Cumberland River Basin
May 2010 Flood Event

Bob Sneed

Chief, Water Management Section

Nashville District

20 May 2010

US Army Corps of Engineers

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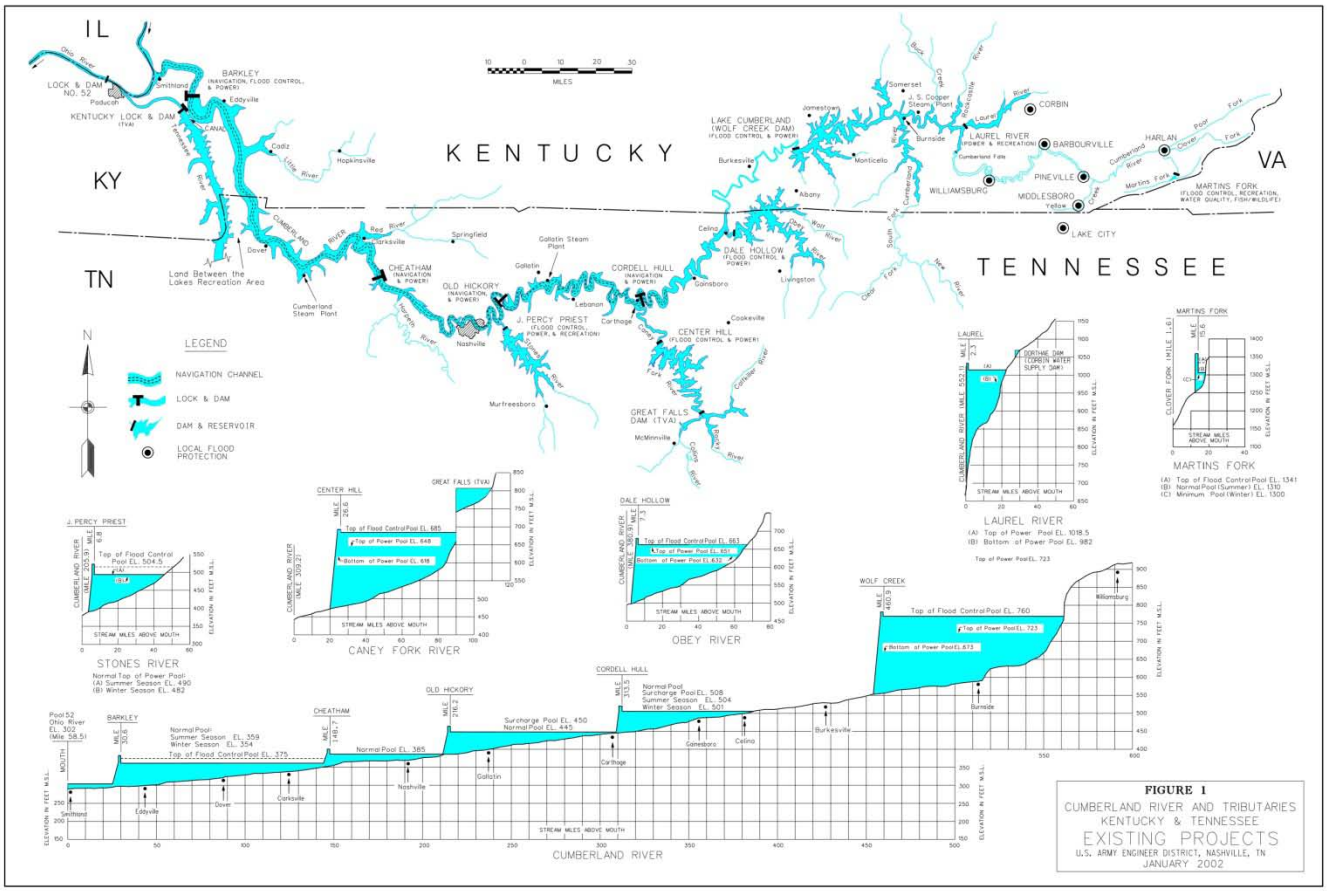
Cumberland River Basin Reservoir System



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Congressionally Authorized Project Purposes

Project	Flood Damage Reduction	Commercial Navigation	Hydropower	Recreation
Wolf Creek Dam				
Dale Hollow Dam				
Cordell Hull Lock & Dam				
Center Hill Dam				
Old Hickory Lock & Dam				
J. Percy Priest Dam				
Cheatham Lock & Dam				
Barkley Lock & Dam				

Project not designed for this purpose	
Project primarily designed for this purpose	

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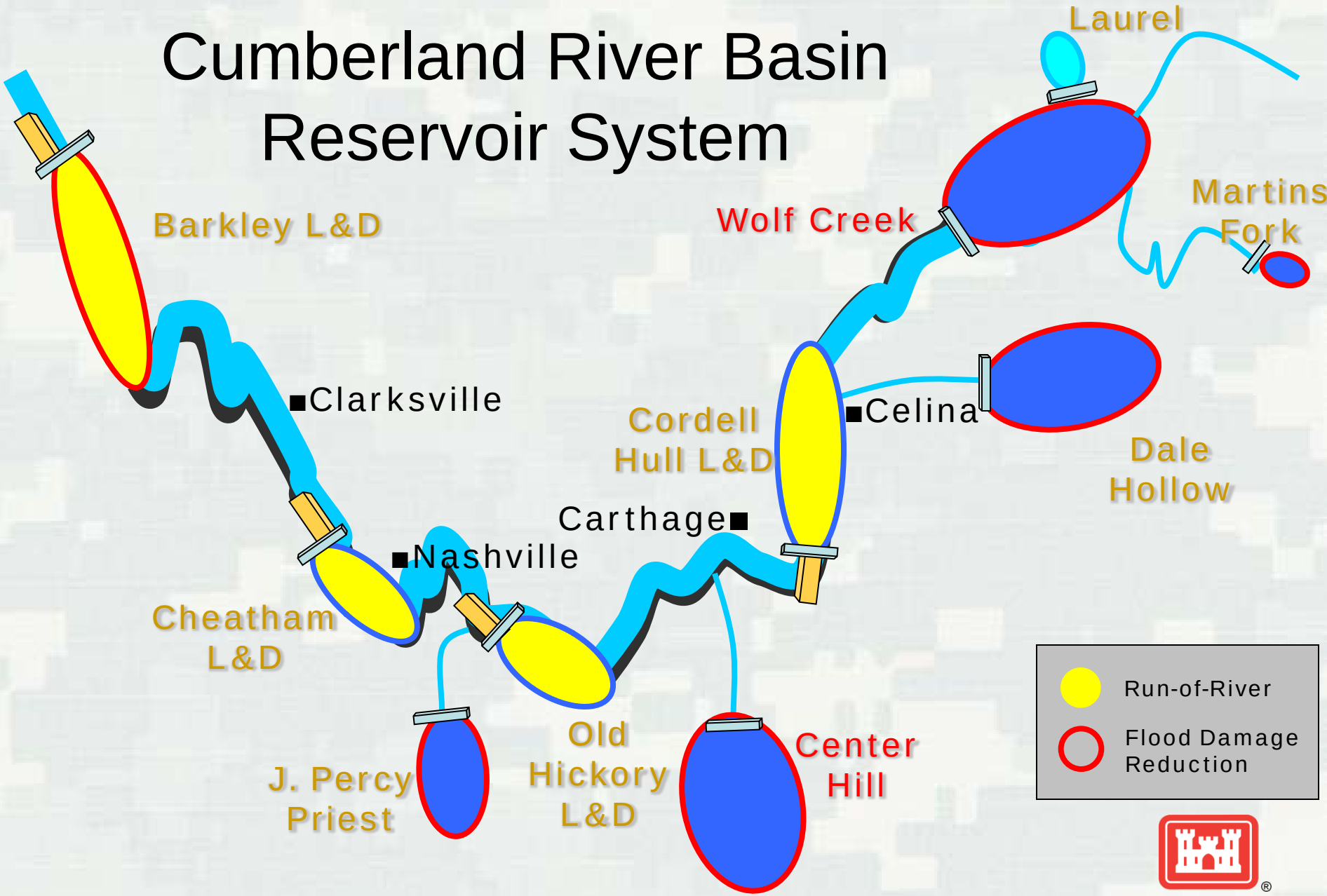
Cumberland River Main-stem Project Drainage Comparison

Project	Local Uncontrolled Drainage Area (mi^2)[1]	Total Drainage Area (mi^2)[2]	Percent Uncontrolled
Cordell Hull Lock & Dam	1,372	8,096	17%
Old Hickory Lock & Dam	2,776	11,647	24%
Cheatham Lock & Dam	4,370	14,160	31%
Barkley Lock & Dam	7,808	17,598	44%

[1] The uncontrolled drainage area is that portion of the watershed that is not upstream of a flood control dam.
[2] The total drainage area includes the entire watershed above the referenced Lock & Dam.

Cumberland River Basin Reservoir System



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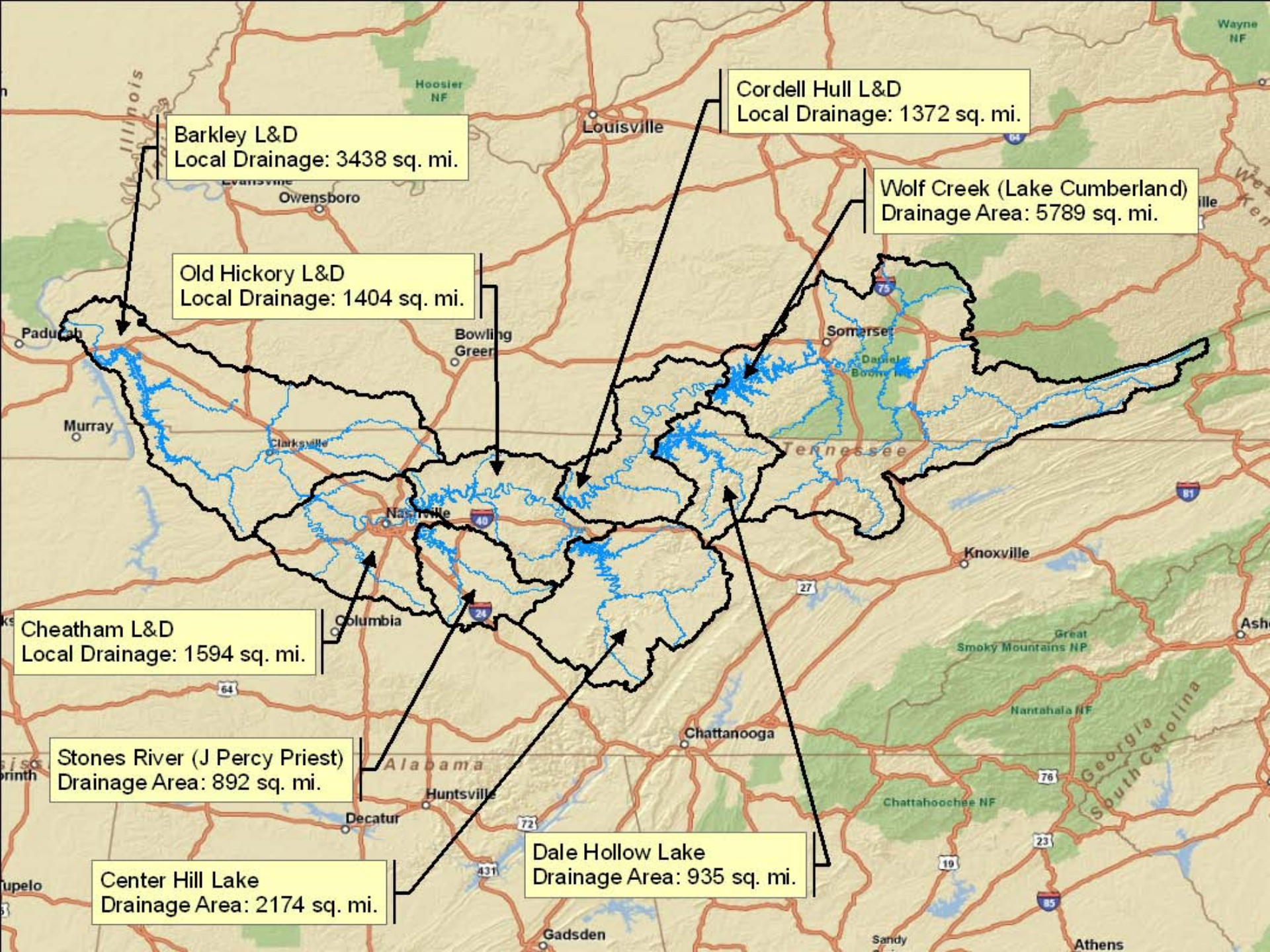
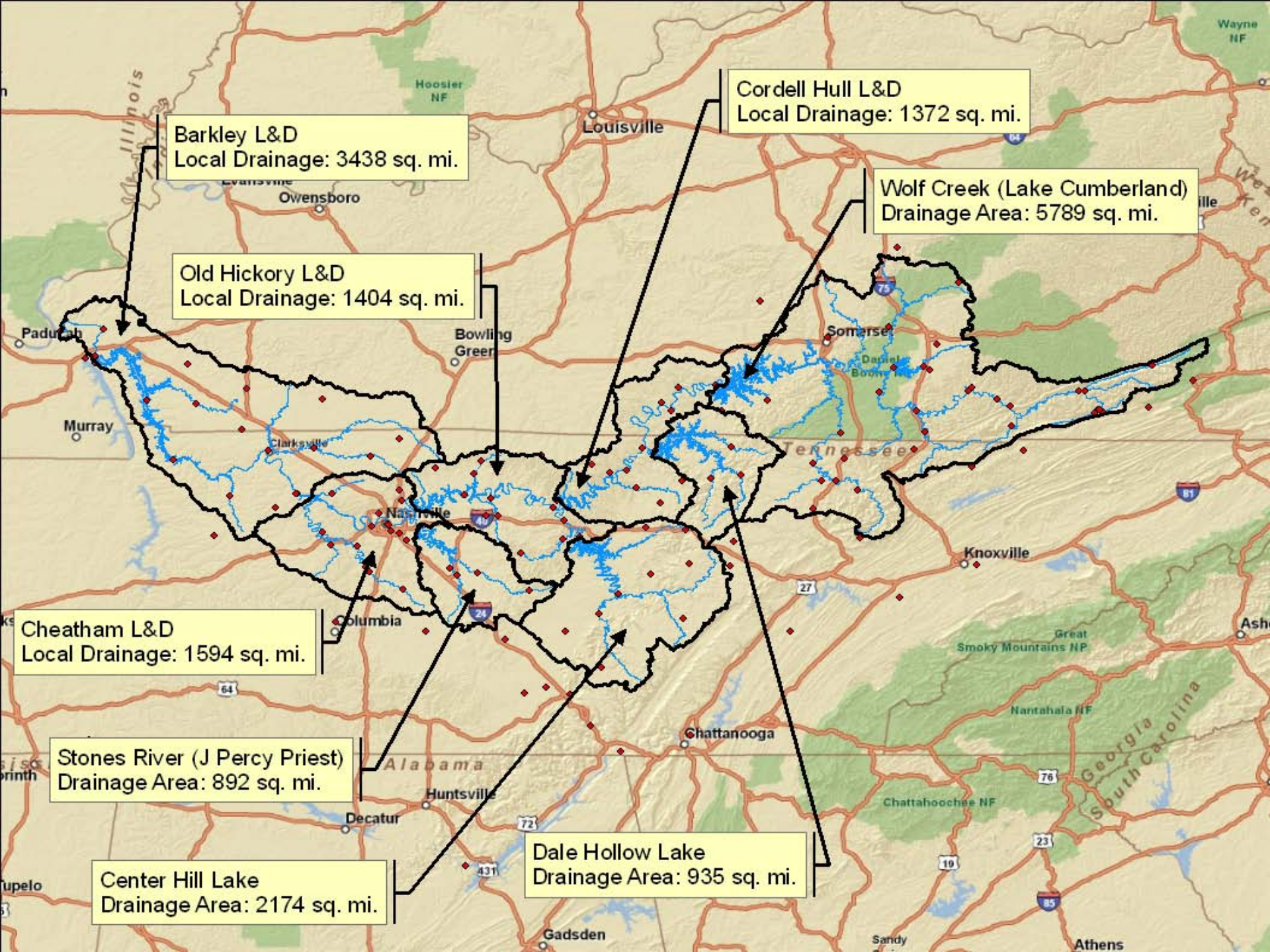

Barkley L&D
Local Drainage: 3438 sq. mi.
Cordell Hull L&D
Local Drainage: 1372 sq. mi.
Wolf Creek (Lake Cumberland)
Drainage Area: 5789 sq. mi.
Old Hickory L&D
Local Drainage: 1404 sq. mi.
Cheatham L&D
Local Drainage: 1594 sq. mi.
Stones River (J Percy Priest)
Drainage Area: 892 sq. mi.
Center Hill Lake
Drainage Area: 2174 sq. mi.
Dale Hollow Lake
Drainage Area: 935 sq. mi.
Louisville
Owensboro
Paducah
Bowling Green
Murray
Clarksville
Nashville
Somerset
Knoxville
Columbia
Chattanooga
Huntsville
Decatur
Gadsden
Athens
Tennessee
Alabama
Illinois
Georgia
South Carolina
Hoosier NF
Wayne NF
Great Smoky Mountains NP
Nantahala NF
Chattahoochee NF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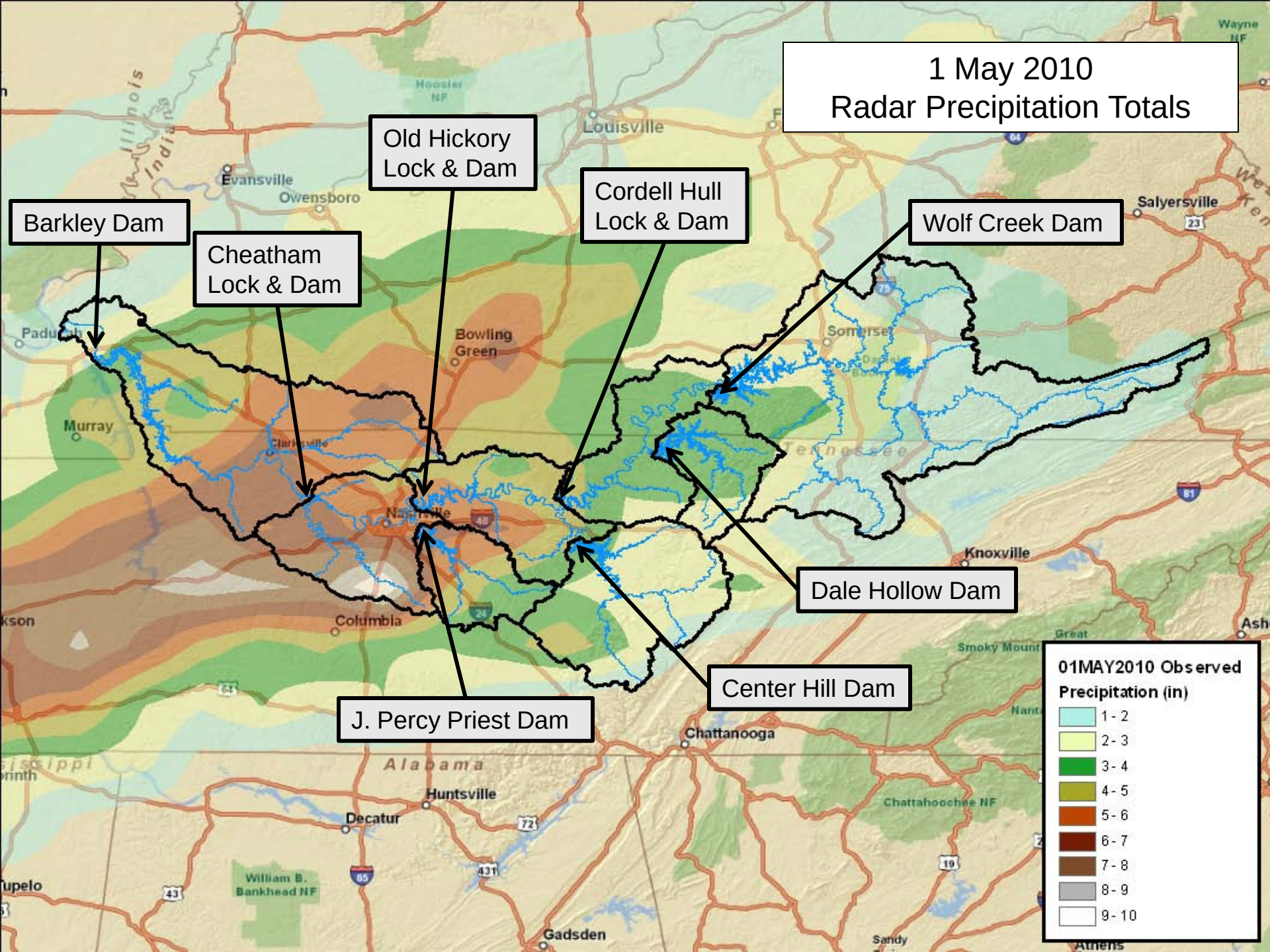
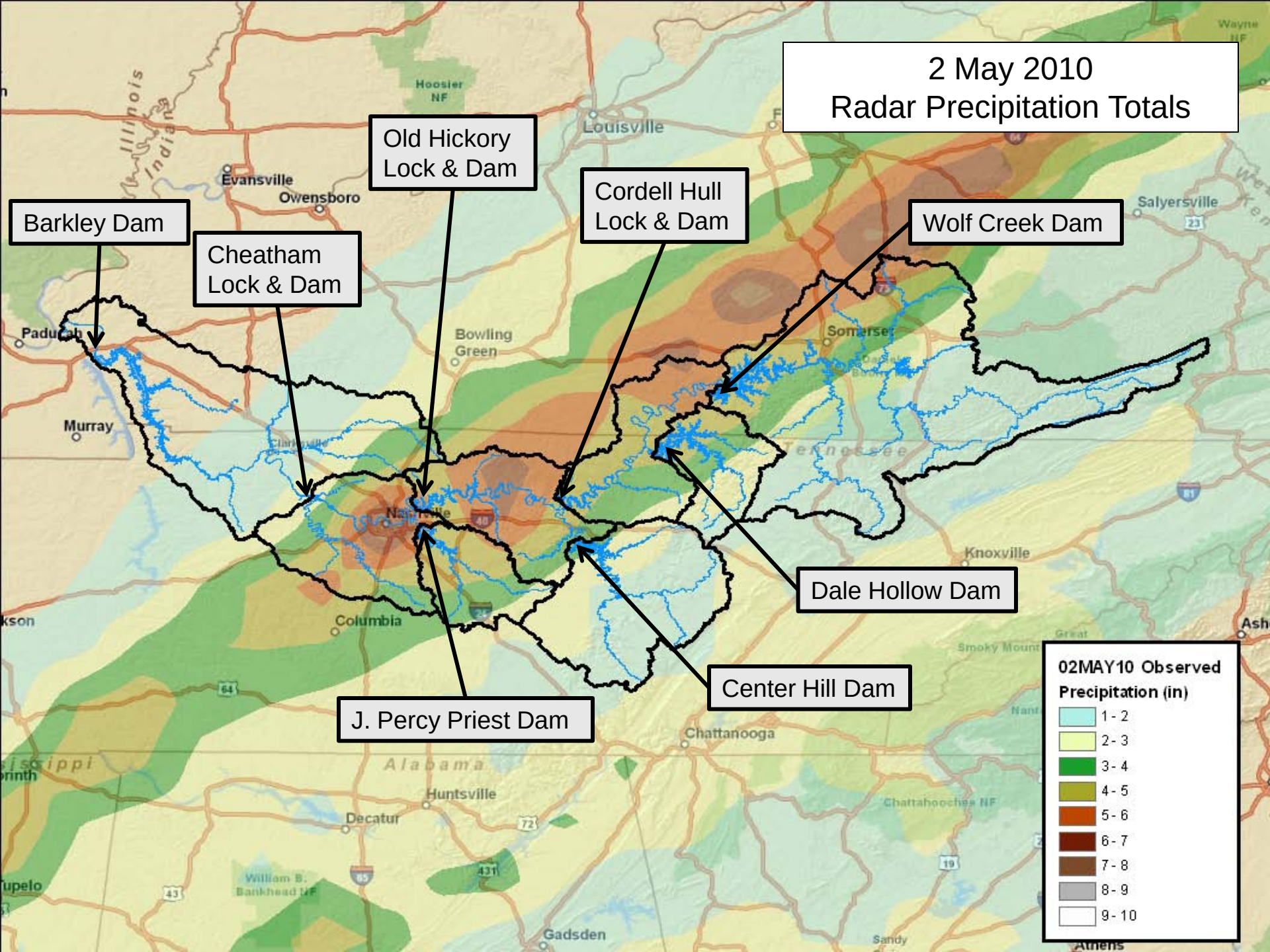
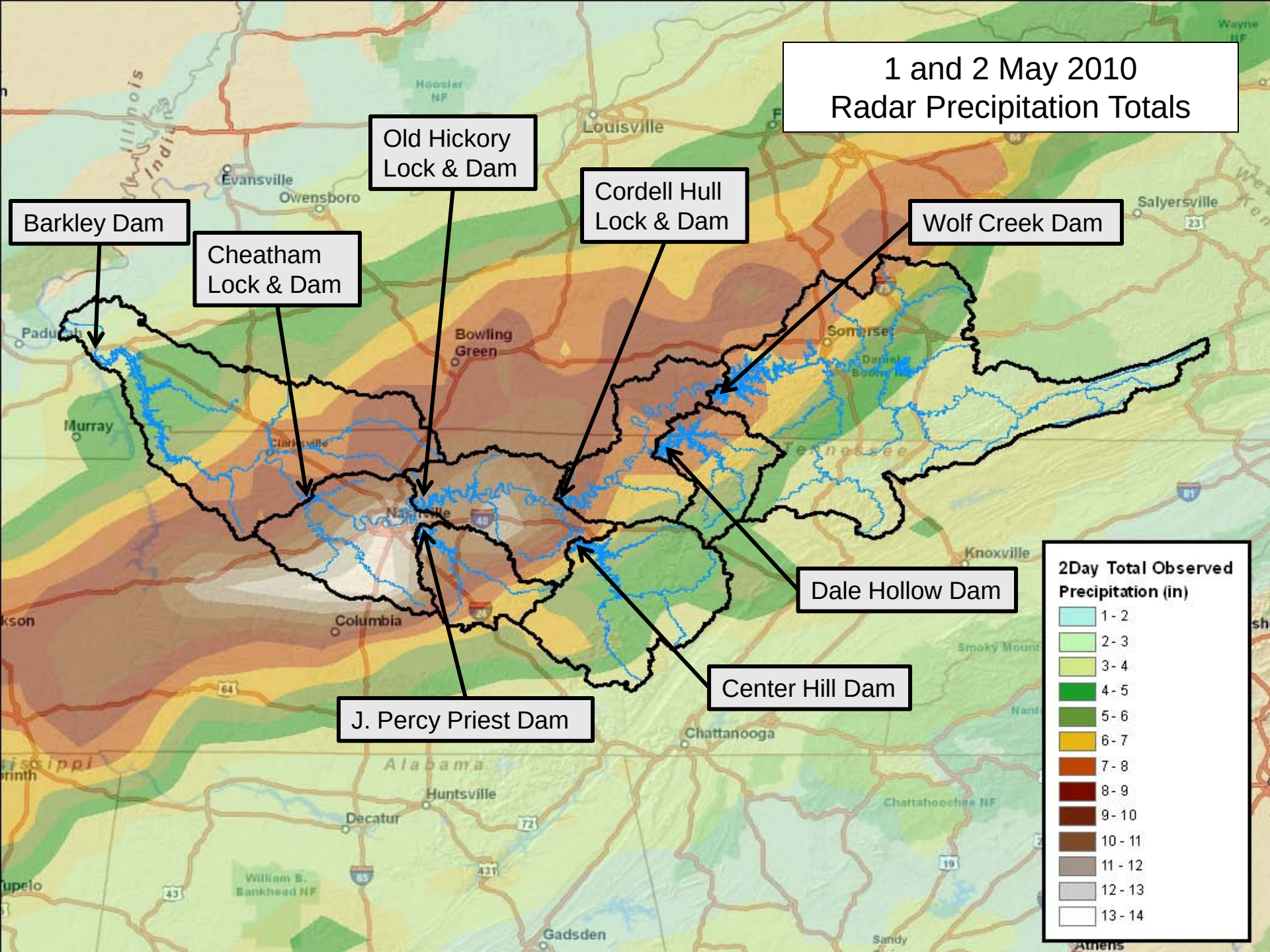
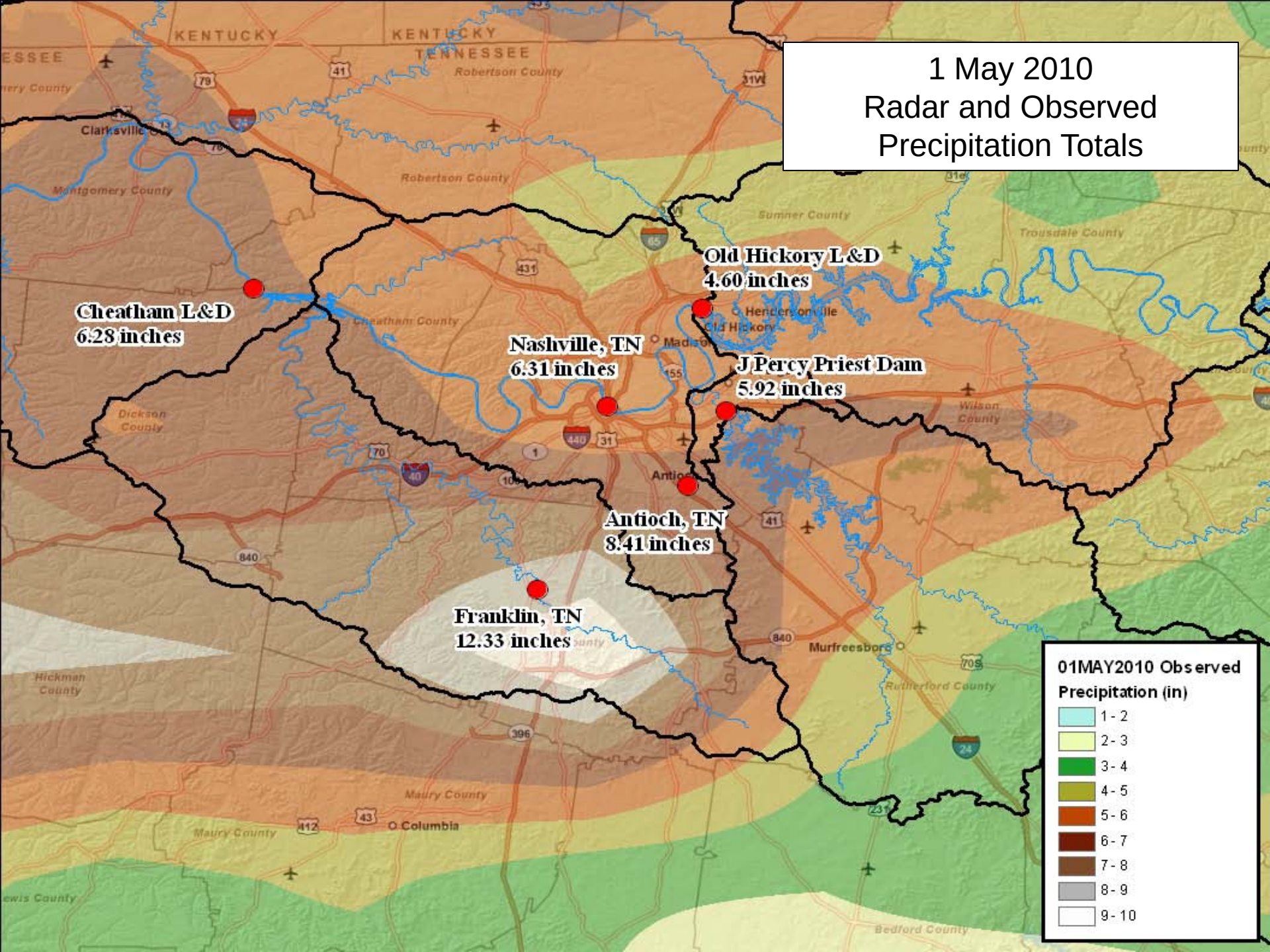
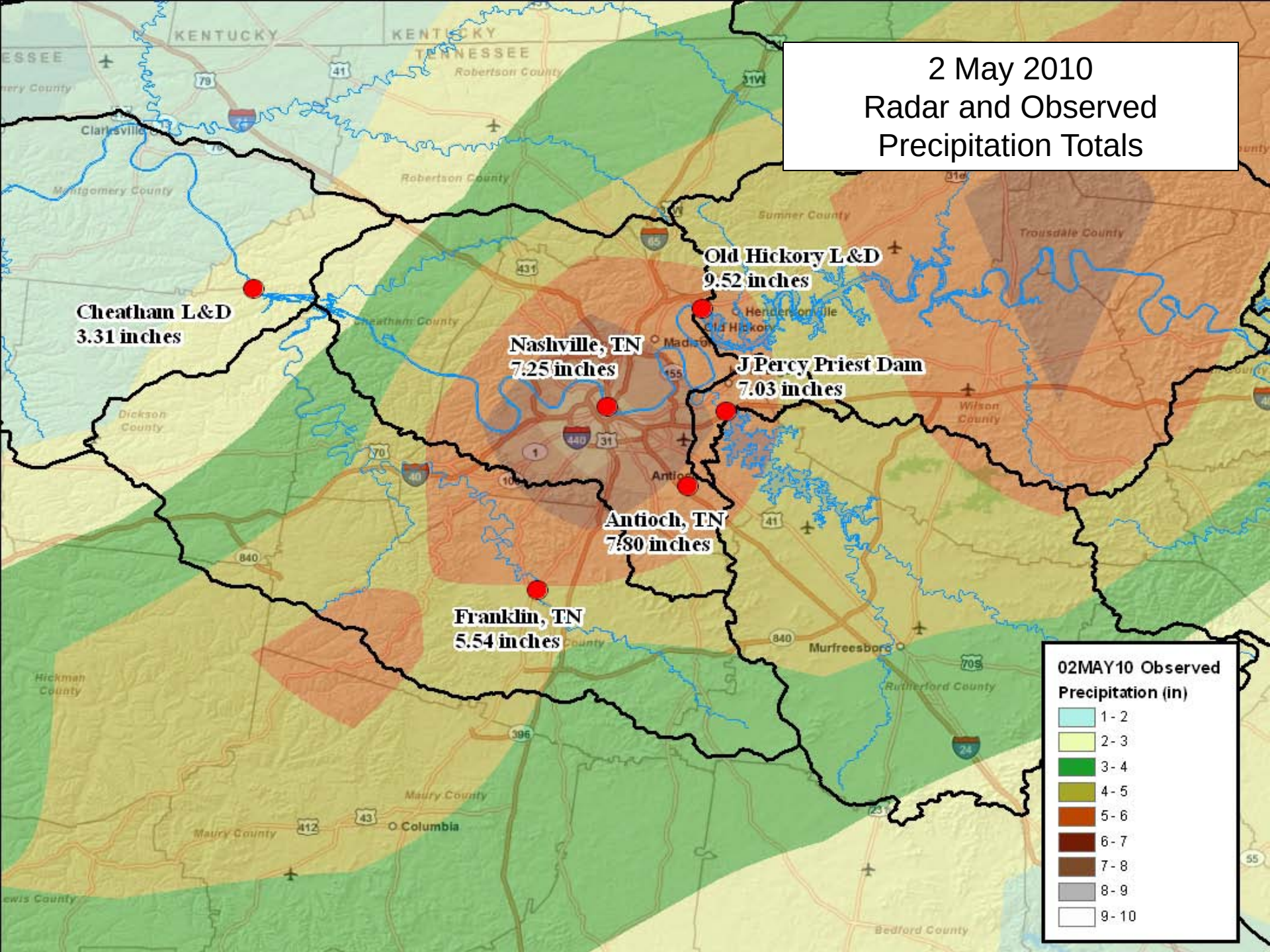
Decatur
Gadsden
Athens
Tennessee
Alabama
Illinois
Hoosier NF
Wayne NF
Great Smoky Mountains NP
Nantahala NF
Chattahoochee NF
Georgia
South Carolina

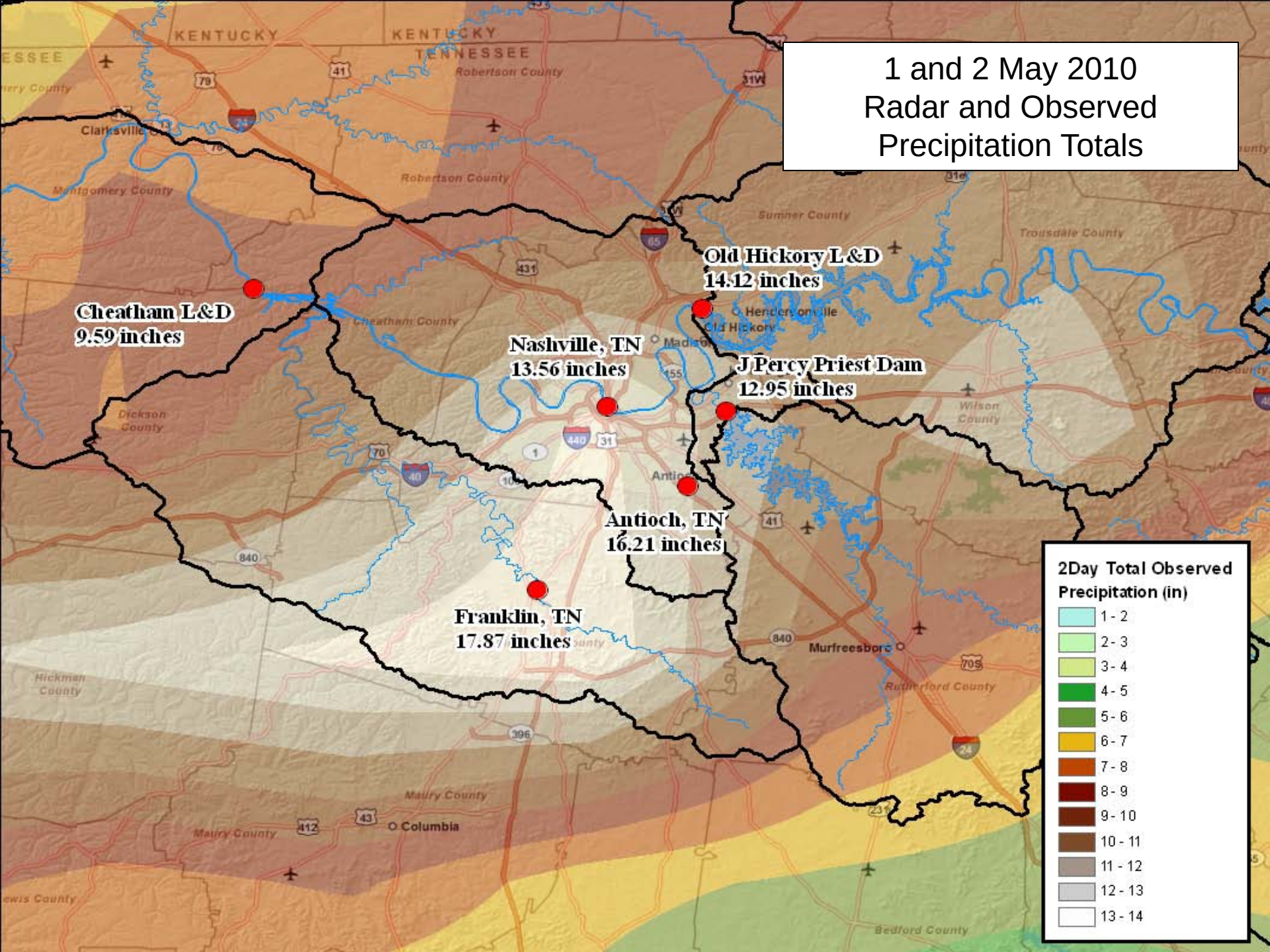

1 May 2010
Radar Precipitation Totals
Barkley Dam
Cheatham Lock & Dam
Old Hickory Lock & Dam
Cordell Hull Lock & Dam
Wolf Creek Dam
Dale Hollow Dam
Center Hill Dam
J. Percy Priest Dam
01MAY2010 Observed Precipitation (in)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
Louisville
Evansville
Owensboro
Salyersville
Bowling Green
Somerset
Murray
Nashville
Knoxville
Columbia
Chattanooga
Huntsville
Decatur
Gadsden
Tennessee
Alabama
Chattahoochee NF
William B. Bankhead NF
Hoosier NF
Wayne NF


2 May 2010
Radar Precipitation Totals
Barkley Dam
Cheatham Lock & Dam
Old Hickory Lock & Dam
Cordell Hull Lock & Dam
Wolf Creek Dam
Dale Hollow Dam
Center Hill Dam
J. Percy Priest Dam
02MAY10 Observed Precipitation (in)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
Louisville
Evansville
Owensboro
Paducah
Murray
Bowling Green
Somerset
Salyersville
Nashville
Columbia
Knoxville
Chattanooga
Huntsville
Decatur
Gadsden
Athens
Hoosier NF
Illinois
Indiana
Tennessee
Alabama
Mississippi
Tupelo
Smoky Mountains
Chattahoochee NF
William B. Bankhead NF


1 and 2 May 2010
Radar Precipitation Totals
Barkley Dam
Cheatham Lock & Dam
Old Hickory Lock & Dam
Cordell Hull Lock & Dam
Wolf Creek Dam
Dale Hollow Dam
Center Hill Dam
J. Percy Priest Dam
2Day Total Observed Precipitation (in)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
Louisville
Evansville
Owensboro
Bowling Green
Somerset
Salyersville
Murray
Nashville
Columbia
Knoxville
Chattanooga
Huntsville
Decatur
Gadsden
Alabama
Tennessee


1 May 2010
Radar and Observed
Precipitation Totals
Old Hickory L&D
4.60 inches
Cheatham L&D
6.28 inches
Nashville, TN
6.31 inches
J Percy Priest Dam
5.92 inches
Antioch, TN
8.41 inches
Franklin, TN
12.33 inches
KENTUCKY
TENNESSEE
Robertson County
Montgomery County
Sumner County
Trousdale County
Cheatham County
Dickson County
Wilson County
Hickman County
Rutherford County
Maury County
Bedford County
Clarksville
Henderson Ville
Old Hickory
Murfreesboro
Columbia
01MAY2010 Observed
Precipitation (in)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10


2 May 2010
Radar and Observed
Precipitation Totals
Cheatham L&D
3.31 inches
Old Hickory L&D
9.52 inches
Nashville, TN
7.25 inches
J Percy Priest Dam
7.03 inches
Antioch, TN
7.80 inches
Franklin, TN
5.54 inches
02MAY10 Observed
Precipitation (in)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
KENTUCKY
TENNESSEE
Robertson County
Montgomery County
Cheatham County
Dickson County
Sumner County
Trousdale County
Wilson County
Hickman County
Maury County
Rutherford County
Bedford County
Clarksville
Henderson
Old Hickory
Madison
Antioch
Murfreesboro
Columbia


1 and 2 May 2010
Radar and Observed
Precipitation Totals
Cheatham L&D
9.59 inches
Nashville, TN
13.56 inches
Old Hickory L&D
14.12 inches
J Percy Priest Dam
12.95 inches
Antioch, TN
16.21 inches
Franklin, TN
17.87 inches
2Day Total Observed
Precipitation (in)
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 9
9 - 10
10 - 11
11 - 12
12 - 13
13 - 14
KENTUCKY
TENNESSEE
Robertson County
Montgomery County
Sumner County
Trousdale County
Cheatham County
Dickson County
Wilson County
Hickman County
Maury County
Rutherford County
Bedford County
Clarksville
Henderson Ville
Old Hickory
Madison
Antioch
Murfreesboro
Columbia

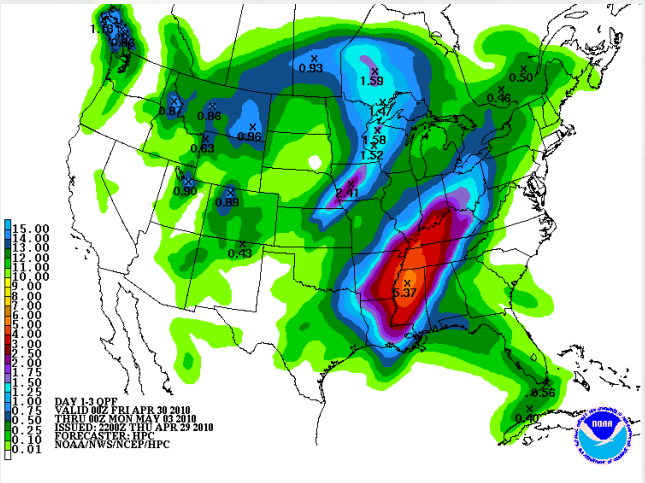
Record Setting Flood Event

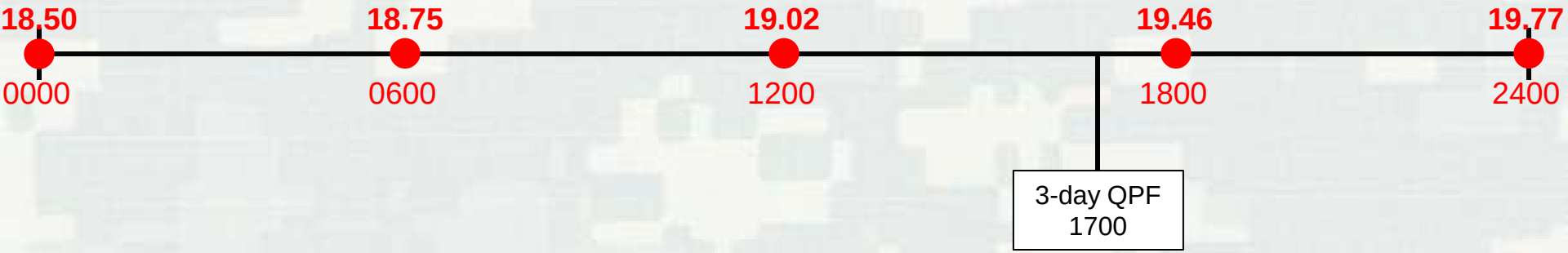
Project	Lake Elevation (ft)		Project Discharge (cfs)	
	May 2010	Previous Record	May 2010	Previous Record
Cordell Hull Lock & Dam	**508.33**	508.00 (May 1984)	**130,100**	123,850 (March 1975)
Old Hickory Lock & Dam	**451.45**	450.17 (May 1984)	**212,260**	165,500 (March 1975)
Cheatham Lock & Dam	**404.15**	398.95 (March 1962)	**240,000**	203,670 (March 1962)
Barkley Lock & Dam	**369.00**	370.04 (May 1984)	**303,200**	241,980 (May 1983)

Components of a Flood Forecast

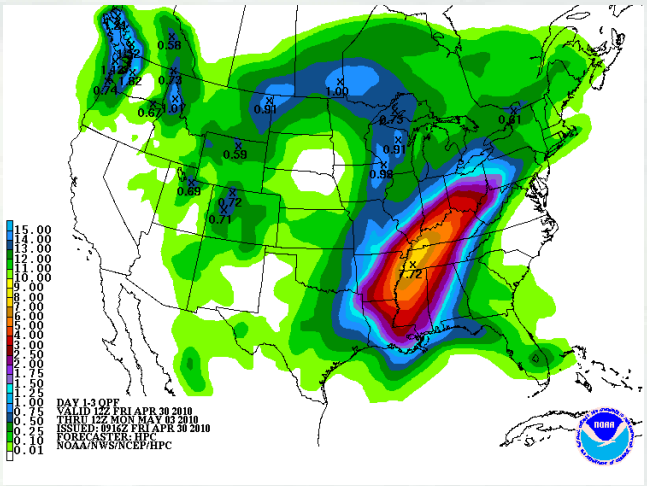
- Precipitation
  - Amount
  - Intensity
  - Location
- Hydrology Modeling
  - Rate of flow from tributary streams
- Hydraulic Modeling
  - Depth of flow in receiving stream
- Releases from Corps Dams
  - Hydropower and spillway gate operations

Thursday - 29 April 2010



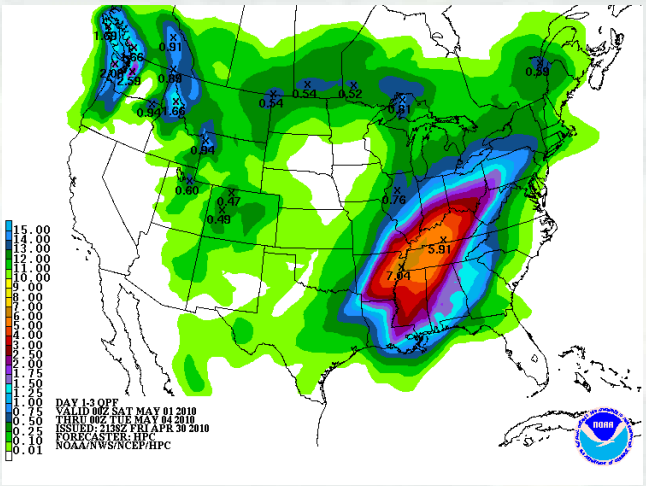


Friday - 30 April 2010



Completed lowering of pools at mainstem projects to prepare for forecasted rain

Cordell Hull ~ 0.5 ft
Old Hickory ~ 0.5 ft
Cheatham ~ 1.0 ft



0000	0600	1200	1800	2400
19.77	20.08	20.17	19.68	19.01

3-day QPF 0416

3-day QPF 2138

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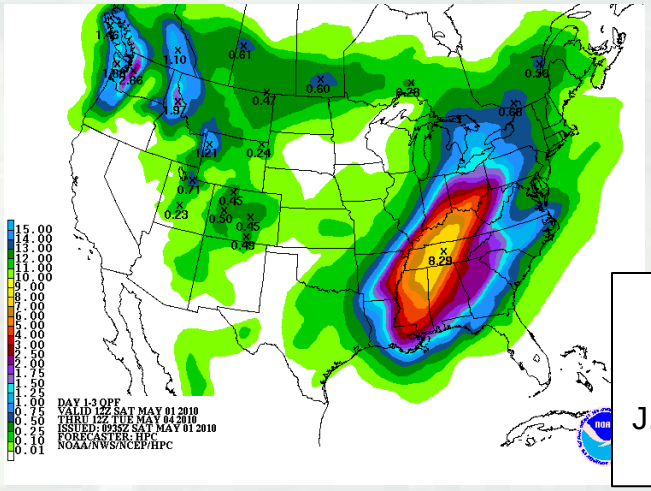
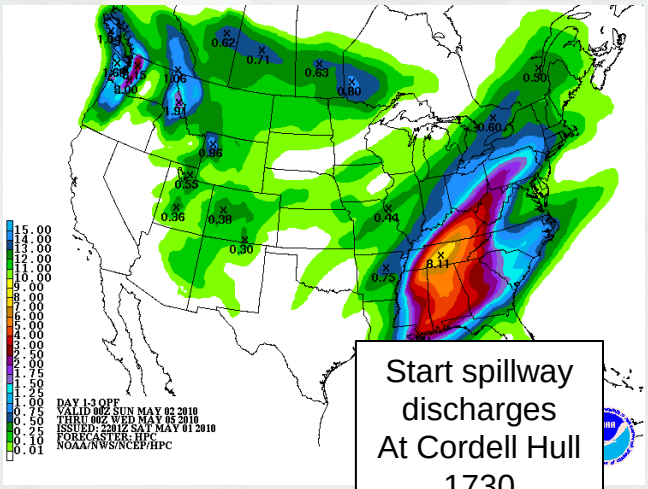
Saturday - 1 May 2010





Start hydropower releases at J. Percy Priest 1000

Start spillway discharges At Cordell Hull 1730

19.01 — 0000

18.83 — 0600

20.79 — 1200

28.04 — 1800

34.52 — 2400

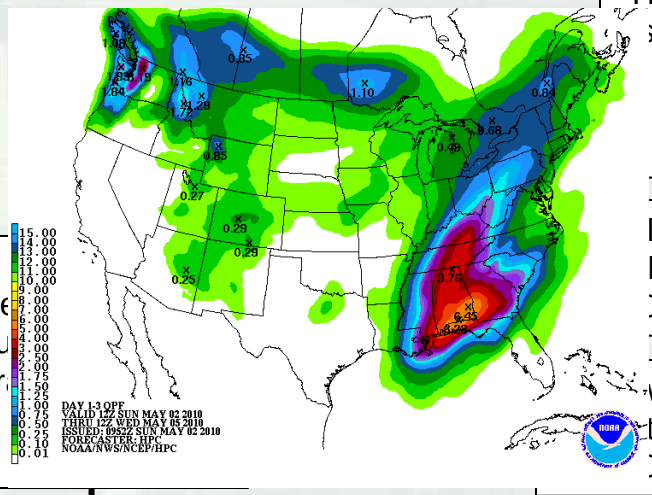
3-day QPF 0435

Start spillway discharges At Old Hickory 1200

3-

Nashville Water Management increased staff Cheatham goes to free flow 1900

Sunday- 2 May 2010



Start rapid spillway release increases at Old Hickory and start spillway release increases at Barkley 1000

le gauge
lood stage
)930

Paducah, KY WFO issues warning of large releases @ Barkley & Kentucky Dams

Old Hickory pool of record 451.45 1400

Center Hill & J. Percy Priest hydropower generation stopped Made first spillway reduction at Old Hickory 2100

Old Hickory gate opening 34 ft. 1700

Dale Hollow hydropower generation stopped 2300

NWS Forecasted Nashville Crest 45.0 on 5/2 @ 1900 1118

34.52 | 37.33 | 42.61 | 46.86 | 49.63

0000 | 0600 | 1200 | 1800 | 2400

3-day QPF 0452

NWS Forecasted Nashville
41.9 on 5/2
0950

NWS/USACE Coordination Conference Call @ 0830

Corps emergency manager sent to TEMA @ 1145

NWS/USACE Coordination Conference Call @ 1330

NWS Forecasted Nashville Crest 48.0 on 5/3 @ 0100 1619

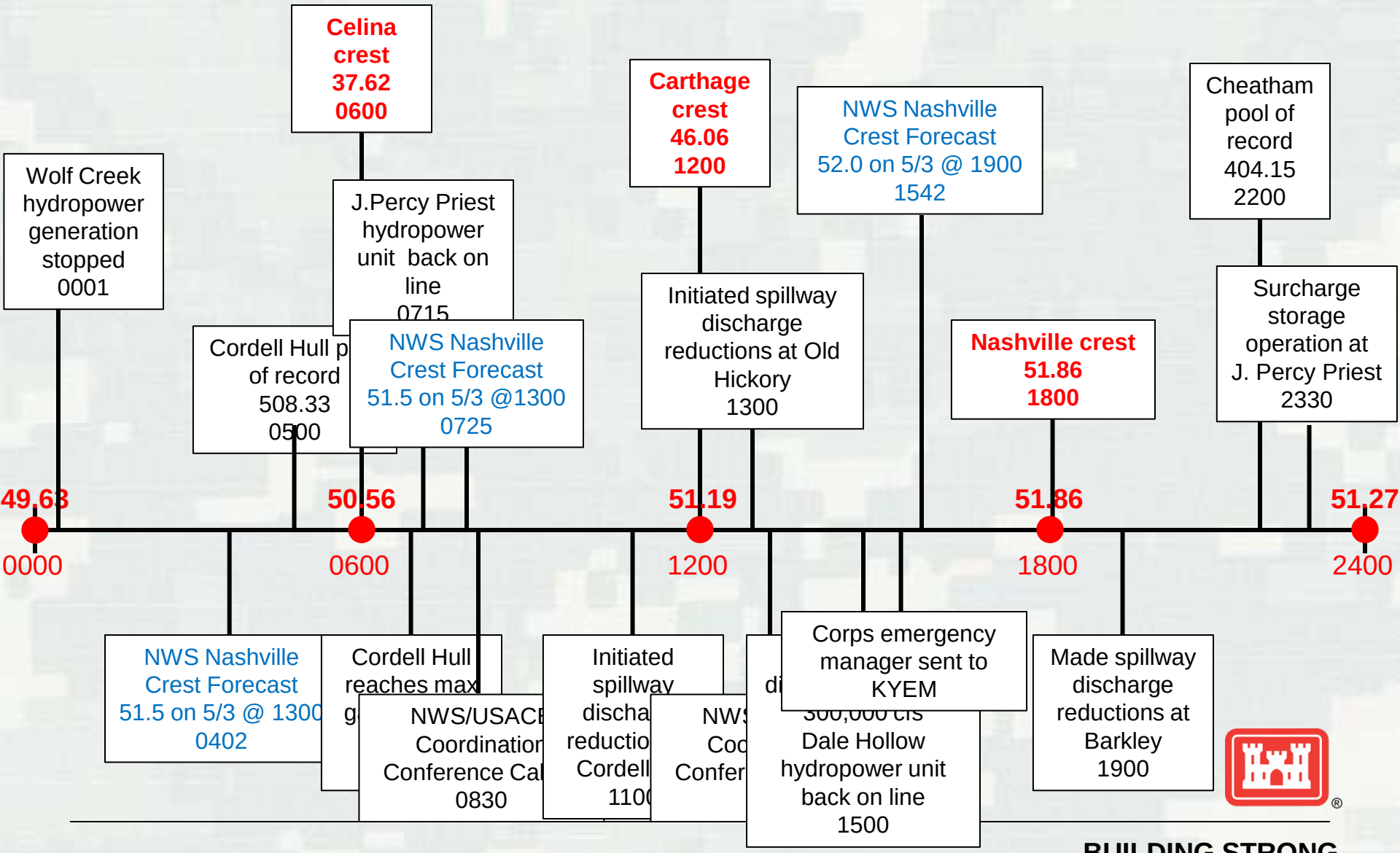
NWS Forec
Nashville Cre
48.0 on 5/3 @
1828

NWS Forecasted Nashville Crest 50.3 on 5/3 @ 1300 2200

Start rapid spillway release increases at Cordell Hull 2200

BUILD

Monday - 3 May 2010



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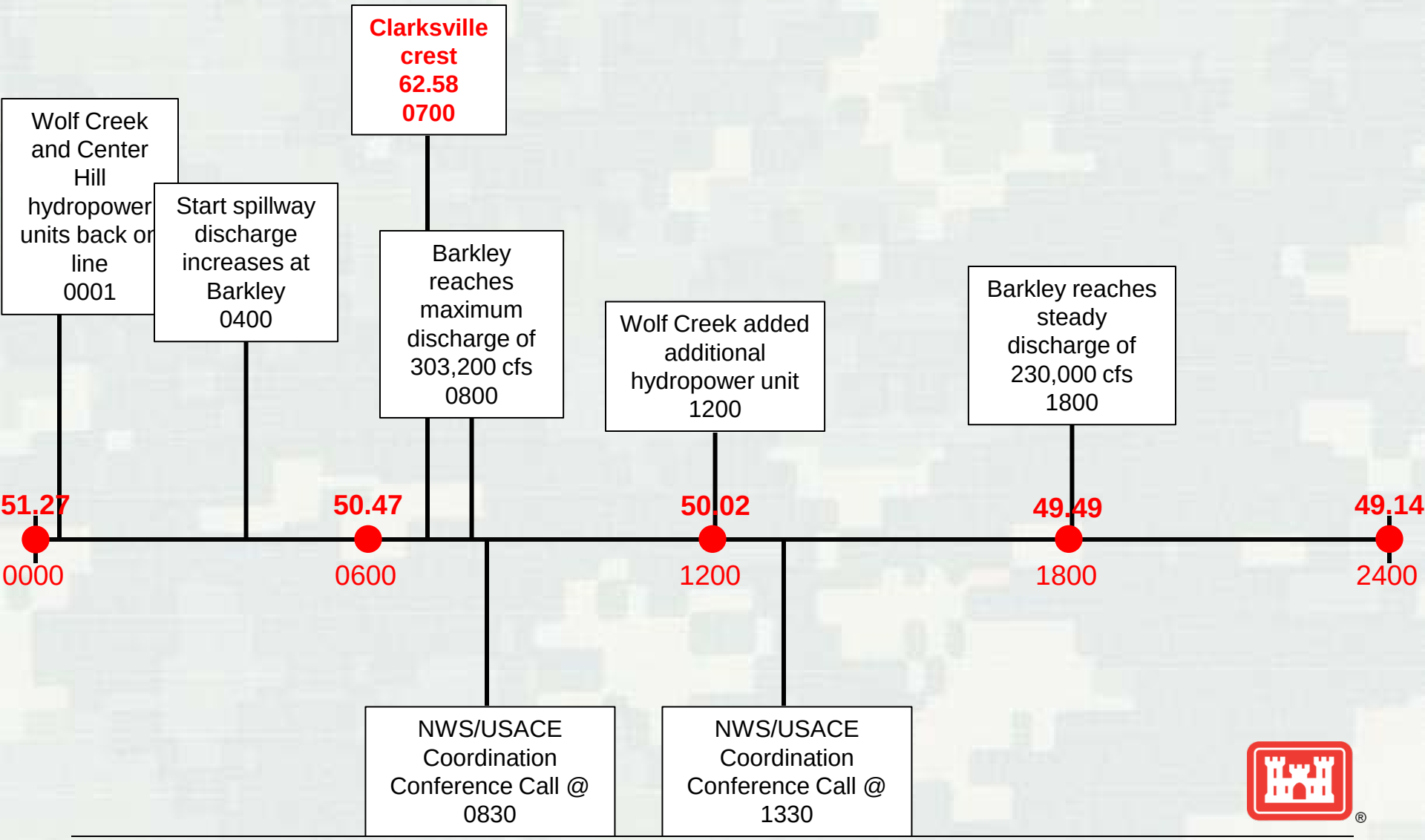
Tuesday- 4 May 2010



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Peak Stages and Discharges at Select Uncontrolled Streams

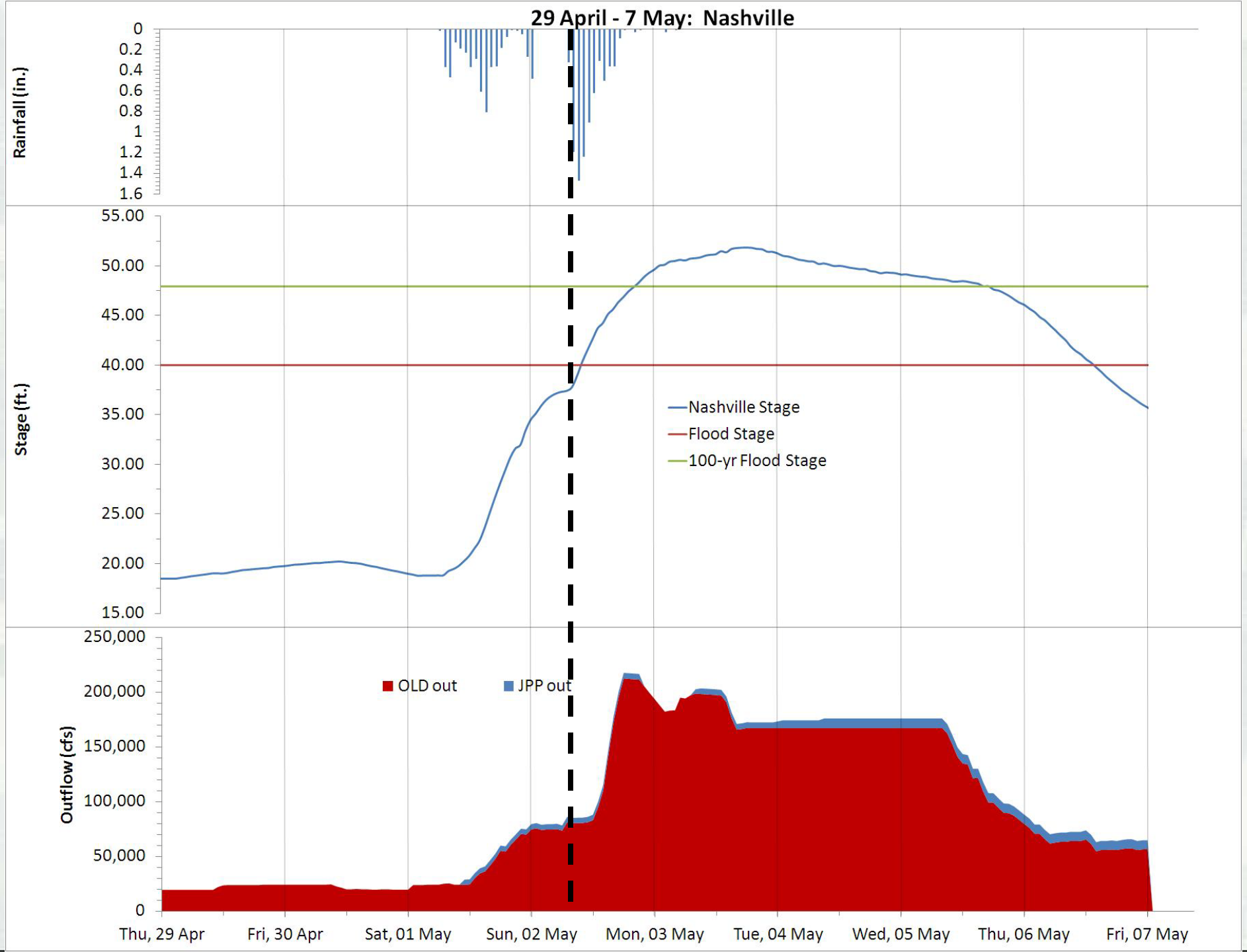
Steam Name	Gauge Name	Peak Stage (ft)	Flow (cfs)	Contributing Drainage Area (mi^2)
Smith Fork Creek	Temperance Hall, TN	26.86 (5/3 @ 0400)	21,020	214
Mill Creek	Woodbine, TN	21.37 (5/1 @ 2030)	28,600	64
Whites Creek	Bordeaux, TN	25.82 (5/2 @ 1130)	No Data	51
Richland Creek	Nashville, TN	19.99 (5/2 @ 1100)	No Data	24
East Fork Stones River	Lascassas, TN	32.38 (5/3 @ 0700)	22,517 (5/2)	262
Harpeth River	Kingston Springs, TN	No Data	49,500	681
Red River	Port Royal, TN	49.47 (5/3 @ 1000)	64,673	935

Water Stored During May 2010 Flood

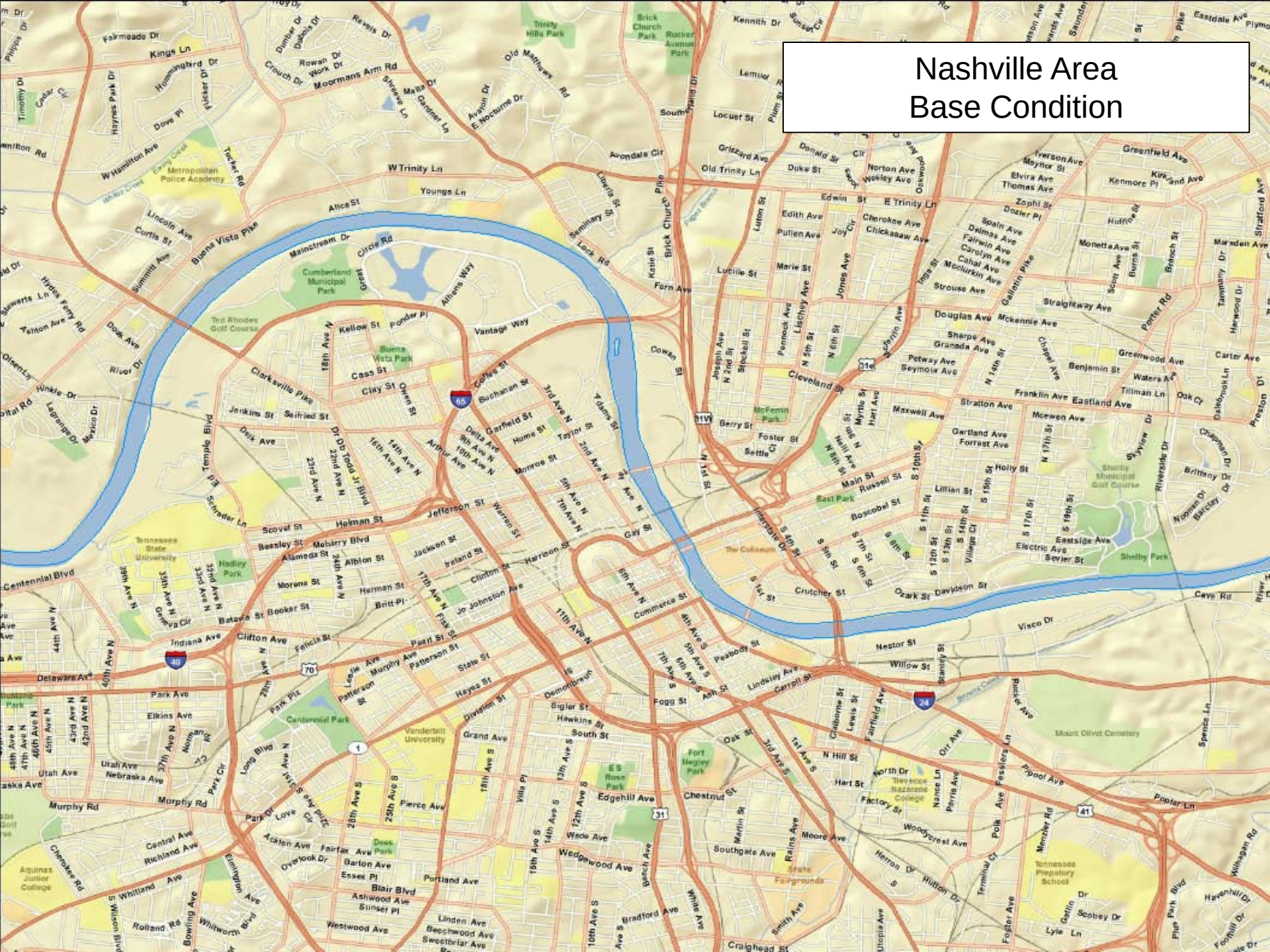
Project	Headwater (0600 Saturday)	Headwater Crest	Water Stored (acre-feet)
Wolf Creek[1]	**682.94**	**703.86**	**867,000**
Dale Hollow	**650.16**	**657.34**	**204,000**
Center Hill[1]	**630.44**	**646.76**	**279,000**
J. Percy Priest	**489.36**	**504.90**	**278,000**
Total			**1,628,000[2]**

[1] Wolf Creek and Center Hill Dams have been classified as DSAC 1 dams and are under pool restrictions to assure the stability of the dams.

[2] This volume of water is roughly equivalent to 530 trillion gallons of water or if stacked on a football field it would be over 1 million feet (207 miles) high.


29 April - 7 May: Nashville
Rainfall (in.)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Stage (ft.)
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
Nashville Stage
Flood Stage
100-yr Flood Stage
Outflow (cfs)
250,000
200,000
150,000
100,000
50,000
0
OLD out
JPP out
Thu, 29 Apr
Fri, 30 Apr
Sat, 01 May
Sun, 02 May
Mon, 03 May
Tue, 04 May
Wed, 05 May
Thu, 06 May
Fri, 07 May

Nashville Area
Base Condition



Peak Stage Inundation
May 2010 Flood

Cumberland Municipal Park
Ted Rhodes Golf Course
Buena Vista Park
Tennessee State University
Hadley Park
Centennial Park
Vanderbilt University
McPemin Park
East Park
Fort Negley Park
ES Rose Park
Dees Park
Shelby Park
Mount Olivet Cemetery
Trevecca Nazarene College
Tennessee Preparatory School
Aquinas Junior College
Metropolitan Police Academy
Trinity Hills Park
Brick Church Park
Rucker Avenue Park
Cumberland River
Interstate 65
Interstate 40
Interstate 24
Interstate 31
Interstate 41
Clarksville Pike
Buena Vista Pike
Jefferson St
Gallatin Pike
Nestor St
Visco Dr
Crutcher St
Davidson St
Oak St
Cleveland St
Franklin Ave
Eastland Ave
Douglas Ave
Mckennie Ave
Straightway Ave
Porter Rd
Greenwood Ave
Carter Ave
Benjamin St
Waters Ave
Tillman Ln
Oak Ct
Stratton Ave
Maxwell Ave
Mcewen Ave
Garland Ave
Forrest Ave
Holly St
Main St
Russell St
Boscobel St
Lillian St
Eastside Ave
Electric Ave
Sevier St
Gay St
Commerce St
Peabody St
Willow St
Lindsley Ave
Carroll St
Fogg St
Ash St
Chestnut St
Edgehill Ave
Wedgewood Ave
Wade Ave
Southgate Ave
Moore Ave
Woodycrest Ave
Hart St
Factory St
Pool Ave
Poplar Ln
Craighead St
Bradford Ave
Portland Ave
Blair Blvd
Ashwood Ave
Sunset Pl
Westwood Ave
Linden Ave
Beechwood Ave
Sweetbriar Ave
Murphy Rd
Utah Ave
Nebraska Ave
Indiana Ave
Clifton Ave
Delaware Ave
Park Ave
Elkins Ave
Centennial Blvd
Morena St
Hanman St
Britt Pl
Batavia St
Booker St
Jo Johnston Ave
Clinton St
Ireland St
Jackson St
Albion St
Alameda St
Beasley St
Mehlary Blvd
Scovel St
Helman St
Jenkins St
Seifried St
Desk Ave
Delta Ave
Garfield St
Hume St
Monroe St
Arthur Ave
Buchanan St
Coffee St
Clay St
Cass St
Kellow St
Ponder Pl
Vantage Way
Athens Way
Mainstream Dr
Circle Rd
Lock Rd
Seminary St
Fern Ave
Lucille St
Marie St
Edith Ave
Pullen Ave
Joy Cir
Cherokee Ave
Chickasaw Ave
Spain Ave
Delmas Ave
Fairwin Ave
Carolyn Ave
Cahal Ave
Mcclurkin Ave
Strouse Ave
Sharpe Ave
Granada Ave
Petway Ave
Seymour Ave
Cleveland St
Berry St
Foster St
Settle Ct
Lischey Ave
Pennock Ave
Jones Ave
Luton St
Lockert St
Katie St
Brick Church Pike
Donald St
Duke St
Norton Ave
Wesley Ave
Old Trinity Ln
Grizzard Ave
Avondale Cir
Locust St
Lemuel
Kenneth Dr
Sunset Cir
Greenfield Ave
Kenmore Pl
Elvira Ave
Thomas Ave
Zophi St
Dozier Pl
Huffine St
Monetta Ave
Scott Ave
Burns St
Branch St
Marsden Ave
Stratford Ave
Tammany Dr
Harwood Dr
Preston Dr
Chapman Dr
Brittany Dr
Noonan Dr
Barclay
Skyview Dr
Riverside Dr
Dalebrook Ln
Chapel Ave
N 14th St
N 17th St
S 10th St
S 15th St
S 17th St
S 19th St
S 12th St
S 13th St
S 14th St
S 11th St
S 8th St
S 7th St
S 6th St
S 5th St
S 4th St
Interstate Dr
Village Cir
Coliseum
Sixth Ave N
Fifth Ave N
Fisk Cir
Pearl St
Felicia St
Patterson St
State St
Hayes St
Division St
Demonbreun
Sigler St
Hawkins St
South St
Grand Ave
Oak St
3rd Ave S
1st Ave S
Orr Ave
Clayborne St
Lewis St
Fairfield Ave
Young Ave
Spence Ln
Fessler's Ln
Polk Ave
Nance Ln
Perrin Ave
Martin St
Rains Ave
Terminal Ct
Herron Dr
Hutton Dr
Smith Ave
Ulpia Ave
Foster Ave
Gatlin Dr
Scobey Dr
Lyle Ln
Havenhill Dr
Foothill Dr
Phillips Park Blvd
Spencer Ln
Mill Creek
Cedar Cir
Trimble Dr
Haynes Park Dr
Dove Pl
Fairmeade Dr
Kings Ln
Hummingbird Dr
Rowan Dr
Work Dr
Moormans Arm Rd
Crouch Dr
Dunbar Dr
Dabbs Dr
Revels Dr
Shreve Ln
Malta Dr
Gardner Ln
Avalon Dr
E Nocturne Dr
Old Matthews Rd
Lemuel
Plum St
Tucker Rd
Curtis St
Lincoln Ave
Summit Ave
Hydes Ferry Rd
Stewarts Ln
Tolson Ave
Dosk Ave
River Dr
Olsen Ln
Winkle Dr
Mexico Dr
Temple Blvd
Schrader Ln
Dr D D Todd Jr Blvd
Kirkland Ave
Meyhor St
Iverson Ave
Hamilton Ave
W Trinity Ln
Youngs Ln
Alice St
E Trinity Ln
Old Trinity Ln
Duke St
Edwin St
Dozier Pl
Spain Ave
Delmas Ave
Fairwin Ave
Carolyn Ave
Cahal Ave
Mcclurkin Ave
Strouse

Inundation if Control Lost at Old Hickory Lock & Dam

Kings Ln
Hummingbird Dr
Fairmeade Dr
Moormans Arm Rd
Trinity Hills Park
Brick Church Park
Rucker Avenue Park
Kennith Dr
Lemuel
Locust St
Old Trinity Ln
Avondale Cir
W Trinity Ln
Metropolitan Police Academy
Lincoln Ave
Curtis St
Buena Vista Pike
Summit Ave
Cumberland Municipal Park
Ted Rhodes Golf Course
Kellom St
Vantage Way
Clarksville Pike
Caas St
Clay St
Buchanan St
Garfield St
Hume St
Monroe St
Jefferson St
Scovel St
Helman St
Beasley St
Meharry Blvd
Alameda St
Albion St
Jackson St
Ireland St
Clinton St
Morena St
Hanman St
Britt Pl
Jo Johnston Ave
Batavia St
Booker St
Indiana Ave
Clifton Ave
Felicia St
Pearl St
State St
Hayes St
Division St
Sigler St
Hawkins St
South St
Grand Ave
Commerce St
Gay St
Peabody St
Lindsley Ave
Carroll St
Fogg St
Ash St
Oak St
Chestnut St
Edgehill Ave
Wade Ave
Wedgewood Ave
Pierce Ave
Murphy Rd
Park Ave
Elkins Ave
Centennial Blvd
Delaware Ave
Utah Ave
Nebraska Ave
Long Blvd
Park Dr
Love Cir
Central Ave
Richland Ave
Ackien Ave
Fairfax Ave
Overlook Dr
Barton Ave
Essex Pl
Blair Blvd
Ashwood Ave
Sunset Pl
Portland Ave
Westwood Ave
Linden Ave
Beechwood Ave
Sweetbriar Ave
Rolland Rd
Whitworth Blvd
Whitland Ave
Bowling Ave
Elmington Ave
Cherokee Rd
Aquinas Junior College
Tennessee State University
Hadley Park
Centennial Park
Vanderbilt University
ES Rose Park
Fort Negley Park
Dees Park
Trevecca Nazarene College
State Fairgrounds
Tennessee Preparatory School
Mount Olivet Cemetery
McPemin Park
East Park
Cleveland St
Berry St
Foster St
Settle Ct
Douglas Ave
Mckennie Ave
Sharpe Ave
Granada Ave
Petway Ave
Seymour Ave
Maxwell Ave
Stratton Ave
Franklin Ave
Eastland Ave
Mcewen Ave
Garland Ave
Forrest Ave
Main St
Russell St
Boscobel St
Lillian St
Holly St
Davidson St
Electric Ave
Sevier St
Eastside Ave
Greenwood Ave
Benjamin St
Waters Ave
Tillman Ln
Oak Ct
Carter Ave
Greenfield Ave
Kenmore Pl
Kirkland Ave
Zophi St
Dozier Pl
Huffine St
Monetta Ave
Marsden Ave
Stratford Ave
Straightway Ave
Porter Rd
Tammany Dr
Harwood Dr
Spain Ave
Delmas Ave
Fairwin Ave
Carolyn Ave
Cahal Ave
Mcclurkin Ave
Strouse Ave
Gallatin Pike
Edwin St
E Trinity Ln
Cherokee Ave
Chickasaw Ave
Edith Ave
Pullen Ave
Marie St
Lucille St
Fern Ave
Jones Ave
Lischey Ave
Pennock Ave
N 5th St
N 6th St
N 14th St
Chapel Ave
Myrtle St
Hart Ave
Neill Ave
N 17th St
S 10th St
S 11th St
S 12th St
S 13th St
S 14th St
S 15th St
S 17th St
S 19th St
S 4th St
S 5th St
S 6th St
S 7th St
S 8th St
Skyview Dr
Riverside Dr
Britney Dr
Chapman Dr
Nopman Dr
Barclay
Preston Dr
Dalebrook Ln
Tennessee Municipal Golf Course
Shelby Park
Cruthers
Hector St
Willow St
Mt Olivet Cemetery
Spence Ln
Poplar Ln
Popoll Ave
Feeslers Ln
Polk Ave
Menzler Rd
Woodycrest Ave
Moore Ave
Southgate Ave
Rains Ave
Martin St
Terminal Ct
Hutton Dr
Herron Dr
Factory St
Hart St
Nance Ln
Perrin Ave
Clayborne St
Lewis St
Orr Ave
Craighead St
Bradford Ave
White Ave
Smith Ave
Utopia Ave
Foster Ave
Gatlin Dr
Scobey Dr
Lyle Ln
Havenhill Dr
Foothill Dr
Phillips Park Blvd
Phillips Dr
Cedar Cir
Haynes Park Dr
Dove Pl
Tucker Rd
Hamilton Ave
Hyde Ferry Rd
Stewarts Ln
Nelson Ave
Doak Ave
River Dr
Olsen Ln
Winkle Dr
Dr Q D Todd Jr Blvd
Desk Ave
Jenkins St
Seifried St
Trader Ln
Tennessee Blvd
Geneva Cir
Dunbar Dr
Dabbs Dr
Revels Dr
Rowan Dr
Work Dr
Crouch Dr
Shreve Ln
Malta Dr
Gardner Ln
Avalon Dr
E Nocturne Dr
Old Matthews Rd
Lebanon Pike
Seminary St
Katie Brace
Fort Negley
Brace St
Donald St
Grizzard Ave
Duke St
Norton Ave
Wesley Ave
Oakwood
Iverson Ave
Mayhor St
Elvira Ave
Thomas Ave
Lutton St
Joy Cir
Inman St
Burns St
Branch St
Scott Ave
Gallatin Pike
Cleveland St
Berry St
Foster St
Settle Ct
Interstate Dr
Cumberland River
Shelby Park
Hector St
Willow St
Davidson St
Eastside Ave
Electric Ave
Sevier St
Lillian St
Holly St
Main St
Russell St
Boscobel St
Stratton Ave
Franklin Ave
Eastland Ave
Mcewen Ave
Garland Ave
Forrest Ave
Douglas Ave
Mckennie Ave
Straightway Ave
Greenwood Ave
Benjamin St
Waters Ave
Tillman Ln
Oak Ct
Carter Ave
Greenfield Ave
Kenmore Pl
Kirkland Ave
Zophi St
Dozier Pl
Huffine St
Monetta Ave
Marsden Ave
Stratford

Inundation Without Dams
Natural Flow Computations

Peak Stage Inundation
May 2010 Flood

Unprecedented Event

- Rainfall
  - Greater than 1:1,000 year event over large area
  - More than double previous 2-day total for Nashville
  - Produced a flash flood on a major river
- Science pushed to the limit
  - Rainfall forecasts
  - Hydrology and hydraulic modeling
- Reservoir system pushed to the limit
  - Record lake levels at several Cumberland River projects
  - Record project discharges
  - Record flood crest for regulated system
    - Nashville - 51.86
    - Clarksville – 62.58
- Lessons Learned
  - NWS – Service Assessment
  - Corps of Engineers – After Action Review