1	(Metropolis Formation)	>125
C	1A Š 1AÕ	QKK-1-215A to 220	1.75/0.5	N/N	H	Unit 5.2	(Metropolis Formation)	>125
D	1A Š 1AÕ	UKK-1-220 to 225	1.25/0.3	S/N	H	Unit 5.1	(Metropolis Formation)	>125
E	1A Š 1AÕ	UKK-1-230 to 235	1.75/0.5	S/N	H	Unit 5.2	(Metropolis Formation)	>125
F	1B Š 1BÕ	UKK-1-350 to 380	3.0/0.4	S/R	M	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
G	1B Š 1BÕ	UKK-1-405 to 415	1.75/0.4	N/R	M	Unit 3.0	(Roxana Silt)	32.1 to 50.7
H	1C Š 1CÕ	UKK-1-530 to 555	2.0/0.4	S/R	L	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
I	1C Š 1CÕ	UKK-1-565 to 575	3.25/1.0	S/N	H	Unit 4.0 (2.0/1.0)	(Unnamed Loess)	53.6 to 75.5
J	1C Š 1CÕ	UKK-1-585 to 590	1.25/1.0	N/N	H	Unit 5.1 (2.0/1.0)	(Metropolis Formation)	>125
K	2A Š 2AÕ	UKK-2-304 to 309	1.5/0.4	W/N	H	Unit 5.1	(Metropolis Formation)	>125
L	2A Š 2AÕ	UKK-2-329 to 349	2.0/0.6	E+W/R	M	Unit 2.0	(Lower Peoria Loess)	21.8 to 30.2
M	2A Š 2AÕ	UKK-2-349 to 354	2.0/0.3	W/N	H	Unit 5.1	(Metropolis Formation)	>125
N	2A Š 2AÕ	UKK-2-354 to 359	1.5/0.3	E/N	H	Unit 5.1	(Metropolis Formation)	>125
O	2A Š 2AÕ	UKK-2-354 to 364	1.0/1.9	W/R	M	Unit 4.0	(Unnamed Loess)	53.6 to 75.5

- Three (3) warp-like features (AA-CC)
- Ten (10) features with vertical separation
  - 7 ≥ age of Unit 4 (Intermediate Silt-53.6 to 75.5 ka)
  - 3 ≤ age of Unit 3 (Roxana Silt-32.1 to 50.7 ka)
- I and J in region of fill; saturated
- Low inclination, DPT data support older defm
- Many vertical steps in Metropolis Fm-fluvial processes

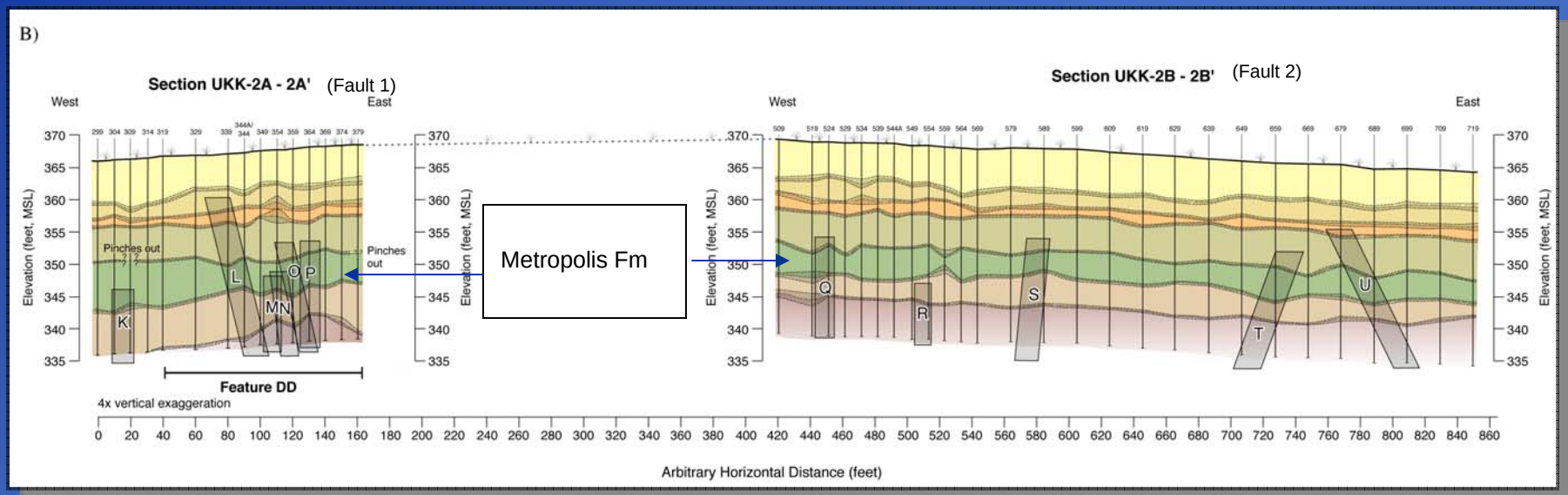
Section UKK-1



GEOLOGIC SECTIONS



Geologic Cross Section (UKK-2)

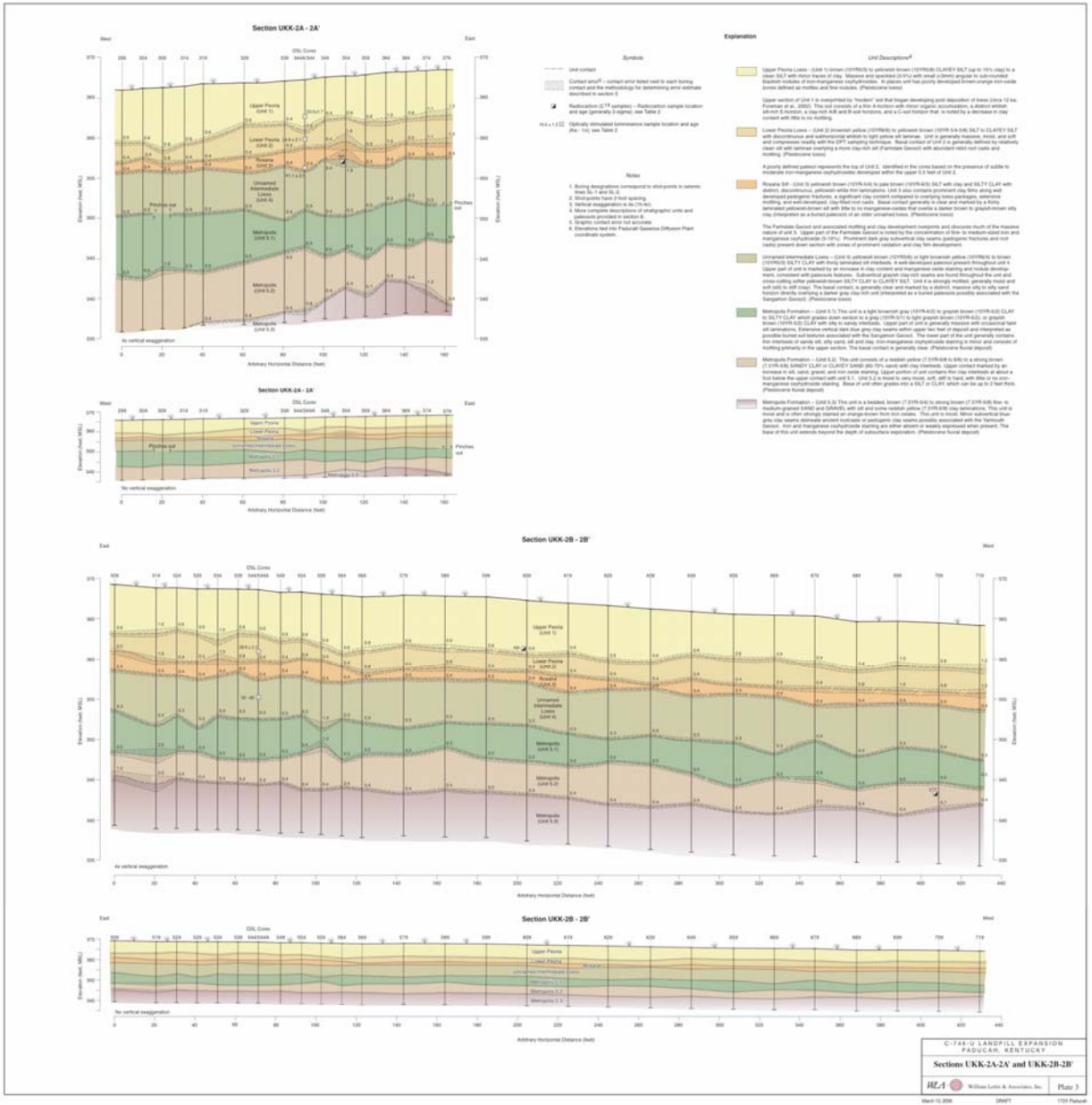


P	2A Š 2AÕ	UKK-2-359 to 369	2.0/0.4	W/N	H	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
Q	2B Š 2BÕ	UKK-2-519 to 524	2.0/0.4	W/N	H	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
R	2B Š 2BÕ	UKK-2-549 to 554	1.0/0.5	E/N	H	Unit 5.2	(Metropolis Formation)	>125
S	2B Š 2BÕ	UKK-2-579 to 589	1.5/0.4	W/N	H	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
T	2B Š 2BÕ	UKK-2-649 to 699	2.0/0.4	E/R	M	Unit 4.0	(Unnamed Loess)	53.6 to 75.5
U	2B Š 2BÕ	UKK-2-669 to 679	2.0/0.4	E/N	L	Unit 3.0	(Roxana Silt)	32.1 to 50.7

A: Limit of resolution of unfaulted unit that lies directly above feature
B: Direction of inferred vertical separation (direction of down-thrown side)/apparent sense of vertical separation N = Normal; R = Reverse
C: H = High-angle (>60□); M = Moderate-angle (² 60□ to 30□³); L = Low-angle (< 30□)
D: Age of youngest basal boundary with vertical separation
E: Ka = 1,000 years
(): Parenthesis indicate possible fault-like feature that comes Ñanomalously closeÒto the ground surface but is believed to be a result of DPT sampling complexities

- One (1) fold-like features (DD)
- Eleven (11) features with distinct elevation change
  - 9 ≥ age of Unit 4 (Intermediate Loess 53.6 to 75.5 k
  - 2 ≤ age of Unit 3 (Roxana Silt 32.1 to 50.1 ka)
- L-w limb antiform; dips E, 2.0 ft Unit 5.3
- U-dips E; elevation changes inconsistent upsection
- Many vertical steps in Metropolis Fm-fluvial processes
- Absence of slickenslides, breccia and clay gouge

Section UKK-2



Summary of Results

- Geophysical data exhibit NE-trending faults with oblique normal and reverse displacement. No master fault identified.
- Seven stratigraphic units: Peoria Loess and Roxana Silt generally flat-lying and mantle pre-existing topography. Lower four units exhibit subtle to abrupt undulations.
- Four folds and 21 features with noticeable elevation changes.
- Closely spaced DPT cores provide evidence for continuity of undeformed late Pleistocene strata (Upper Peoria Loess), thus evidence for the absence of Holocene displacement.
- Most recent fault displacement (14 features), if present at the site, is constrained to post-date deposition of the Unnamed Intermediate Silt (53.6 to 75.5 ka)
- Inferred age of faulting consistent with age of faulting in Southern Illinois
- No evidence for Holocene (<11,000 year) faulting at the site