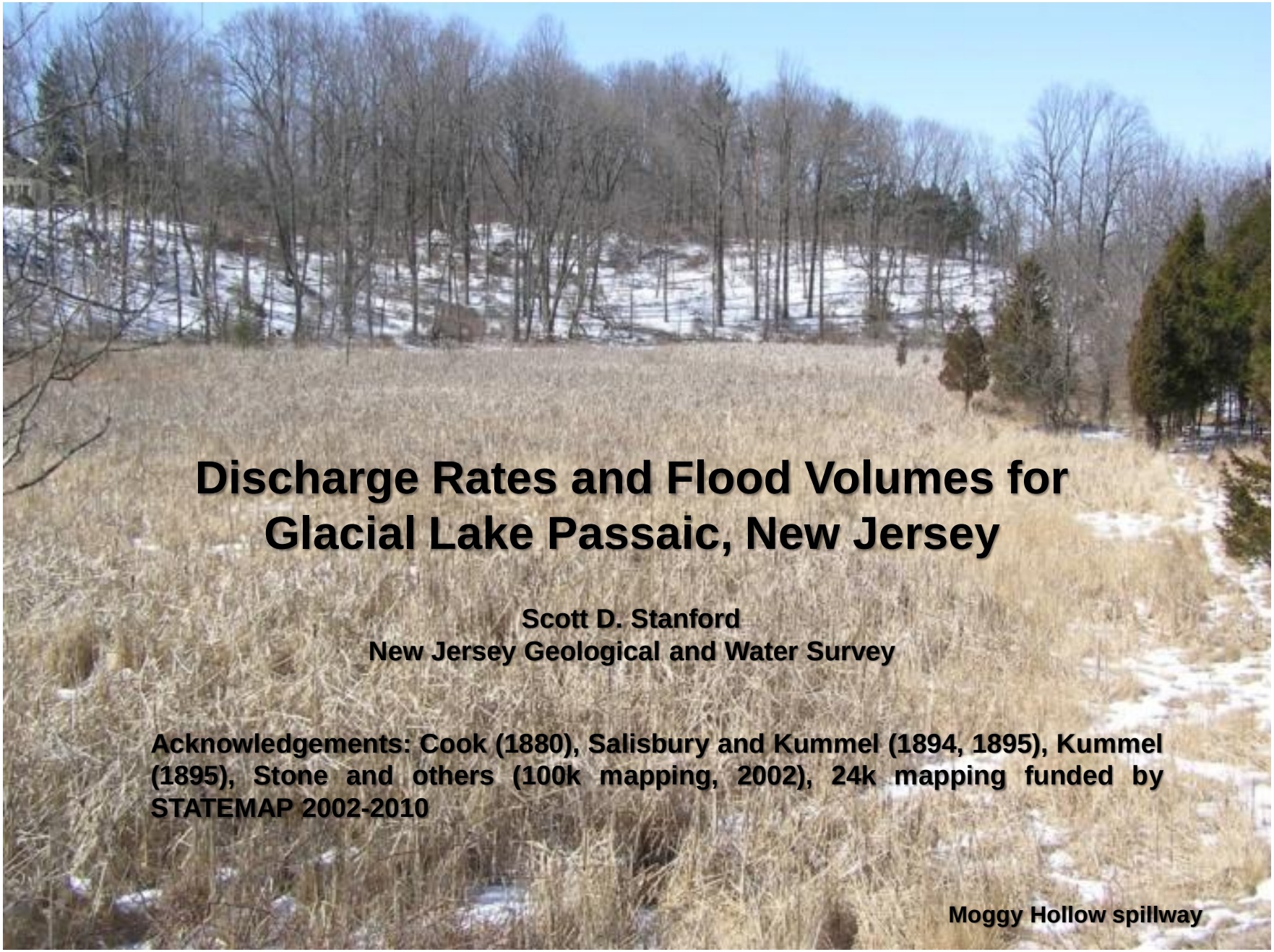
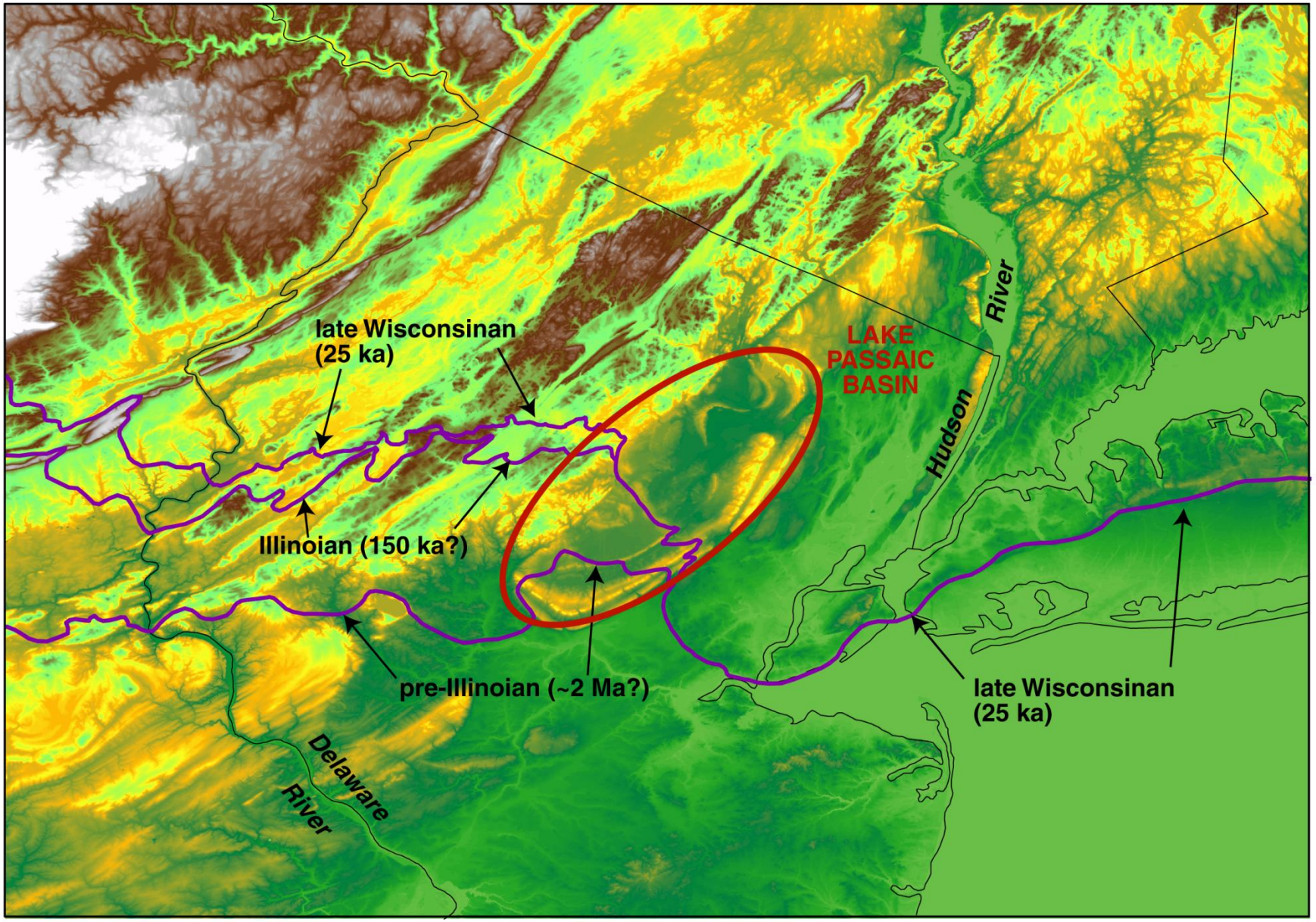


Discharge Rates and Flood Volumes for Glacial Lake Passaic, New Jersey

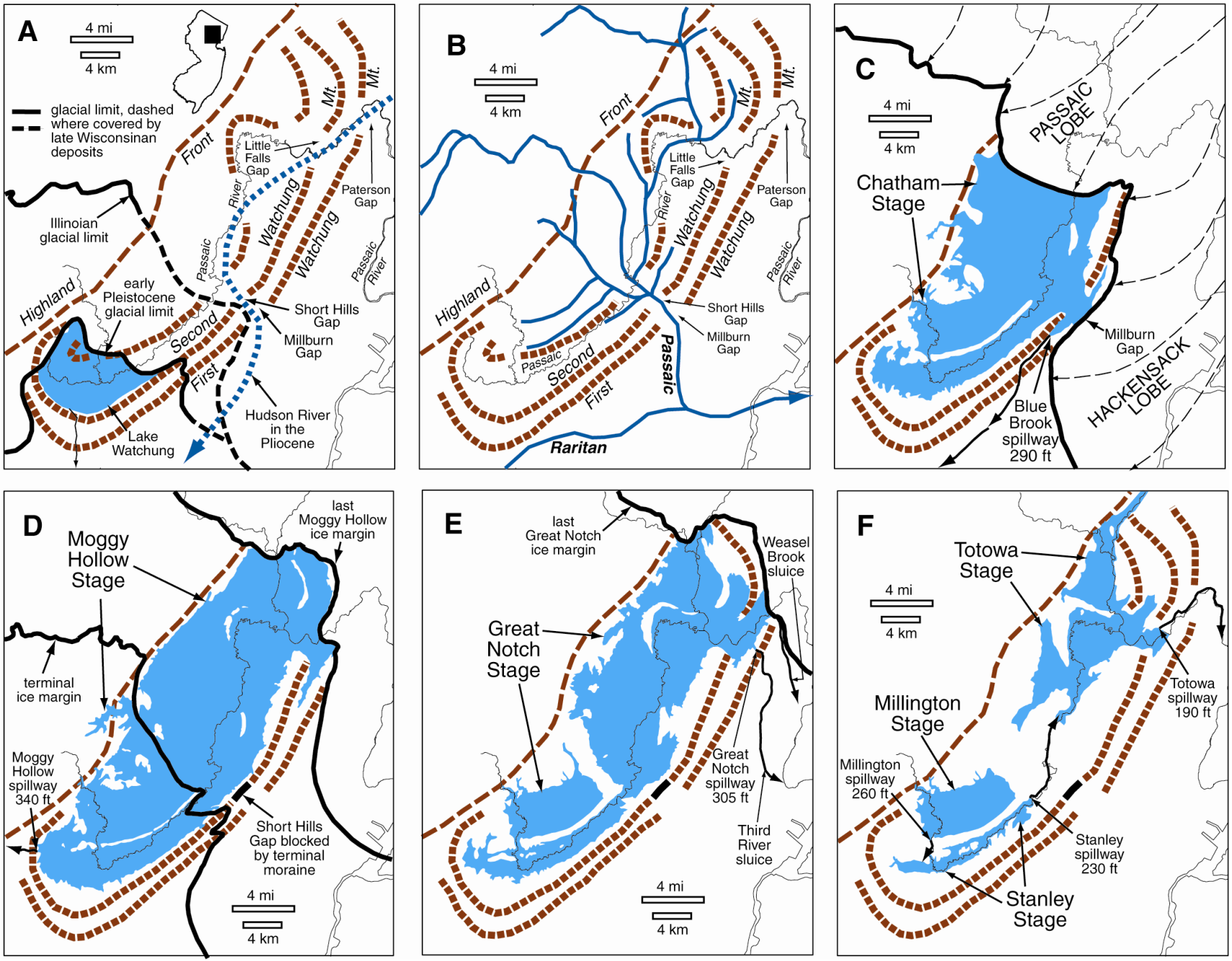
Scott D. Stanford
New Jersey Geological and Water Survey

Acknowledgements: Cook (1880), Salisbury and Kummel (1894, 1895), Kummel (1895), Stone and others (100k mapping, 2002), 24k mapping funded by STATEMAP 2002-2010

Moggy Hollow spillway



DEM from USGS National Elevation Data


A
4 mi
4 km
glacial limit, dashed where covered by late Wisconsinan deposits
Front
Mt.
Mt.
Little Falls Gap
Paterson Gap
River
Watchung
Watchung
Watchung
Illinoian glacial limit
Passaic
Passaic River
Highland
early Pleistocene glacial limit
Short Hills Gap
Millburn Gap
Second
First
Hudson River in the Pliocene
Lake Watchung
B
4 mi
4 km
Front
Mt.
Mt.
Little Falls Gap
River
Watchung
Watchung
Watchung
Paterson Gap
Passaic River
Highland
Short Hills Gap
Millburn Gap
Passaic
Second
First
Passaic
Raritan
C
4 mi
4 km
PASSAIC LOBE
Chatham Stage
Millburn Gap
HACKENSACK LOBE
Blue Brook spillway 290 ft
D
Moggy Hollow Stage
last Moggy Hollow ice margin
terminal ice margin
Moggy Hollow spillway 340 ft
Short Hills Gap blocked by terminal moraine
4 mi
4 km
E
last Great Notch ice margin
Weasel Brook sluice
Great Notch Stage
Great Notch spillway 305 ft
Third River sluice
4 mi
4 km
F
Totowa Stage
4 mi
4 km
Totowa spillway 190 ft
Millington Stage
Millington spillway 260 ft
Stanley spillway 230 ft
Stanley Stage

Manning Equation

$$Q = VA = \frac{1.49}{n} AR^{\frac{2}{3}} S$$

Q = discharge (ft^3/s)
V = velocity (ft/s)
A = channel cross-sectional area (ft^2)
n = Manning roughness coefficient
R = hydraulic radius (ft) = A/wetted perimeter
S = channel slope (ft/ft)

Manning (1891) after Gauckler (1867)

Blue Brook sluiceway

Discharge estimates at Feltville using the Manning equation:

Width of channel=200 ft

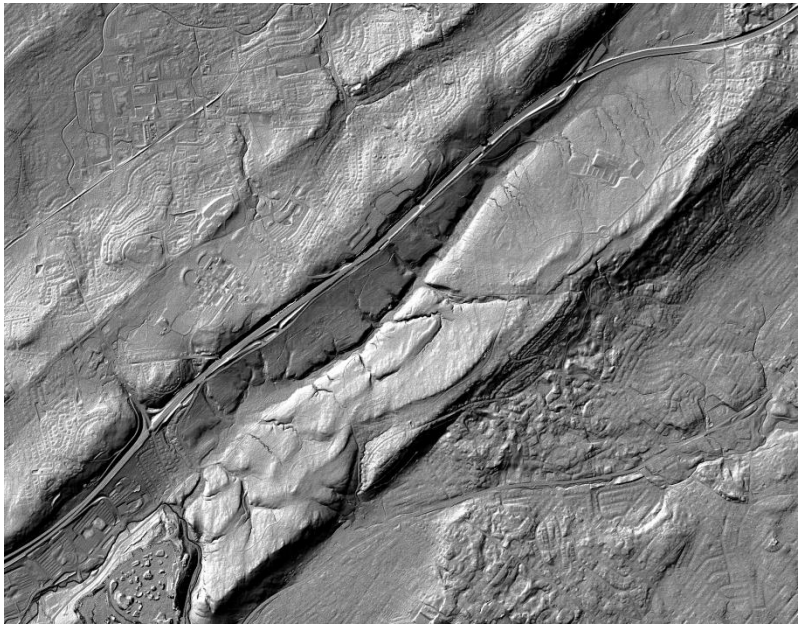
Slope=0.006

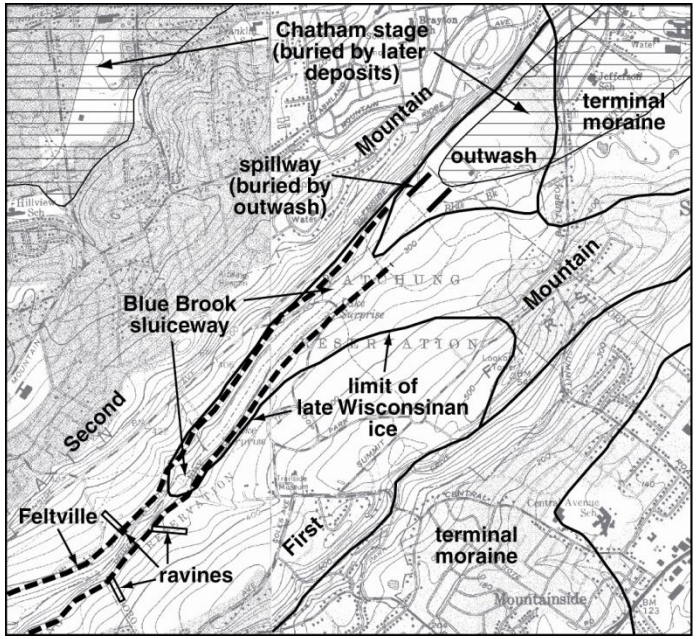
Manning roughness=0.045 (typical for bedrock channels)

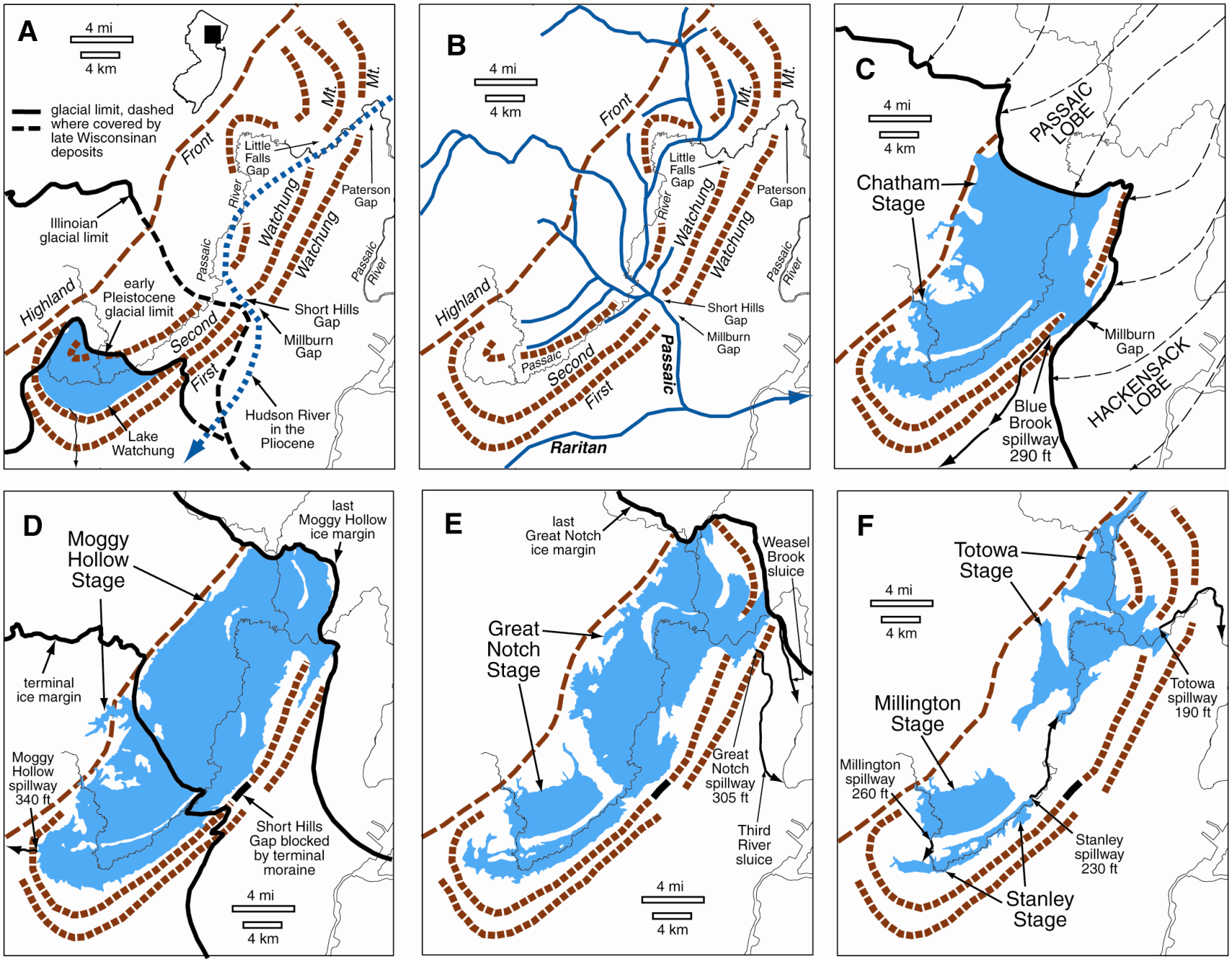
For 20 ft flow depth, v=16 ft/s and Q=65,000 ft ^{3}/s

For 10 ft flow depth, v=10 ft/s and Q=22,000 ft ^{3}/s

Discharge for 1903 flood of record for the Passaic at Great Falls in Paterson=34,000 ft^3/s






A
4 mi
4 km
glacial limit, dashed where covered by late Wisconsinan deposits
Front
Mt.
Mt.
Little Falls Gap
Paterson Gap
River
Watchung
Watchung
Watchung
Illinoian glacial limit
Passaic
Passaic River
Highland
early Pleistocene glacial limit
Short Hills Gap
Millburn Gap
Second
First
Hudson River in the Pliocene
Lake Watchung
B
4 mi
4 km
Front
Mt.
Mt.
Little Falls Gap
River
Watchung
Watchung
Watchung
Paterson Gap
Passaic River
Highland
Short Hills Gap
Millburn Gap
Passaic
Second
First
Passaic
Raritan
C
4 mi
4 km
PASSAIC LOBE
Chatham Stage
Millburn Gap
HACKENSACK LOBE
Blue Brook spillway 290 ft
D
Moggy Hollow Stage
last Moggy Hollow ice margin
terminal ice margin
Moggy Hollow spillway 340 ft
Short Hills Gap blocked by terminal moraine
4 mi
4 km
E
last Great Notch ice margin
Weasel Brook sluice
Great Notch Stage
Great Notch spillway 305 ft
Third River sluice
4 mi
4 km
F
Totowa Stage
4 mi
4 km
Totowa spillway 190 ft
Millington Stage
Millington spillway 260 ft
Stanley spillway 230 ft
Stanley Stage

Moggy Hollow sluiceway

Discharge estimates using the Manning equation:

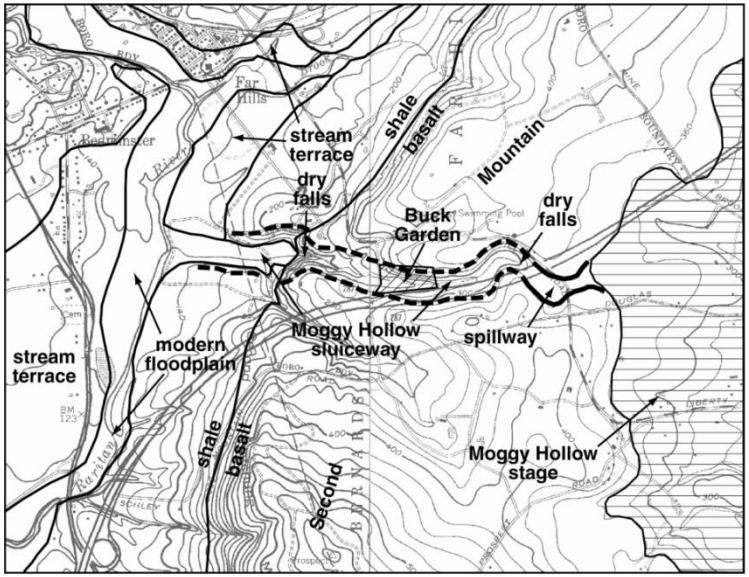
Width of channel=200 ft

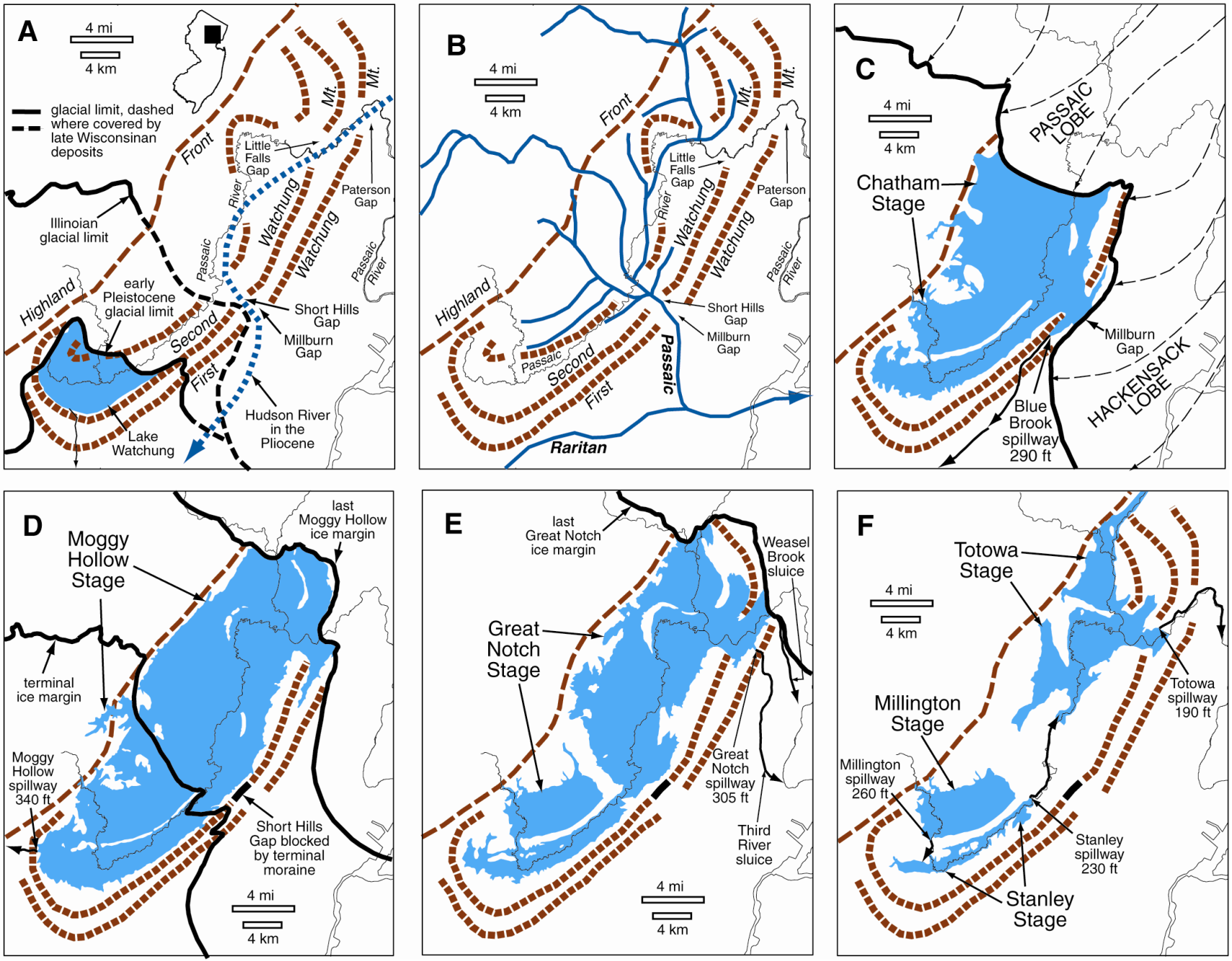
Slope=0.04 (steeper than other sluices)

Manning roughness=0.045

For 10 ft flow depth, v= 27 ft/s and Q=54,000 ft^3/s

Operated for ~1000 years, longer than other sluices

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Hudson River in the Pliocene
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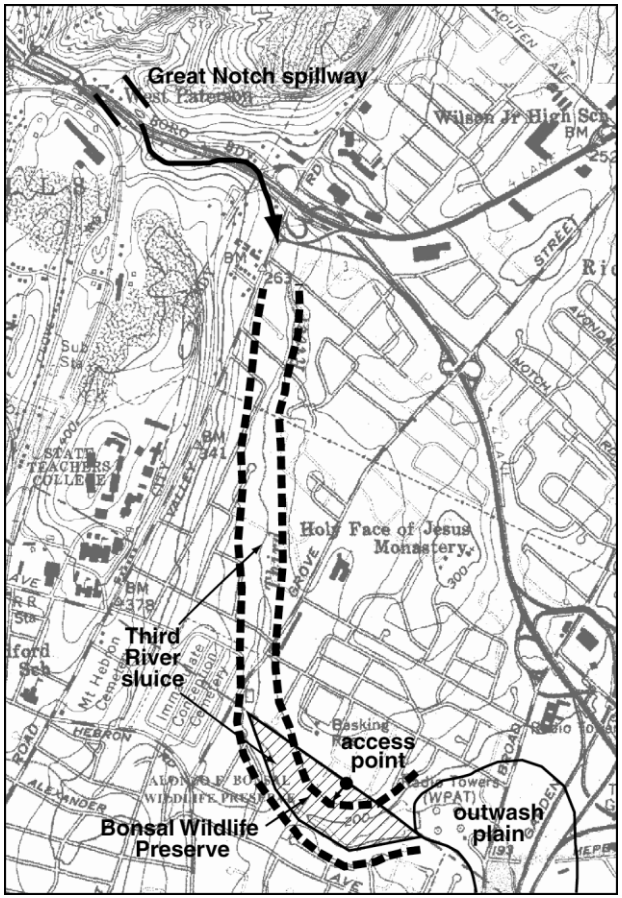
Third River sluice
4 mi
4 km
F
Totowa Stage
4 mi
4 km
Totowa spillway 190 ft
Millington Stage
Millington spillway 260 ft
Stanley spillway 230 ft
Stanley Stage

Great Notch spillway and Third River sluice



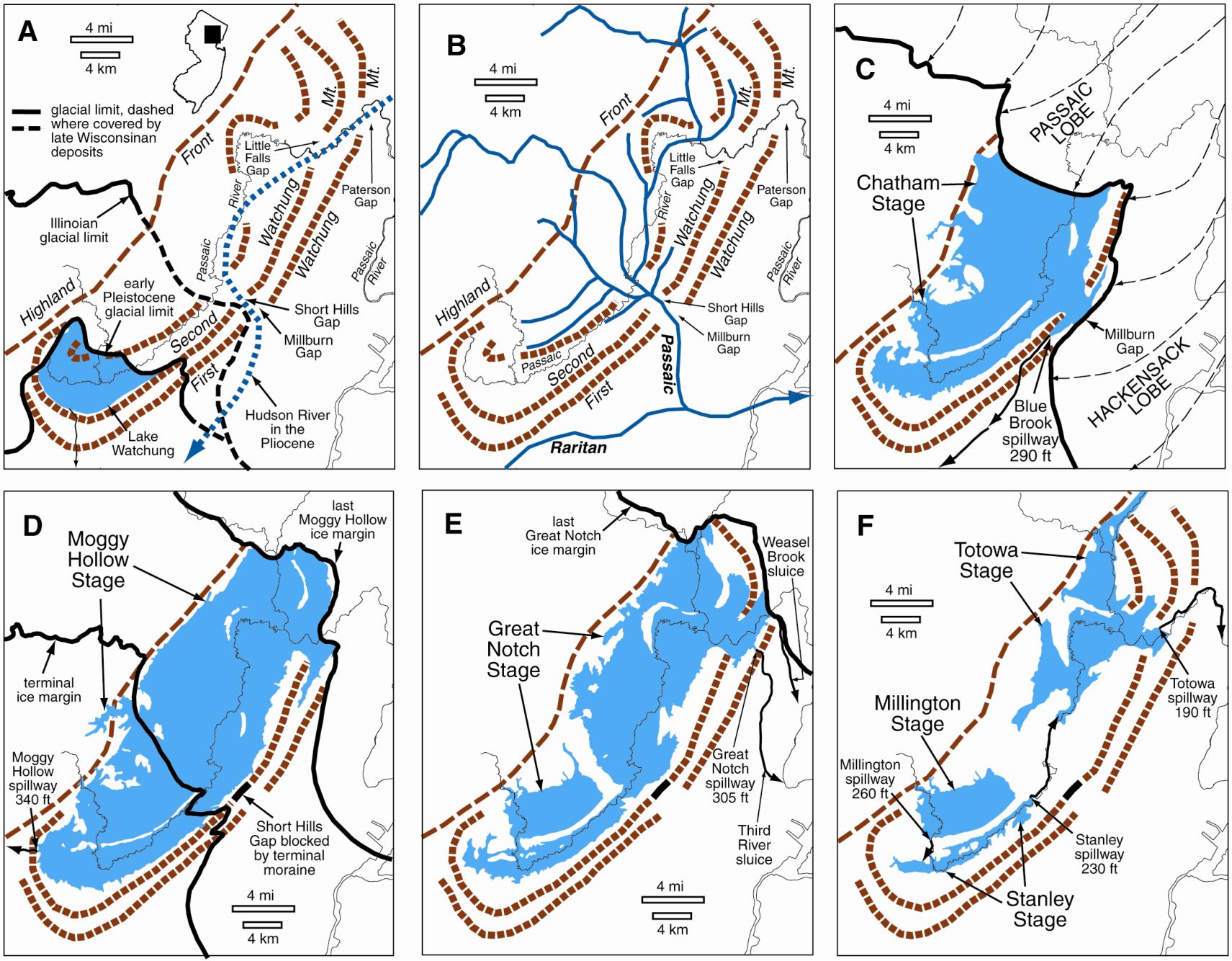
Drop from Moggy Hollow to Great Notch stage released 2.5 mi^3 of water (80 foot decline in lake level)

Discharge estimates for Third River sluice using the Manning equation:

Width of channel=300 ft, Slope=0.009 , Manning roughness=0.045

For 20 ft flow depth, v= 20 ft/s and Q=125,000 ft^3/s. Initial flood drains in about a month.

For 10 ft flow depth and 200 ft width (half bankfull), Q=27,000 ft^3/s. Sufficient for non-peak post-flood drainage of Great Notch stage.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Passaic River
Highland
early Pleistocene glacial limit
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Hudson River in the Pliocene
Lake Watchung
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4 mi
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River
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Paterson Gap
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Weasel Brook sluice
Great Notch Stage
Great Notch spillway 305 ft
Third River sluice
4 mi
4 km
F
Totowa Stage
4 mi
4 km
Totowa spillway 190 ft
Millington Stage
Millington spillway 260 ft
Stanley spillway 230 ft
Stanley Stage

Weasel Brook sluice and drainage of Great Notch stage

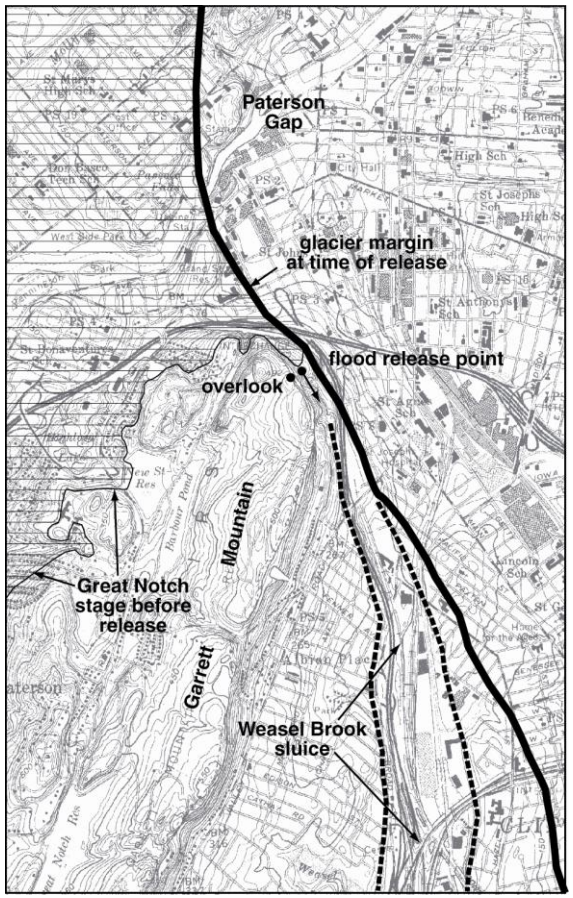
Drainage of Great Notch stage released 1.2 mi^3 of water (105 foot decline in lake level)

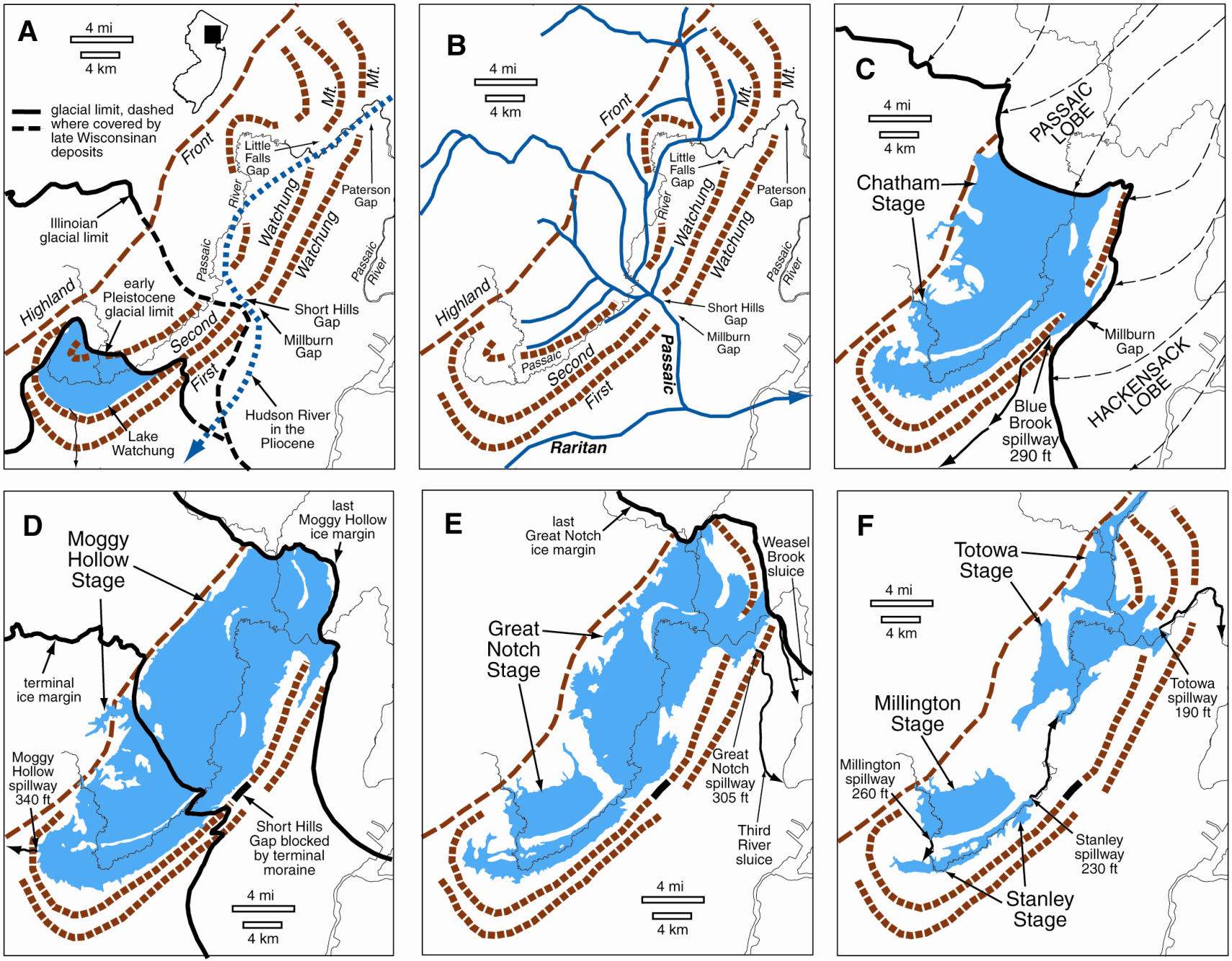
Discharge estimates for Weasel Brook sluice using the Manning equation:

Width of channel=1000 ft, Slope=0.015 , Manning roughness=0.045

For 10 ft flow depth, v= 18 ft/s and Q=180,000 ft^3/s. Drains in about 11 days.

Little post-flood drainage because channel is ice-walled, and ice front retreated.

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Passaic River
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4 mi
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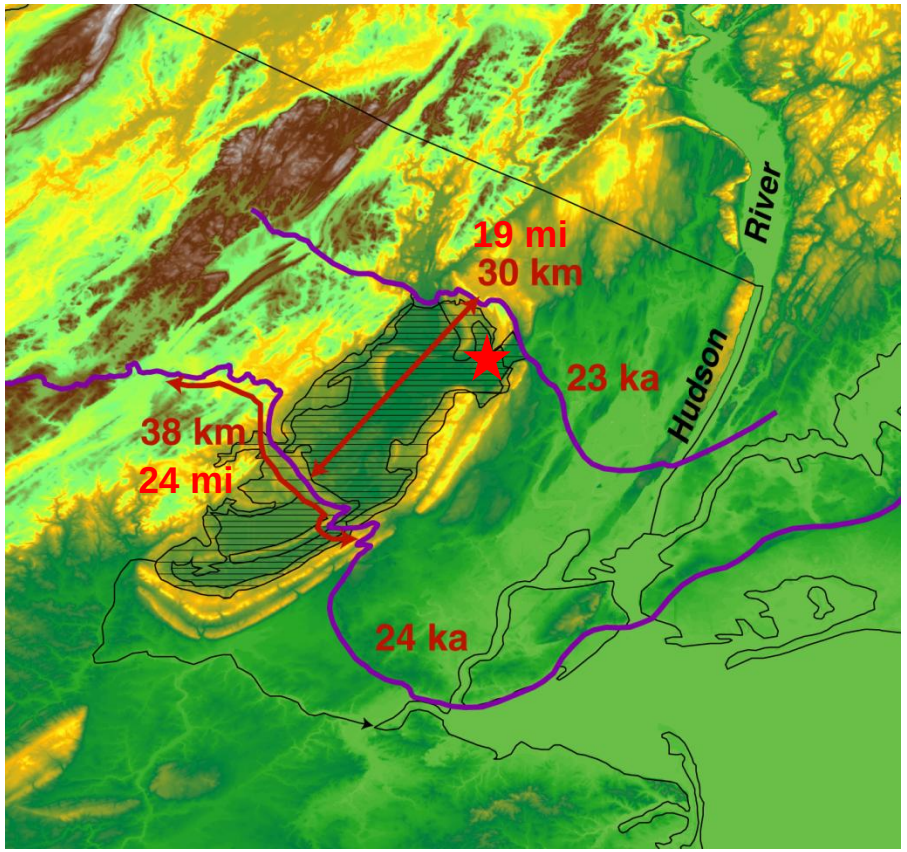
Millington spillway 260 ft
Stanley spillway 230 ft
Stanley Stage

At terminal position, 24 miles of ice margin drains through Moggy Hollow.

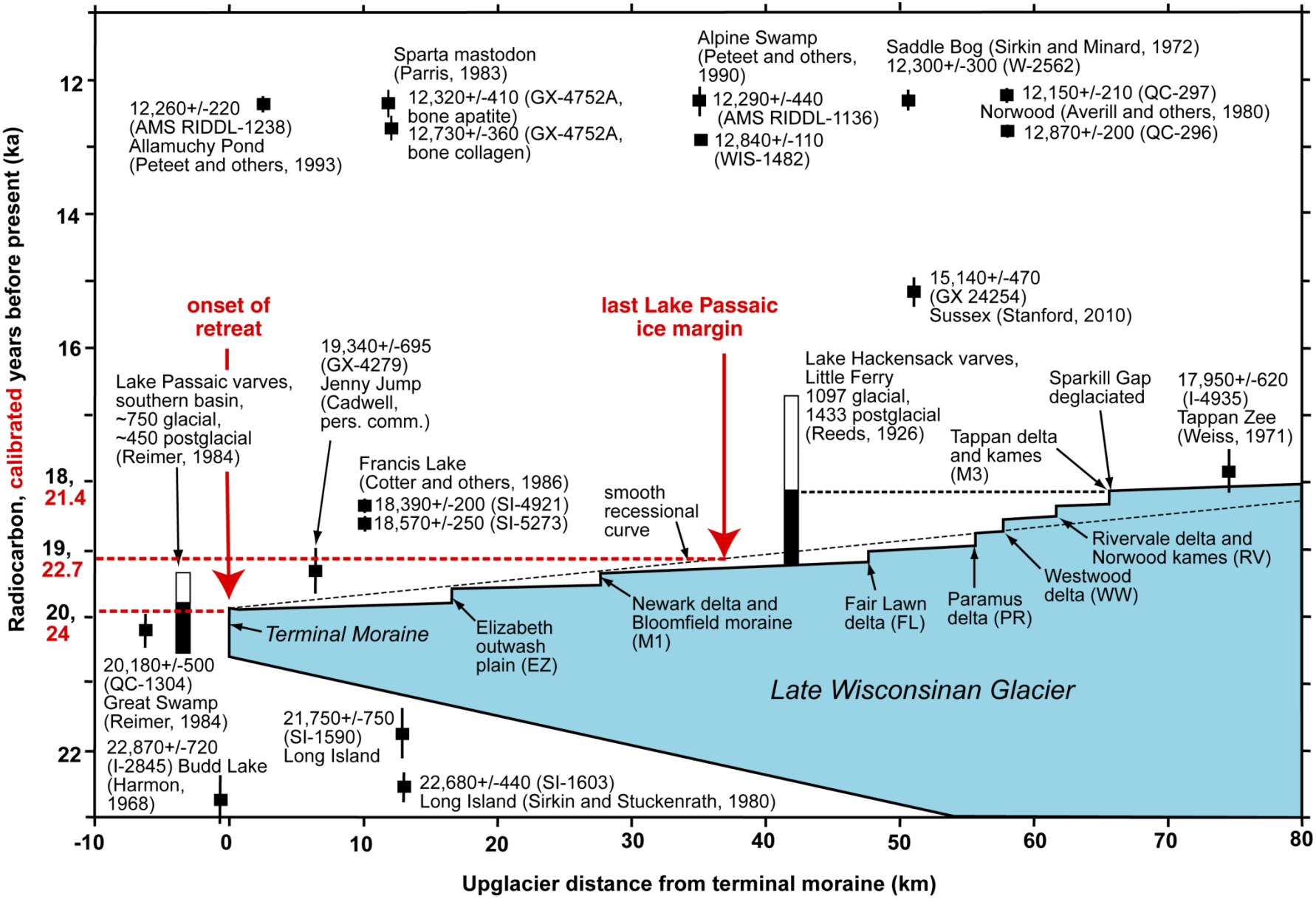
Moggy Hollow discharge of 54,000 ft^3/s gives 36,820 ft^3/day per foot of ice margin, which in turn gives 0.41 ft/day of ice-surface lowering for the 19-mile length of glacier in the basin, assuming stagnant ice.

This converts to about 150 ft/year of ice-margin retreat, compared to about 100 ft/year inferred from deglaciation chronology.

Adjust by allowing for reduced melting in winter and for active ice.



readvance till on deformed lacustrine sand, Wayne, NJ


Radiocarbon, calibrated years before present (ka)
12
14
16
18, 21.4
19, 22.7
20, 24
22
-10
0
10
20
30
40
50
60
70
80
Upglacier distance from terminal moraine (km)
12,260+/-220 (AMS RIDDL-1238) Allamuchy Pond (Peteet and others, 1993)
Sparta mastodon (Parris, 1983)
12,320+/-410 (GX-4752A, bone apatite)
12,730+/-360 (GX-4752A, bone collagen)
Alpine Swamp (Peteet and others, 1990)
12,290+/-440 (AMS RIDDL-1136)
12,840+/-110 (WIS-1482)
Saddle Bog (Sirkin and Minard, 1972)
12,300+/-300 (W-2562)
12,150+/-210 (QC-297)
Norwood (Averill and others, 1980)
12,870+/-200 (QC-296)
15,140+/-470 (GX 24254) Sussex (Stanford, 2010)
onset of retreat
last Lake Passaic ice margin
Lake Passaic varves, southern basin, ~750 glacial, ~450 postglacial (Reimer, 1984)
19,340+/-695 (GX-4279) Jenny Jump (Cadwell, pers. comm.)
Francis Lake (Cotter and others, 1986)
18,390+/-200 (SI-4921)
18,570+/-250 (SI-5273)
smooth recessional curve
Lake Hackensack varves, Little Ferry 1097 glacial, 1433 postglacial (Reeds, 1926)
Sparkill Gap deglaciated
17,950+/-620 (I-4935) Tappan Zee (Weiss, 1971)
Tappan delta and kames (M3)
Rivervale delta and Norwood kames (RV)
Westwood delta (WW)
Paramus delta (PR)
Fair Lawn delta (FL)
Newark delta and Bloomfield moraine (M1)
Elizabeth outwash plain (EZ)
Terminal Moraine
Late Wisconsinan Glacier
20,180+/-500 (QC-1304) Great Swamp (Reimer, 1984)
22,870+/-720 (I-2845) Budd Lake (Harmon, 1968)
21,750+/-750 (SI-1590) Long Island
22,680+/-440 (SI-1603) Long Island (Sirkin and Stuckenrath, 1980)

Flooding

Damaging floods in 1810, 1865, 1878, 1882, 1886, 1896, 1902, 1903, 1920, 1936, 1945, 1951, 1952, 1968, 1984, 1999, 2007, 2010, March 2011, August 2011