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IN THE SUPREME COURT OF PENNSYLVANIA

LEAGUE OF WOMEN VOTERS OF PENNSYLVANIA, *et al.*,	:	
Petitioners,	:	
v.	:	Docket No. 159 MM 2017
THE COMMONWEALTH OF PENNSYLVANIA, *et al.*,	:	
Respondents.	:	

STATEMENT OF RESPONDENT THOMAS W. WOLF IN SUPPORT OF HIS PROPOSED REMEDIAL CONGRESSIONAL MAP PURSUANT TO COURT'S ORDERS OF JANUARY 22 AND JANUARY 26, 2018

TABLE OF CONTENTS

TABLE OF AUTHORITIES

Page(s)

Cases

Other Authorities

INTRODUCTION

On January 22, 2018, this Court found that Pennsylvania's Congressional Redistricting Act of 2011 (the "2011 Plan") "clearly, plainly and palpably violates the Constitution of the Commonwealth of Pennsylvania." The Court gave the Pennsylvania General Assembly an opportunity to remedy this constitutional violation and provided it with clear criteria for drafting a new congressional districting map and ample time to draft and adopt such a map. The General Assembly squandered this opportunity, failing to submit a map. Instead, two individual Respondents, Speaker Michael C. Turzai and President Pro Tempore Joseph B. Scarnati, III ("Legislative Respondents"), put their own map before the Court.

Because the legislature cannot or will not remedy the constitutional violation it created when it enacted the sharply partisan 2011 Plan, the Court must act quickly to adopt a new congressional districting map. Governor Wolf thus submits a proposed map ("Governor's Map"), which is attached as Exhibit A and has been submitted to the Court electronically. The Governor's Map is constitutional, fair, and evenhanded, and complies in every respect with this Court's Order. Governor Wolf therefore respectfully asks the Court to adopt the Governor's Map.

STATEMENT OF THE CASE

At the five-day non-jury trial held in the Commonwealth Court in December 2017, Petitioners demonstrated that Pennsylvania's oddly shaped congressional districts are the products of a deliberate effort to minimize the value of votes for Democratic congressional candidates and maximize the number of congressional seats held by Republicans. (*See* COL at 124-25, ¶¶ 51, 58 ("partisan considerations are evident" in the 2011 Plan; the 2011 Plan was "intentionally drawn so as to grant Republican candidates an advantage in certain districts within the Commonwealth"; and the 2011 Plan "overall favors Republican Party candidates in certain congressional districts.").) Nonetheless, the Commonwealth Court held that Petitioners had failed to make out a claim because, *inter alia*, they had not "articulated a judicially manageable standard" for identifying unconstitutional partisan gerrymandering. (*Id*. at 126-27 ¶ 61.)

This Court immediately ordered briefing and heard oral argument. Notably, at oral argument, Legislative Respondents' counsel represented that the General Assembly "would like at least three weeks" to draw a new map. (*See* Oral Argument, January 17, 2018 (Torchinsky) at 1:46:05.)[1] On January 22, 2018, the Court issued a *per curiam* order (the "Order"), holding that the 2011 Plan "clearly,

[1] Legislative Respondents' co-counsel suggested the General Assembly "need[s] a month" – only slightly more time than the Court allotted. (*See* Oral Argument, January 17, 2018 (Braden) at 2:12:45.)

plainly and palpably violates the Constitution of the Commonwealth of Pennsylvania," striking it as unconstitutional, and enjoining its use in the May 2018 primary elections. (Order at Paragraph "First".) The Order stated that "should the Pennsylvania General Assembly choose to submit a congressional districting plan that satisfies the requirements of the Pennsylvania Constitution, it shall submit such plan for consideration by the Governor on or before February 9, 2018" – 18 days from the date of the Order. (*Id.*)[2] "[S]hould the General Assembly not submit a congressional districting plan on or before February 9, 2018," the Order continued, this Court would "proceed expeditiously to adopt a plan." (*Id.*)

The Order explained: "to comply with this Order, any congressional districting plan shall consist of congressional districts composed of compact and contiguous territory; as nearly equal in population as practicable; and which do not divide any county, city, incorporated town, borough, township, or ward, except where necessary to ensure equality of population." (*Id.* at "Fourth".)

The Court followed this Order by issuing an opinion on February 7 (the "Opinion") that reiterated the Order's criteria and stated that "nothing in this

[2] The General Assembly moved the 2011 Plan through the legislative process within eight days. (*See* FOF ¶¶ 100-109, 112-117, 121.)

Opinion is intended to conflict with, or in any way alter, the mandate set forth in our Order of January 22, 2018." (Op. at 4, 123.)

On January 26, 2018, Legislative Respondents sought an emergency stay of this Court's Order in the United States Supreme Court. On February 5, 2018, Justice Alito denied this request. Finally, on February 9, 2018, without legislation, the Legislative Respondents submitted a map and brief to this Court.

ARGUMENT

I. The Governor's Proposed Map Is Fair, Constitutional, and Respects the Criteria Set Forth by the Court.

A. The Governor's Map Respects Traditional Districting Principles

As this Court made clear, there exist "certain neutral criteria" that have been "traditionally utilized to guide the formation of legislative districts." (Op. at 119.) These standards "place the greatest emphasis on creating representational districts that both maintain the geographical and social cohesion of the communities in which people live and conduct the majority of their day-to-day affairs." (*Id*.) A paramount concern to the framers of the Commonwealth's Constitution was preventing the dilution of anyone's vote. (*Id.* at 119-20.) To safeguard against this "pernicious prospect" our framers imposed the important safeguards of geographical contiguity of political subdivisions and barring the splitting of these subdivisions to create legislative districts. (*Id*.) From this, certain requirements were imposed: "(1) the population of such districts must be equal, to the extent

possible; (2) the district that is created must be comprised of compact and contiguous geographical territory; and (3) the district respects the boundaries of existing political subdivisions contained therein, such that the district divides as few of those subdivisions as possible." (*Id.* at 120-21.)

This Court found these principles to be "deeply rooted in the organic law of our Commonwealth" and that they "continue to be the foundational requirements which state legislative districts must meet under the Pennsylvania Constitution." (*Id.* at 121.) This Court, therefore, had no trouble in finding these "neutral benchmarks to be particularly suitable as a measure in assessing whether a congressional districting plan dilutes the potency of an individual's ability to select the congressional representative of his or her choice." (*Id.*) Because, when "an individual is grouped with other members of his or her community in a congressional district for purposes of voting, the commonality of the interests with the other voters in the community increases the ability of the individuals to elect a congressional representative for the district who reflects his or her personal preferences." (*Id.* at 122.)

In the end, to pass constitutional muster under the Pennsylvania Free and Equal Elections Clause, congressional districts in this Commonwealth must be "composed of a compact and contiguous territory; as nearly equal in population as practicable; and which do not divide any county, city, incorporated town, borough,

township, or ward, except where necessary to ensure quality of population." (*Id.* at 123.) Applying these organic and foundational principles, the Governor's Map easily passes constitutional muster.

- CD 1—Schuylkill West (Philadelphia/Delaware): District 1 connects West Philadelphia with similar municipalities of Chester City, Sharon Hill, Ridley Park, and Darby. Much of the district is connected by Interstate 95 and routes 291 and 420. SEPTA's 69th Street Terminal in Upper Darby serves the district, along with the Airport Line, Wilmington/Newark Line, and the Media/Elwyn Line. This is an Opportunity District (in other words, Black and Latino voters make up the majority of voters in the district).

- CD 2—Schuylkill East (Philadelphia): District 2 keeps intact the communities of Northwest Philadelphia, North Philadelphia, Center City, and South Philadelphia. SEPTA connects the district through multiple bus and train lines (including the Broad Street Line and Market-Frankford Line). Interstate 95 runs up the district. This is an Opportunity District (in other words, Black and Latino voters make up the majority of voters in the district). This district does not intentionally "pack" African American voters into this one singular Philadelphia district.

- CD 3—The Northwest Corner: District 3 includes Erie and the surrounding counties. For the western tip of Pennsylvania, manufacturing, retail trade, and healthcare and social assistance are the largest industry employers across all six counties. From shipping ports and vineyards to hiking and biking trails, the northern I-79 corridor of the Lake Erie region that borders Ohio and New York includes counties that are designated transitional as their economic status. District 3 includes Erie, along with other third-class cities, including Meadville, Sharon, and Titusville. Unlike other maps, this map keeps Erie County intact and builds the district along the Ohio and New York borders (keeping a distinct Northwestern PA regional district), instead of pulling in counties from central Pennsylvania.

- CD 4—The 83 Corridor: Close to the Maryland border and rich with Pennsylvania history, District 4 is proximate to several interstates, making it a busy corridor for the trucking industry, commuters, and visitors to central Pennsylvania. In fact, these three counties are connected via interstates 81, I-83, I-76 and US 11/15, creating ease of travel between counties, cities, boroughs, and townships. Residents of Cumberland, Adams and York counties are also united by a sense of southern Pennsylvania pride, good K-12 schools and top-rated public and private colleges and universities, such as Dickinson College, Gettysburg College, York College, Central Penn College, and Penn State York. Many I-83 corridor residents commute to Harrisburg for work, including many commonwealth employees. This region boasts farmland, state parks, ski resorts, and seasonal festivals, as well as a variety of industries from health care and retail to technology, and manufacturing.

- CD 5—Pennsylvania Wilds: District 5 joins some of the most rural communities in Pennsylvania and is known for its tourism and outdoor assets, including the largest free-roaming elk herd in the northeastern United States, the darkest skies on the East Coast, and several state parks and outdoor recreational opportunities. This region includes all of Potter, McKean, Cameron, Clinton, Elk, Forest, Venango, Clarion, Butler, Armstrong, Jefferson, Clearfield, and part of Centre counties. District 5 is a rural district that also includes seven of the region's third-class cities - Lock Haven, Bradford, DuBois, Franklin, Oil City, Parker City, and St. Marys.

- CD 6—Keystone: District 6 encompasses the entirety of Chester County and parts of southern Berks and western Delaware Counties. The suburban Philadelphia communities it encompasses are very similar economically, demographically, and culturally. This shared identity makes a compact district that includes all of Chester County logical. This district is home to some of the top performing school districts statewide and nationally. Western Delaware County is very similar, and includes communities that fall along Rt. 1/Rt. 202, which creates regional continuity. The 2011 map siphons off

communities within Chester and Western Delaware Counties to create partisan advantage, and is considered one of the most gerrymandered districts in the nation.

- CD 7—Montgomery County: District 7 includes almost all of Montgomery County. The size of the county requires a split—Montgomery County's population is too large to have a single congressional district. Montgomery County is one of fastest growing counties in Pennsylvania. It includes cities and towns with similarities in size or governance including Lower Merion, Abington, Cheltenham, Norristown, Upper Dublin, Horsham, and Lower Providence. Many of the residents commute to Philadelphia or one of the business parks in King of Prussia, Lansdale, Blue Bell, Horsham or Fort Washington. The county includes a higher concentration of those employed in Professional and Technical Services compared to the commonwealth. This is a stark contrast to the 2011 map and the Joint Submission which unnecessarily splice Montgomery County into four separate districts.

- CD 8—Greater Bucks County: District 8 includes all communities of Bucks County outside of those immediately adjacent to Philadelphia and connects them with similar communities on the southern borders of both Lehigh and Northampton Counties. These communities are close to New Jersey and include many similar economic traits, such as a density of trucking, shipping, and logistics companies.

- CD 9—Greater Johnstown Altoona: District 9 unifies Johnstown and Altoona, two communities with deep historical and economic ties, which have been split since the 2011 maps were put in place. It brings this region together with similar smaller metropolitan areas of third class cities like Indiana, McConnellsburg, Huntingdon, and Chambersburg in southcentral Pennsylvania. This area shares interests in tourism, resource development, and a tradition of manufacturing.

- CD 10—Coal Country: In District 10, the discovery of natural gas in the Marcellus formation has provided an economic boost over the past decade in a region which was historically powered

by anthracite coal. Energy production unites this region that spans the northeast portion of the state, bordering New York state. Shale production has brought new residents to the area, as well as economic growth beyond energy – housing and retail included. Coal Country is one of the most rural and heavily forested parts of the northeastern United States, and one of the least densely populated.

- CD 11—The Mid-State: Known as the Susquehanna Valley, District 11 unites the Capital region to include Harrisburg and the West Shore of the Susquehanna River, which have similar political interests, thus keeping "neighbors" and communities of interest together. The district boasts many small towns, and both public and private colleges and universities, and major health care centers like Penn State Hershey and Geisinger Medical Center in Danville. In addition to state government, this district is home to various industries, including candy and confection giant The Hershey Company, and smaller manufacturers in the northern portion of the district. Many residents of this district are commuters; people live and work throughout these counties, and cross the Susquehanna River for shopping and entertainment.

- CD 12—Turnpike West: District 12 groups portions of the Pittsburgh Metropolitan Area into one district. The economy of this district was traditionally driven by resource extraction but has transitioned towards outdoor recreation with the Laurel Highlands and the Great Allegheny Passage Trail helping to drive tourism to the area. Unlike the prior version, this map unifies the Westmoreland County community, as opposed to dividing it into two districts. It no longer blatantly isolates Westmoreland County from its third-largest city, New Kensington. After more than 25 years, this map reunites the southern portion of Somerset County with its county seat, Somerset, Pennsylvania.

- CD 13—Greater Northeast Philadelphia: District 13 includes Northeast Philadelphia and the dense suburban communities in lower Montgomery County and lower Bucks County. Interstate 95 runs along the side of the district, and many residents are

served by multiple SEPTA lines, including Market-Frankford and Trenton lines. These communities share transportation services through SEPTA and health services through Aria Hospital System, which serves the city and counties.

- CD 14—Pittsburgh: District 14 is centered on the City of Pittsburgh and connects it with much of the immediate suburbs. The district extends eastward to communities along the Parkway East and south into the upper Mon Valley. These communities share significant interests economically, including an evolving technology sector and strong educational and medical institutions.

- CD 15—Reading-Lehigh Valley: District 15 combines the region's four third-class cities of Allentown, Bethlehem, Easton, and Reading, with their shared heritage of manufacturing and common interests, into one district. This map recognizes the communities are similar in economies and histories and should be together. The district is more compact than the current map, which meanders from Allentown to the Harrisburg suburbs.

- CD 16—South Central: District 16 includes all of Lancaster County and neighboring portions of Lebanon and Berks counties. This district shares a rich agricultural heritage and identity, even as the district's economy modernizes increasingly towards manufacturing and logistics. The separation from Chester County makes sense because the South Central region is both culturally and geographically distinct from Chester County, where a large section of the county was coupled with the seventh district in the 2011 map.

- CD 17—Northeast Corner (Scranton-Wilkes-Barre): District 17 includes all of Wayne, Pike, Monroe, and Lackawanna counties, and part of Luzerne County. It unites the Wilkes-Barre, Scranton, and Stroudsburg regions, which have previously been divided into multiple districts. These communities, along with Nanticoke, Pittston, and Carbondale, share cultural and geographical similarities as part of the Pocono Mountain region. The outdoors and recreation are

central to this district's way of life, with many state parks, forests, and game lands within the region. The district is a fast-growing home to many bedroom communities for New York City, and some parts are included in the metropolitan area. For this reason, Pike and Monroe counties are some of the fastest growing populations in the state. Creating a compact and contiguous district for this region allows for cultural continuity, whereas the 2011 map includes these areas and extends all the way to southwestern Mifflin County, a nearly five-hour drive, and drastically different demographic makeup.

- CD 18—Southwest Corner: District 18 combines the major energy-producing counties of Fayette, Greene, Washington and part of Allegheny into one compact district in the southwest with their shared industries of gas exploration and mining. The district unites businesses and families of the Mon Valley communities—communities with common interests and history—and is more compact than the current map, which excludes Fayette County.

In sum, the Governor's Map respects and upholds the constitutional roots of the criteria set forth in the Court's Order. The Governor's Map minimizes the total number of county splits.[3] The Map's lines are rational, rather than meandering hither and yon. The districts seek to keep communities together, rather than lasso around them or cut them apart. Traditionally linked communities are kept intact—for example, Allentown, Reading, Easton, and Bethlehem are in the same district. Wilkes-Barre and Scranton are as well. And, so, too, is Harrisburg and its West

[3] Virtually every "split" was made to keep communities of interest in the same congressional district. The splits in the Fifth (Tioga County) and the Eleventh (Mifflin County) were necessary to preserve the numeric equality of each district.

Shore suburbs. Philadelphia County's natural boundary—the Schuylkill River—provides the demarcation of those districts. Bedford-Altoona-Johnstown are in a district together and Pittsburgh is a district. Erie County remains whole and that district borders the Ohio border and the sparsely populated areas of the Woodlands are together in a single congressional district. York, Adams, and most of Cumberland County (tied together by I-81 and I-83) are in a district together and Pennsylvania Dutch Country (Lancaster and much of Lebanon and Berks) is as well. The Tenth District encompasses what has traditionally (and more recently) been Pennsylvania's energy producing region—from anthracite coal to natural gas. And Montgomery County remains virtually its own district.

B. Statistical Analysis Underscores the Key Attributes of the Governor's Map.

1. Splits of Political Subdivisions

(a) **County Splits.** The Governor's Map splits 16 districts. Thirteen of these are split two ways, and three are split three ways. See Ex. C, Duchin Report at 15.

(b) **Municipality Splits.** The Governor's Map splits 14 municipalities; 5 of these splits are due to the fact that the municipalities themselves cross county lines. See Ex. C, Duchin Report at 16.

(c) **Precinct Splits.** See Ex. C, Duchin Report at 16-17.

2. Compactness Scores

Compactness scores are set forth at Page 14 of Ex. C, Duchin Report.

C. Mathematical Analysis Demonstrates That the Governor's Map, in Contrast to Legislative Respondents' Map, Gives Pennsylvania Voters a Fair and Unbiased Opportunity to Participate in Congressional Elections.

In order to assess potential remedial districting maps, Governor Wolf retained a nonpartisan expert: Moon Duchin of Tufts University, a renowned mathematician and redistricting expert. *See* Duchin Curriculum Vitae, attached as Exhibit B. As described in her Report, attached as Exhibit C, Dr. Duchin was initially asked to use best practices from mathematics and statistics to assess whether potential maps were extreme outliers along partisan lines. Dr. Duchin used procedures called "Markov chains" to build ensembles of potential maps comparable to the maps she analyzed. *See* Ex. C at 2 (explaining Markov chain process). For each map that she assessed, Dr. Duchin produced ensembles of a billion or more maps based on the traditional districting principles set forth in this Court's January 22 Order: respect for political boundaries, compactness, and population parity, as well as the principle of zero population deviation. *Id.* Dr. Duchin then assessed the subject map against the enormous collection of maps in the ensemble that she had created, using two measures of partisan skew: the mean-median score and the efficiency gap. *Id.* at 3. The more skewed a map is in comparison to its ensemble, the more likely that the mapmakers deliberately skewed the map to achieve partisan ends.

Dr. Duchin's analysis showed that the Legislative Respondents' Map was an extreme outlier in terms of partisan skew. She produced over three billion maps similar to the Legislative Respondents' Map that were at least as compact and preserved at least as many counties as the Legislative Respondents' Map, keeping population deviation within a 1% threshold. The fraction of maps in this sample that were more Republican-skewed than the Legislative Respondents' Map was less than one in 3.4 million. Dr. Duchin concluded there is less than a 0.1% chance that the Turzai-Scarnati plan was drawn in a non-partisan way. *Id.* at 1.

Dr. Duchin performed a similar analysis of the Governor's Map.[4] In sharp contrast to the Legislative Respondents' Map, the Governor's Map exhibited no partisan skew in comparison to its ensemble. It displayed all the characteristics of what it, in fact, is: a plan drawn with the sole goal of respecting the tenets of traditional redistricting criteria. *Id.* at 7 (Governor's Map "falls squarely within the ensemble of similar plans created using nonpartisan criteria, which gives no reason at all to believe that it was drawn with Democratic-favoring partisan intent."). The images included in Dr. Duchin's report put the contrast between the fair approach of the Governor's map and the skewed approach of the 2011 Plan and the Legislative Respondents' Map into sharp focus. The Governor's Map falls well

[4] Dr. Duchin did not participate in creating the Governor's Map, and developed her tests before she received the Governor's Map.

within the ensemble of similar maps using both the mean-median and efficiency gap tests. The 2011 Plan and the Legislative Respondents' Map, on the other hand, fall far outside the collection of billions of maps in their ensembles. *Id.* at 5-6.

II. This Court Has the Authority – and, Indeed, the Responsibility – to Adopt a Remedial Map.

A. The General Assembly, Given Ample Opportunity to Draw a Constitutional Map, Has Failed to Do So.

Legislative Respondents claim that compliance with this Court's order to draw a constitutional map was "impossible." (LR Br. 6.) But their position rests on the fallacy that Legislative Respondents' time to comply with the Order did not begin to run until the Court had, in effect, justified its order with a written opinion. (*Id.* 7-8.) Legislative Respondents' interpretation of events is contradicted by the plain language of this Court's Order and by the actions of Legislative Respondents themselves. The map submitted by Legislative Respondents does not comply with the Court's Order or the Pennsylvania Constitution and must be rejected.

1. Legislative Respondents Had the Information They Needed to Draw a Constitutional Map On January 22.

The January 22 Order provided Legislative Respondents with all the information they needed to comply with this Court's ruling. Specifically, the Order set forth clear, familiar criteria for redrawing the map, specifying that "*to comply with this Order*, any congressional districting plan shall consist of: congressional districts composed of compact and contiguous territory; as nearly

equal in population as practicable; and which do not divide any county, city, incorporated town, borough, township, or ward, except where necessary to ensure equality of population." *See* Order at Paragraph "Fourth" (emphasis added). These traditional districting principles have "deep roots in Pennsylvania constitutional law," *Holt v. 2011 Legislative Reapportionment Comm'n*, 38 A.3d 711, 745 (Pa. 2012), and have been used by this Court to evaluate congressional districting maps. *See Mellow*, 607 A.2d at 215. They are also widely recognized by courts, both state and federal, considering challenges to congressional redistricting plans. *See, e.g.*, *Shaw v. Reno*, 509 U.S. 630 (1993); *Vieth v. Jubelirer*, 541 U.S. 267 (2004); *see also Legislature v. Reinecke*, 516 P.2d 6 (Cal. 1973). Indeed, at oral argument, Legislative Respondents assured this Court that they were well aware of these traditional districting principles and how to apply them. *See* Jan. 17, 2018 Oral Argument (Torchinsky) at 1:32:15.

The Court's Opinion did not change any of these criteria. To the contrary, it repeated the wording of the Order verbatim and "emphasize[d] that, while explicating our rationale, nothing in this Opinion is intended to conflict with, or in any way alter, the mandate set forth in our Order of January 22, 2018." Op. at 4; *see also id.* at 123. The General Assembly was fully capable of applying the criteria set forth by the Court in its Order to any new map that they drafted:

Legislative Respondents were well aware of these criteria before the Opinion was issued.

2. Legislative Respondents Were Capable of Enacting a Map in the Time Allotted.

Based upon Legislative Respondents' admissions at oral argument to this Court and the General Assembly's history, three weeks was a reasonable amount of time to draft and vote on a remedial map.

Legislative Respondents suggest to this Court that legislating is such a slow process that the General Assembly could never have hoped to vote on a remedial map in the time allowed. (*See* LR Br. at 6-8.) Legislative Respondents, however, have the power, and remain empowered, to suspend all the rules that they describe and to speed legislation along; indeed, they used some of these powers to enact the 2011 Plan in a matter of days. First, for example, although the Pennsylvania House and Senate traditionally sit only three days a week, the majority leaders of each chamber have the power to schedule extra sessions on any weekday or weekend, and frequently do so. Pa. Const. art. III, § 4. Second, each chamber of the General Assembly has the power, and may on a two-thirds vote, suspend any and all of the rules set forth in Legislative Respondents' Brief. House Rule 77, para. 1. Indeed, the General Assembly took advantage of this option in 2011 while considering the 2011 Plan. (*See* FOF ¶¶ 126(c)-(d).) Finally, the General Assembly can hasten consideration of legislation by using the "shell bill"

mechanism, in which a bill with dummy language is introduced and moved through several procedural stages, and then amended to incorporate the intended language. This mechanism, like the rules suspension mechanism, was used to speed passage of the 2001 and 2011 Plans. (*See* FOF ¶¶100-106; *see also* Senate Bill 1249, Printer's Number 1520 (2011).)

The Legislative Defendants failed to use any of these tools to expedite consideration of a remedial map. In fact, the General Assembly did create a "shell bill" and moved it through the legislative process. This process started in the Senate on January 29, 2018, when the chamber as introduced Senate Bill 1034, P.N. 1441. *See* Pa. Gen. Assemb. S.B. 1034 Reg. Sess. 2017-2018 (2018). The Senate considered the measure on January 29 and 30 and approved it on final passage on January 31. *Id*. The bill then moved to the House of Representatives, where it was reported to the State Government Committee on February 1, and reported out of committee and given first consideration on February 6. *Id.* At no point did Legislative Defendants incorporate their map into the "shell bill," or permit the General Assembly to vote on their map.

Of course, had they done so, the bill could have been subject to second and third consideration in the House, and passed the Senate – a process that would have taken a maximum of three session days. Instead, however, the "shell bill" process came to a halt. Legislative Respondents did not schedule additional session days

or attempt to put their map to a vote after submitting it to the Court. The House held no session days after February 6, despite the fact that it had two more days, February 8 and 9, where it could have done so. Similarly, the Senate did not hold session on either of these days. As a result, rather than engaging in this process, which is entrusted to them under the Pennsylvania Constitution, Legislative Respondents abandoned their legislative duties, and instead submitted their map directly to this Court.

3. Legislative Respondents' Map Does Not Comply With the Court's Order.

The Legislative Respondents' map is not a product of the General Assembly, and thus did not comply with this Court's Order. The Court's instruction was that "should the Pennsylvania General Assembly choose to submit a congressional districting plan that satisfies the requirements of the Pennsylvania Constitution, it shall submit such plan for consideration by the Governor on or before February 9, 2018." *See* Order at paragraph "Second." This Order contemplated a districting plan passed by both chambers of the General Assembly as the bicameral branch of state government vested with the power to enact legislation. Pa. Const. art. II § 1. It did not authorize Legislative Respondents to bypass the legislative process and propose their own map.

Moreover, Legislative Respondents cannot claim that the map they submitted on February 9 was "produced by the legislative branch of

Pennsylvania's government" simply because it was created by a few elected officials within that branch. (LR Br. 14.) Legislative Respondents' mere status as the elected presiding officers of their respective chambers does not give them any authority to act on behalf of the entire General Assembly. The General Assembly, as a lawmaking body, never considered or voted upon the proposed map. There was no deliberation on, or opportunity to amend, its contents. The map was never subject to any of the "constitutional requirements for the passage of legislation" outlined by Legislative Respondents at length in their brief. (LR Br. 6.)

4. Legislative Respondents' Map Does Not Comply with the Pennsylvania Constitution

Legislative Respondents' map should also be rejected because it is just as egregiously partisan as the 2011 Plan. For example, Legislative Respondents boast that their proposed map "retains 68.8% of the populations of existing districts in the same districts." (LR Br. 13.) But this fact is a liability, not an achievement. Legislative Respondents have effectively admitted that they incorporated partisanship into the plan by leaving current districts intact.

In their Letter to Governor Wolf filed with the Court, Legislative Respondents argued that their decision to retain almost 70% of an unconstitutional map was justified because preserving the cores of existing districts and avoiding contests between incumbents have been recognized as "valid, neutral state

redistricting policies." (*See* Feb. 13, 2018 Letter at p. 1.) However, there is no legal justification for using these criteria when they have the effect of perpetuating the constitutional violation the new map is supposed to remedy. Accordingly, courts consistently reject remedial maps that rely on these criteria to further bake unconstitutional discrimination into a redistricting scheme.

For example, in *Covington v. North Carolina*, a three-judge panel invalidated a districting map as a racial gerrymander and rejected a Republican-proposed remedial map that purported to preserve the cores of existing districts and to protect incumbents, reasoning that "whereas a state redistricting body may have a 'legitimate' interest in 'preserving the cores of prior districts' so as to ensure an incumbent prevails in his new district when initially drawing a redistricting plan . . . a remedial plan drawn to preserve the core of a racially gerrymandered district would perpetuate the racial gerrymander." *Covington v. North Carolina*, No. 1:15CV399, 2018 WL 505109, at *17 (M.D.N.C. Jan. 21, 2018) (internal citations, quotation marks and brackets omitted), *stayed in part on other grounds by North Carolina v. Covington*, No. 17A790, 2018 WL 720758 (U.S. Feb. 6, 2018). The *Covington* court's reasoning applies with equal force to a political gerrymander.

Similarly, in *Daggett v. Kimmelman*, a three-judge panel rejected a proposed remedial map submitted by the New Jersey State Senate because it preserved the cores of districts that had been deemed unconstitutional, while bearing "little if any

relationship" to the cores of valid congressional districts. *Daggett v. Kimmelman*, 580 F. Supp. 1259, 1262 (D.N.J.), *aff'd sub nom. Karcher v. Daggett*, 467 U.S. 1222 (1984). The panel also rejected the proposed remedial plan because although it avoided contests between incumbents, it did so "only because some incumbents moved in 1982 or ran outside their home district, thereby managing to win elections from unconstitutional districts." *Id.* Legislative Respondents' interests in preserving unconstitutional districts and protecting the incumbents within them have never been deemed "valid, neutral state redistricting policies." They should not be endorsed here.

Legislative Defendants' map is rife with other indicia of gerrymandering as well. For example, as set forth in greater detail in the amicus briefs submitted to this Court, the map continues to dilute Democratic votes across the state by disproportionately and unnecessarily splitting counties with large concentrations of Democrats. *See, e.g.*, Amicus Brief by Amicus Curiae Concerned Citizens for Democracy, at 10; Brief of Amicus Curiae Schneider and Wolf at 42, 48, 66.[5] Mathematical analysis further demonstrates that the Legislative Defendants' map is an extreme outlier intentionally drawn in a partisan way. *See supra* Section I.C.

[5] Motions for leave to file these amicus briefs are currently pending before this Court.

B. Given the General Assembly's Failure to Draw a Constitutional Map When Given a Fair Opportunity to Do So, the Court Must Step In to Prevent Further Constitutional Violations.

1. The U.S. Constitution Does Not Undercut This Court's Authority to Remedy Laws That Violate the Pennsylvania Constitution.

Legislative Respondents continue to argue that the U.S. Constitution impedes any Court-ordered remedy for the unconstitutional 2011 Plan. But as this Court held in *Erfer*, the U.S. Constitution does not "suspend[] the constitution of our Commonwealth vis-à-vis congressional reapportionment" and with it, the Court's ability to review state constitutional challenges to districting plans. *Erfer v. Com.*, 794 A.2d 325, 331 (Pa. 2002). The U.S. Supreme Court has safeguarded this principle over and over again, ruling that the U.S. Constitution does not limit, and in fact "leaves with the States primary responsibility for apportionment of their federal congressional and state legislative districts," and that that responsibility is shared by a state's "legislative *or* judicial branch." *Growe v. Emison*, 507 U.S. 25, 33-34 (1993) (emphasis in original). Indeed, the U.S. Supreme Court has consistently recognized "[t]he power of the judiciary of a State to require valid reapportionment," *Scott v. Germano*, 381 U.S. 407, 409 (1965), and affirmed the state court's proper role as an "agent[] of apportionment." *Growe*, 507 U.S. at 34.

The U.S. Supreme Court has also explicitly rejected the argument that redistricting legislation is exempt from a state's regular checks and balances on

state lawmaking power. *See, e.g.*, *Ohio ex rel. Davis v. Hildebrant*, 241 U.S. 565 (1916); *Smiley v. Holm*, 285 U.S. 355 (1932); *Ariz. State Legislature v. Ariz. Indep. Redistricting Comm'n*, 135 S. Ct. 2652 (2015). To the contrary, the U.S. Supreme Court has ruled that the Elections Clause does not "endow the Legislature of the state with power to enact laws in any manner other than that in which the Constitution of the state has provided that laws shall be enacted." *Smiley*, 285 U.S. at 368. In Pennsylvania, laws enacted by the legislature must comply with the Pennsylvania Constitution, and under that constitution this Court has the ultimate authority to invalidate any law that violates constitutional standards and to craft an appropriate remedy to enforce those standards. *See* Pa. Const. art. V §§ 1, 2, 10; *see also Pap's A.M. v. City of Erie*, 812 A.2d 591, 611 (2002); *Fillman v. Rendell*, 986 A.2d 63, 75 (Pa. 2009).

There is also nothing in the U.S. Constitution limiting this Court's authority to adopt a remedial map in the face of the Legislative Respondents' failure to enact constitutional legislation. The U.S. Supreme Court has consistently recognized that judicial authority includes the power to redraw legislative maps when legislatures have failed to cure legal violations. *See, e.g.*, *Abrams v. Johnson*, 521 U.S. 74, 101 (1997) (affirming a district court's redistricting plan); *Connor v. Finch*, 431 U.S. 407, 425-26 (1977) (directing district court to fashion a "constitutionally permissible apportionment plan"); *Chapman v. Meier*, 420 U.S. 1,

27 (1975) (recognizing that district court will need to adopt a plan if the State legislature fails). The U.S. Supreme Court has not only recognized that state courts are authorized to engage in this practice, but has "specifically *encouraged*" them to do so under certain circumstances. *Scott v. Germano*, 381 U.S. 407, 409 (1965) (per curiam) (emphasis added); *accord Growe*, 507 U.S. at 33. This Court did so in *Butcher* and in *Mellow*; it can and should do so again here. *See Butcher v. Bloom*, 216 A.2d 457, 459 (Pa. 1966) (per curiam); *Mellow v. Mitchell*, 607 A.2d 204, 205 (Pa.), *cert. denied sub nom Loeper v. Mitchell*, 506 U.S. 828 (1992) (denying certiorari after Pennsylvania Supreme Court adopted a new legislative apportionment scheme).

2. Important Constitutional Rights Are at Stake

So long as Legislative Respondents are allowed to prevaricate, Pennsylvania voters' core constitutional rights hang in the balance. As this Court affirmed, Article I, Section 5 guarantees citizens of Pennsylvania a "right to free and equal elections," and this includes "a voter's right to equal participation in the electoral process for the selection of his or her representatives in government." (Maj. Op. 100). The 2011 Plan eviscerates that right, "dilut[ing] Petitioners' power to vote for congressional representatives who represent their views" while entrenching Republican dominance over the state's congressional delegation. (*Id.* 128.) Allowing this violation to continue into another election cycle is intolerable. This

Court has clearly, and repeatedly, held that the fundamental rights guaranteed by the Pennsylvania Constitution "cannot lawfully be infringed, even momentarily[.]" *Pap's A.M. v. City of Erie*, 812 A.2d 591, 607 (2002). It is also unnecessary. The Court has at least one fair, constitutional alternative that can be implemented in time for the 2018 election cycle.

CONCLUSION

For the reasons stated above, Respondent Thomas W. Wolf respectfully requests that the Court adopt his proposed map.

Respectfully submitted,

HANGLEY ARONCHICK SEGAL PUDLIN & SCHILLER

Dated: February 15, 2018

/s/ Mark A. Aronchick

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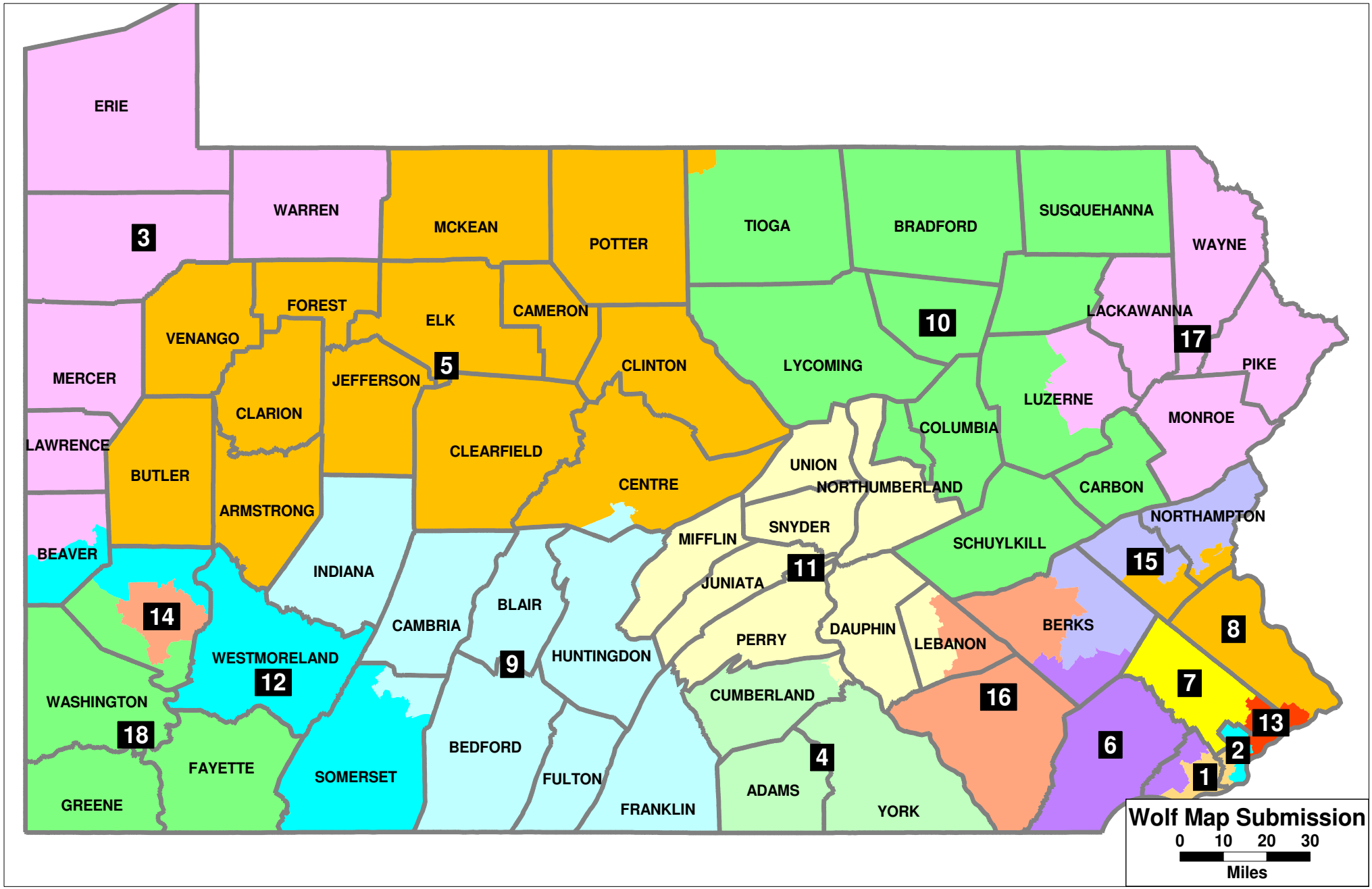
EXHIBIT A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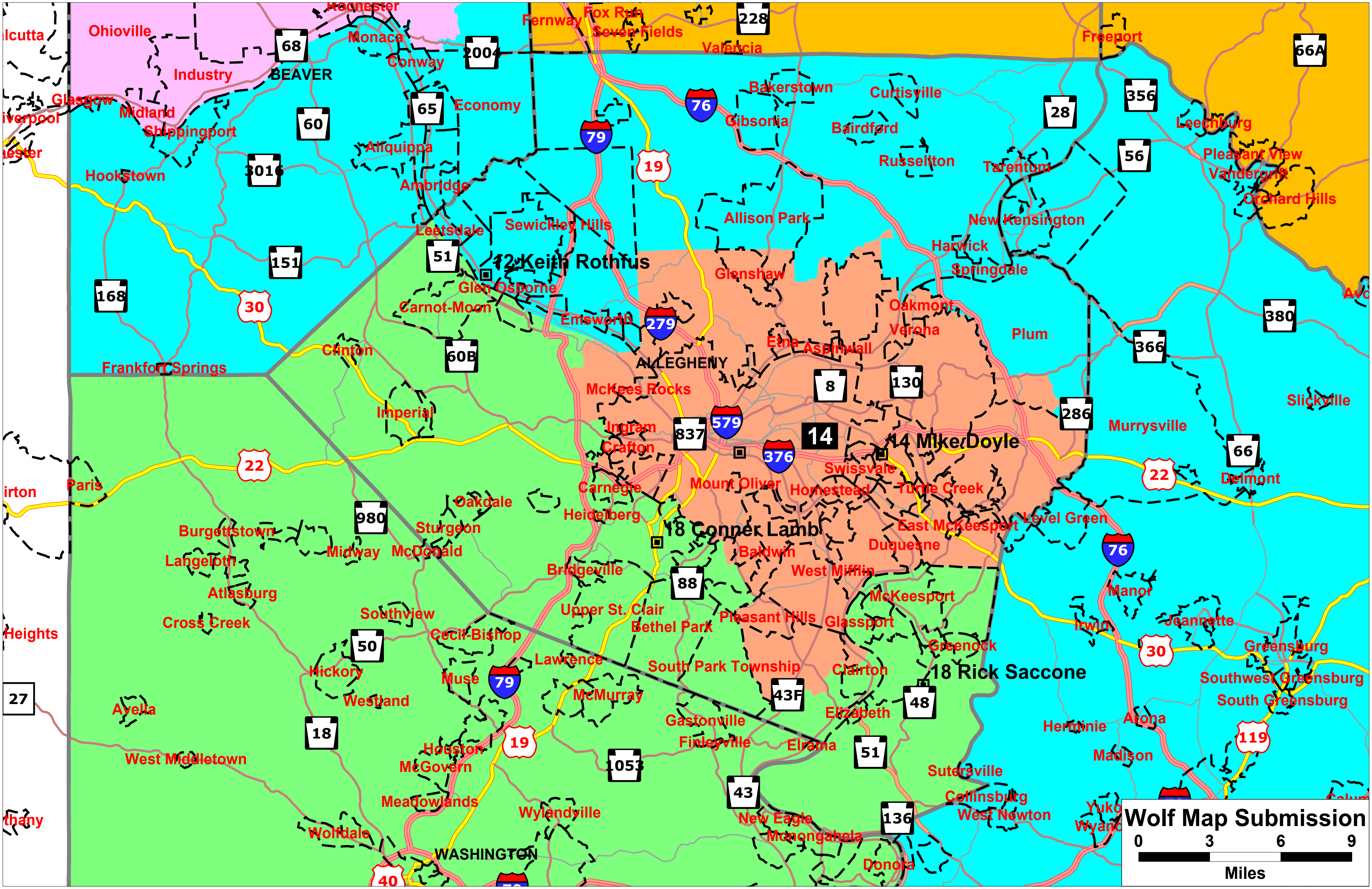

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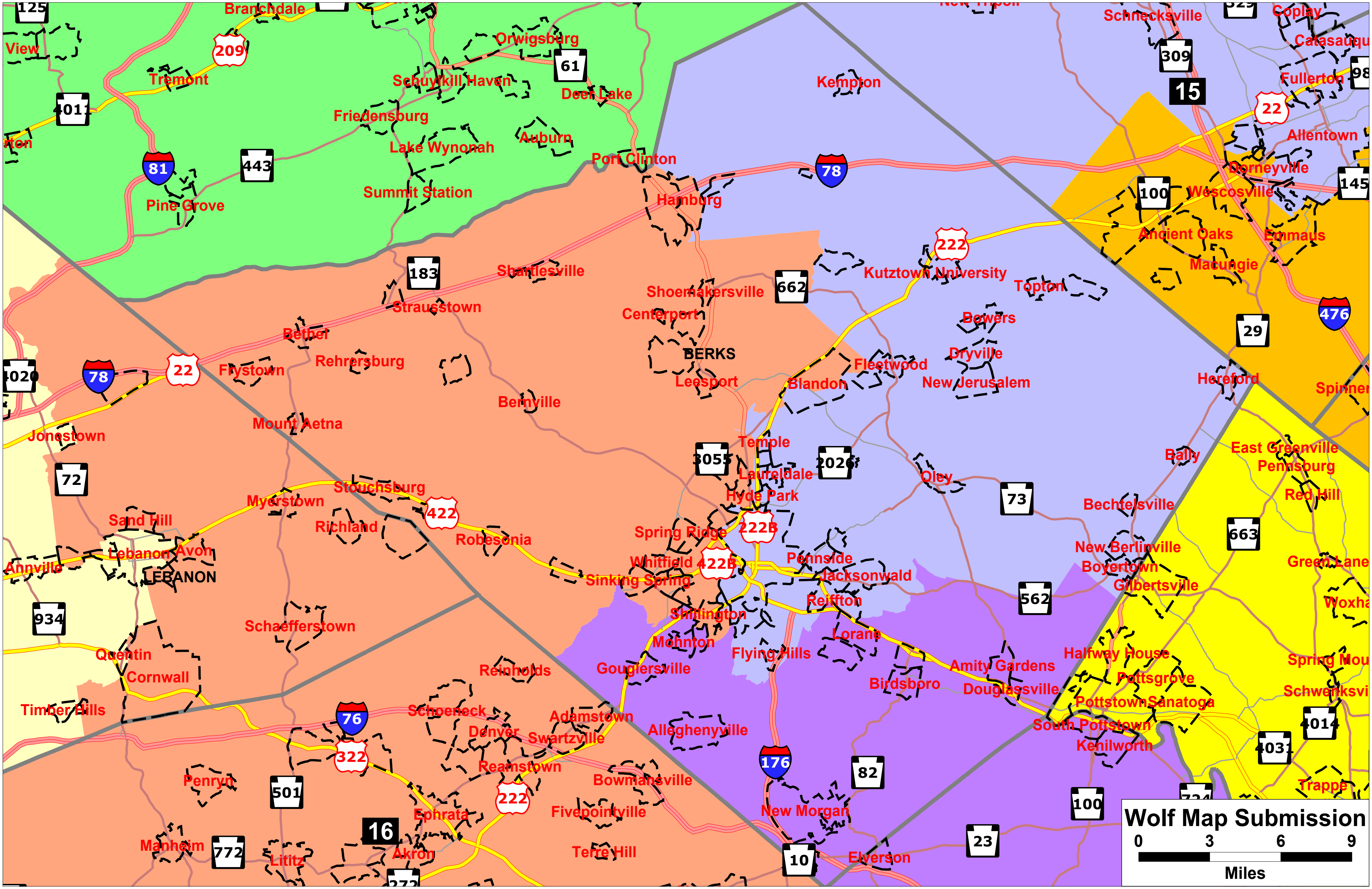

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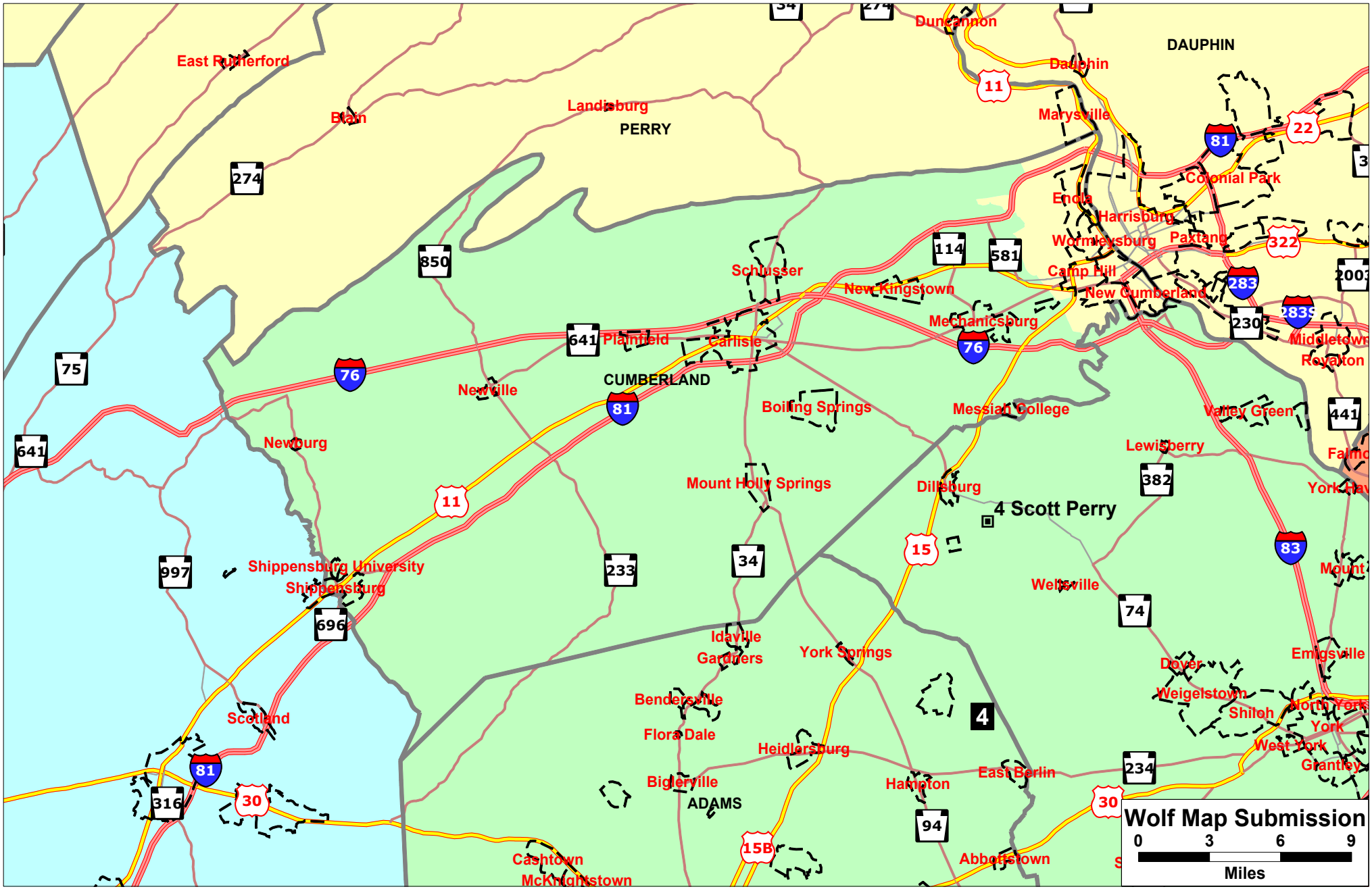
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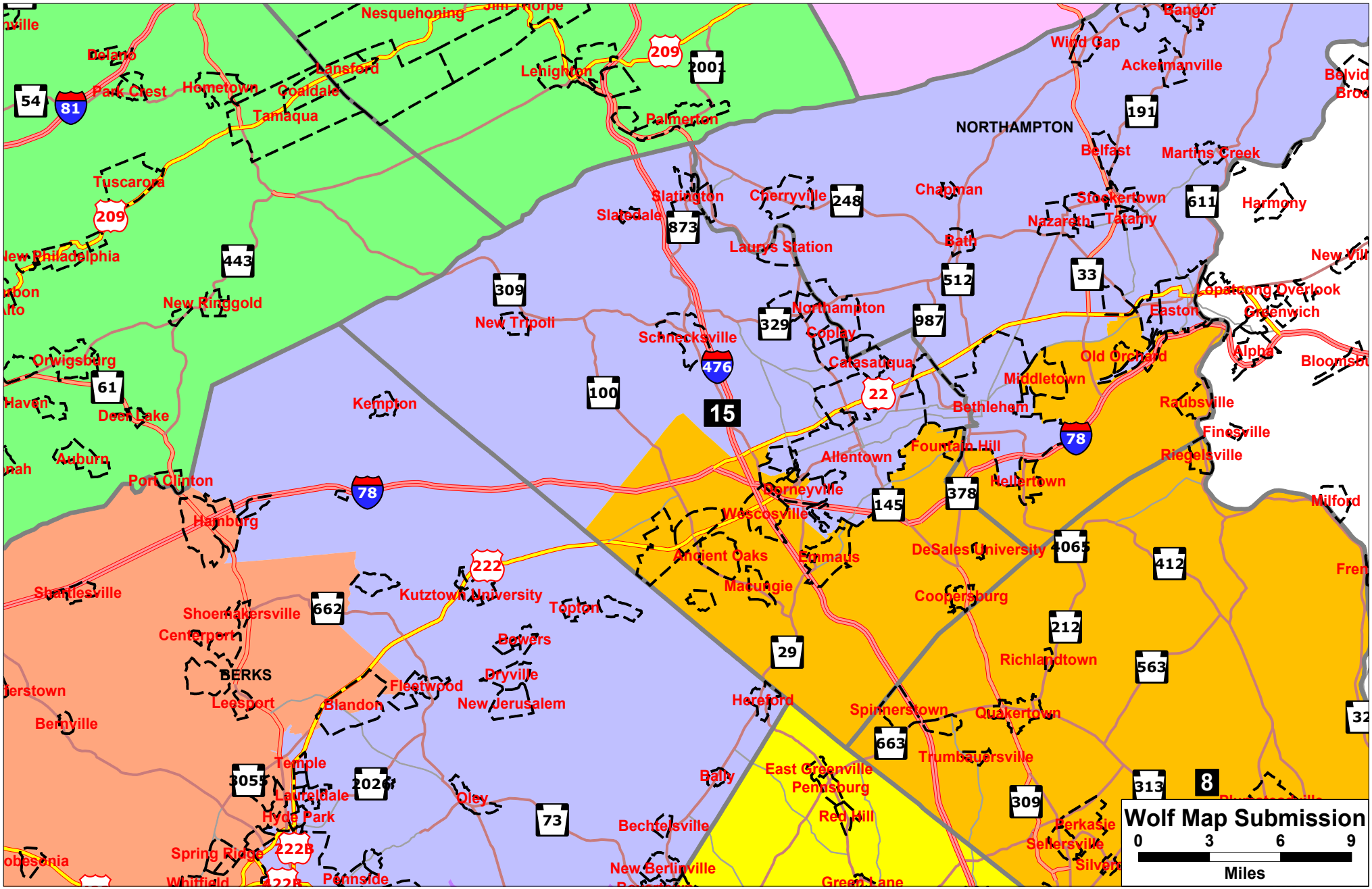
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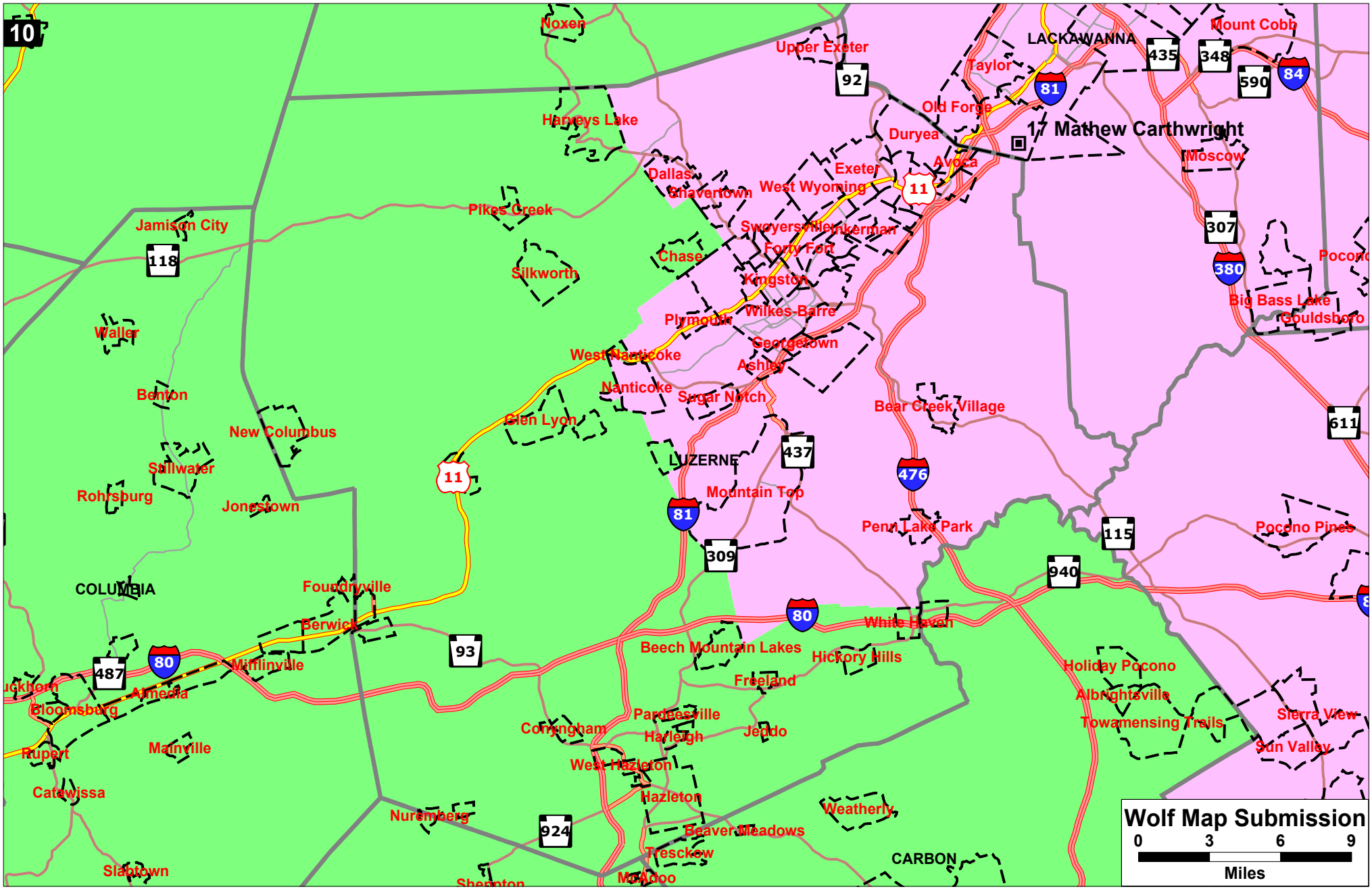
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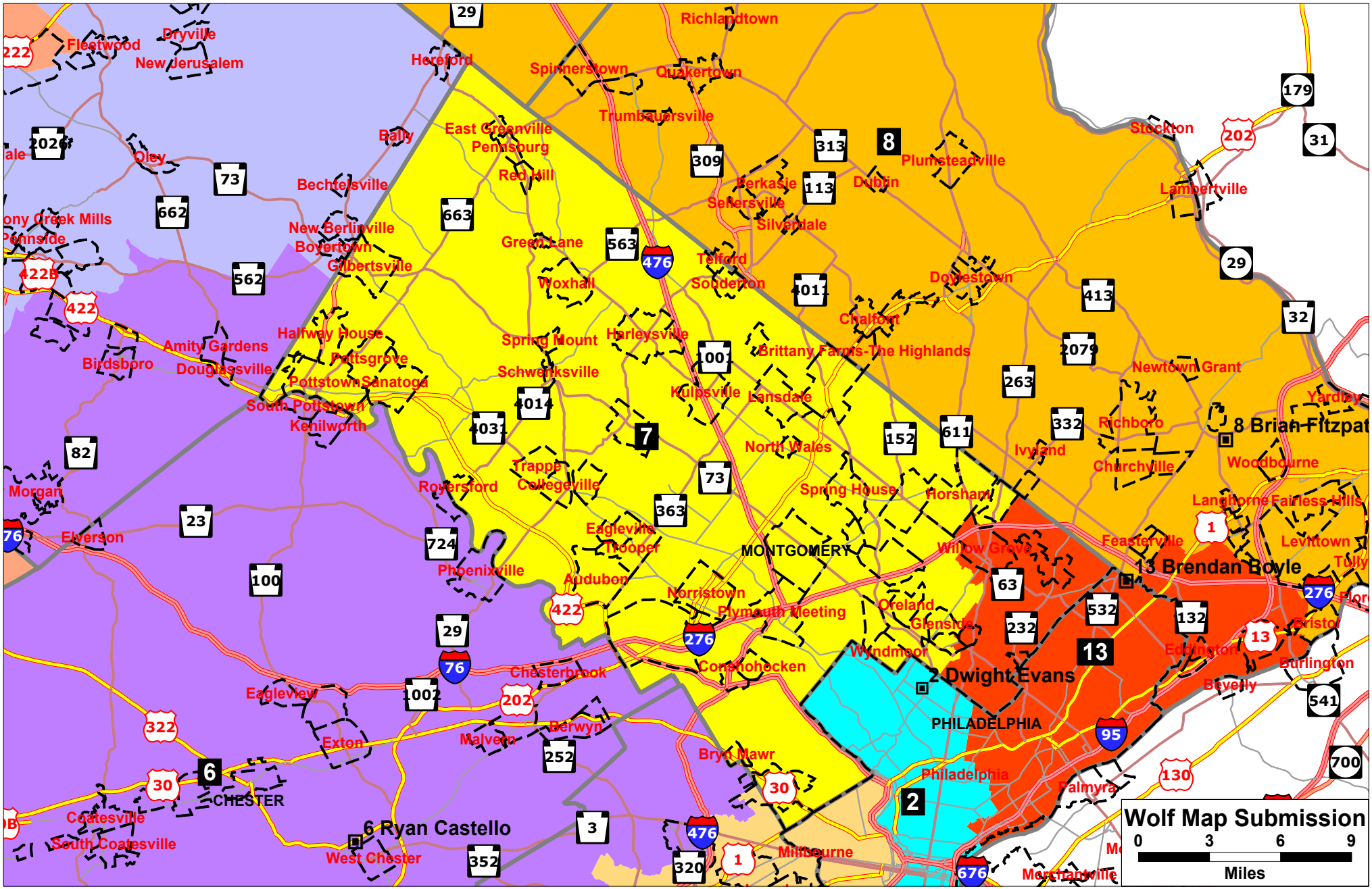
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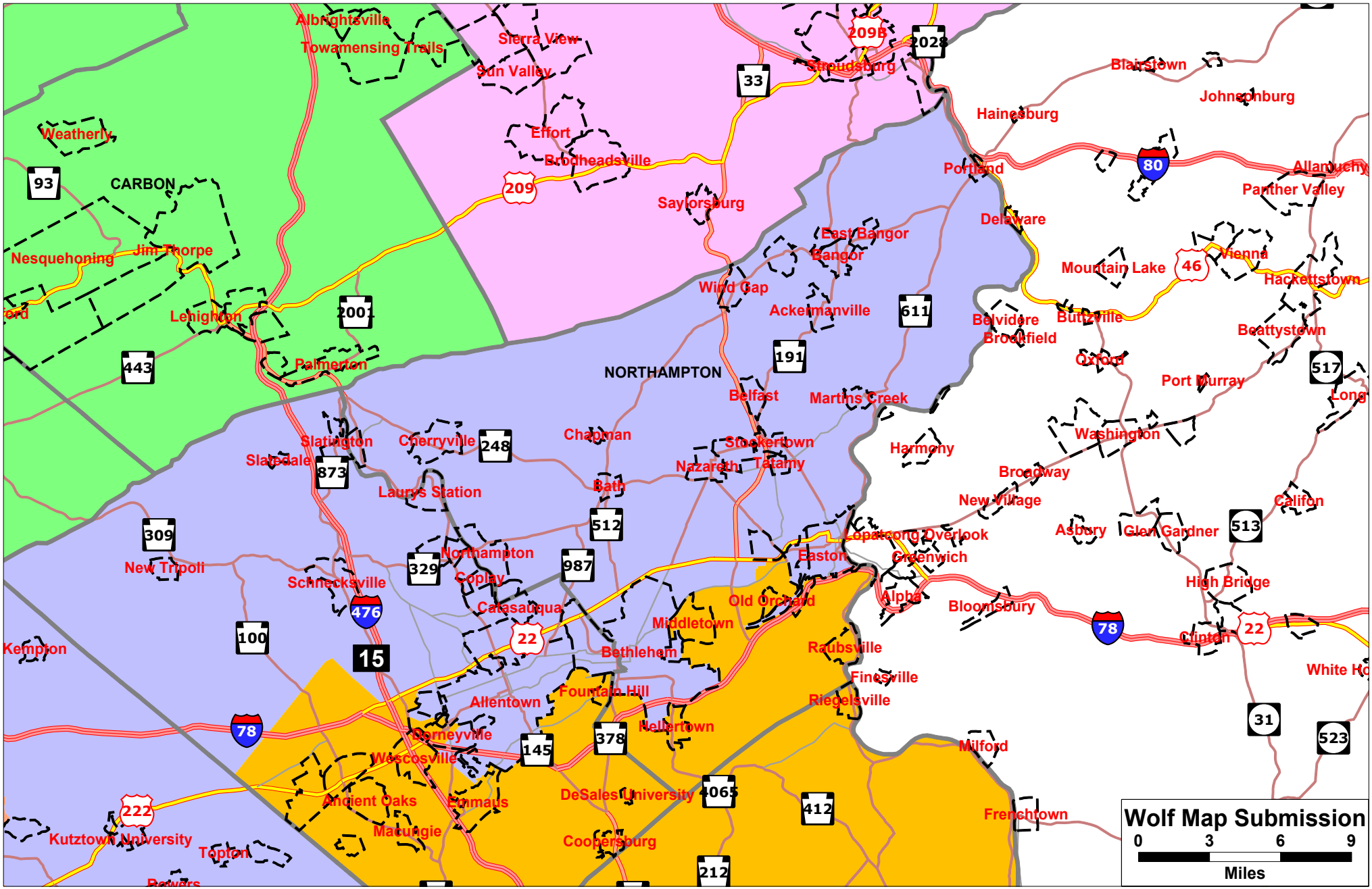
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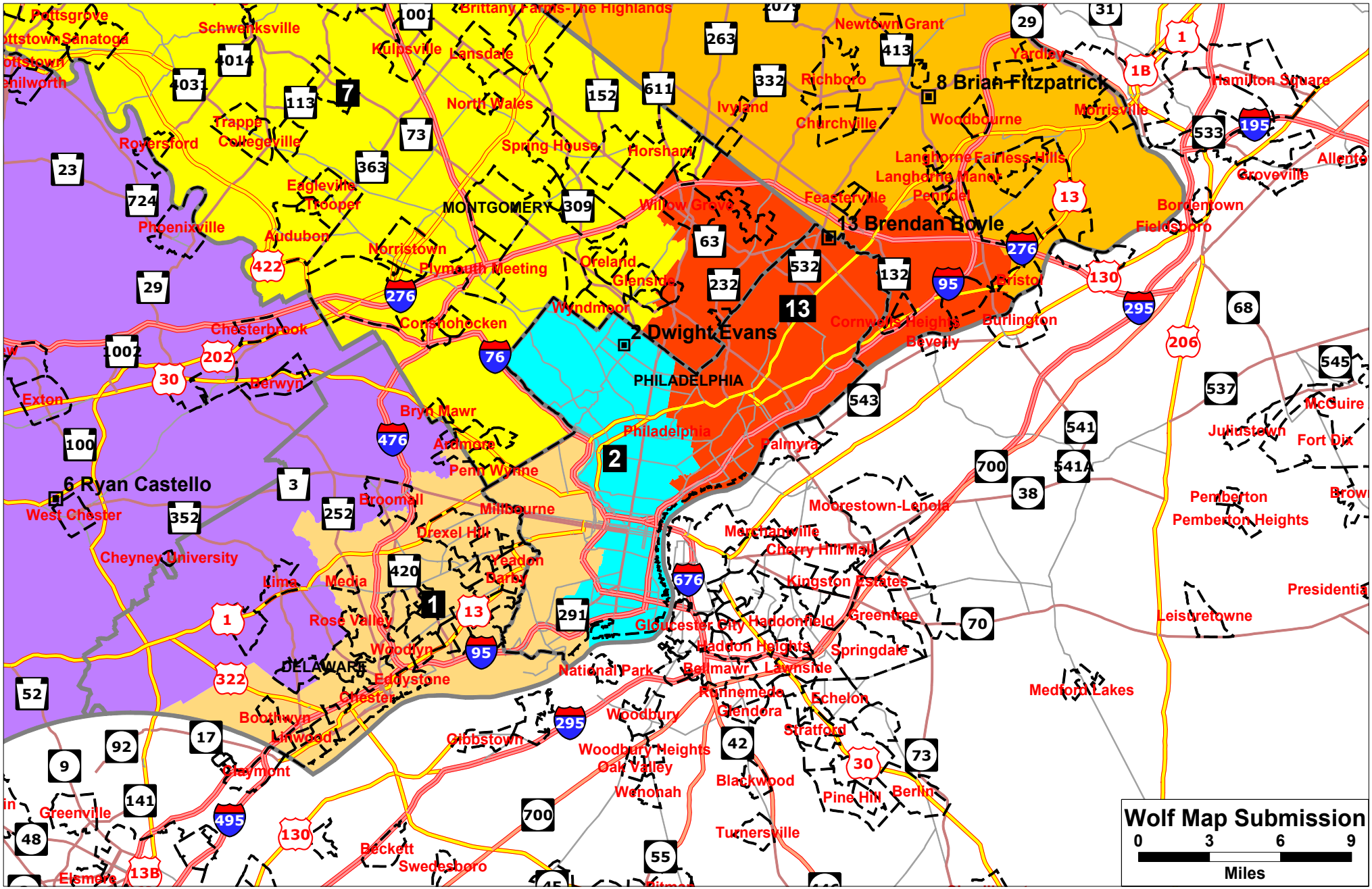
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EXHIBIT B

Moon Duchin

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Mathematics · STS · Tisch College of Civic Life | Tufts University

Education

University of Chicago MS 1999, PhD 2005
Mathematics
Advisor: Alex Eskin Dissertation: *Geodesics track random walks in Teichmüller space*

Harvard University BA 1998
Mathematics and Women's Studies

Appointments

Tufts University
Associate Professor 2015—
Assistant Professor 2011–2015

Director | Program in Science, Technology, & Society 2015—
Senior Fellow | Tisch College of Civic Life 2017—

University of Michigan
Assistant Professor (postdoctoral) 2008–2011

University of California, Davis
NSF VIGRE Postdoctoral Fellow 2005–2008

Research Interests

Geometric group theory, growth of groups, mapping class groups, nilpotent groups.
Geometric topology, hyperbolicity, Teichmüller theory.
Large-scale geometry, metric geometry, isoperimetric inequalities.
Random walks, random groups, dynamics of group actions.
Civil rights, redistricting, geometry of gerrymandering.
History, philosophy, anthropology of science and mathematics.

Awards & Distinctions

Fellow of the American Mathematical Society class of 2017
NSF CAREER award - Finer coarse geometry 2013–2018
NSF grants - Finer coarse geometry, Metric geometry of groups and surfaces 2009–2015
Bernstein Faculty Fellowship, Tufts University 2013–2015
Professor of the Year, Tufts Math Society 2012–2013
American Institute of Mathematics SQuaRE grant for five-person working group 2009–2011
AAUW Dissertation Fellowship 2004–2005
NSF Graduate Fellowship 1998–2002
Lawrence and Josephine Graves Prize for Excellence in Teaching (U Chicago) 2002
Radcliffe Research Partnership 1996–1997
Robert Fletcher Rogers Prize (Harvard) 1995–1996

Selected Publications & Preprints

Towards discrete geography
Preprint. (with Bridget Tenner)

Gerrymandering metrics: How to measure? What's the baseline?
Proceedings of the American Academy for Arts and Sciences, special issue on Redistricting and Representation, *To appear*.

Rebooting the mathematics of gerrymandering: How can geometry track with our political values?
The Conversation (online magazine), October 2017. (with Peter Levine)

A formula goes to court: Partisan gerrymandering and the efficiency gap
Notices of the American Mathematical Society **64** No. 9 (2017), 1020–1024. (with Mira Bernstein)

International mobility and U.S. mathematics
Notices of the American Mathematical Society **64**, No. 7 (2017), 682–683.

Discrete Ricci curvature for Cayley graphs
Submitted. (with Assaf Bar-Natan and Robert Kropholler)

Rational growth in the Heisenberg group
Submitted. (with Michael Shapiro)

Random nilpotent groups I
International Math. Res. Not., doi:10.1093/imrn/rnv370 (2017), 1–33.
(with Matthew Cordes, Yen Duong, Meng-Che Ho, and Ayla Sánchez)

Hyperbolic groups
chapter in *Office Hours with a Geometric Group Theorist*, eds. Matt Clay and Dan Margalit, Princeton University Press (2017), 177–203.

Counting in groups: Fine asymptotic geometry
Notices of the American Mathematical Society **63**, No. 8 (2016), 871–874.

A sharper threshold for random groups at density one-half
Groups, Geometry, and Dynamics **10**, No. 3 (2016), 985–1005.
(with Katarzyna Jankiewicz, Shelby Kilmer, Samuel Lelièvre, John M. Mackay, and Ayla Sánchez)

Equations in nilpotent groups
Proceedings of the AMS **143** (2015), 4723–4731. (with Hao Liang and Michael Shapiro)

Statistical hyperbolicity in Teichmüller space
Geometric and Functional Analysis, Volume 24, Issue 3 (2014), 748–795. (with Howard Masur and Spencer Dowdall)

Fine asymptotic geometry of the Heisenberg group
Indiana University Math Journal 63 No. 3 (2014), 885–916. (with Christopher Mooney)

Pushing fillings in right-angled Artin groups
Journal of the London Math. Society, Volume 87, Issue 3 (2013), 663–688.
(with Aaron Abrams, Noel Brady, Pallavi Dani, and Robert Young)

Spheres in the curve complex
In the Tradition of Ahlfors and Bers VI, Contemp. Math. **590** (2013), 1–8. (with Howard Masur and Spencer Dowdall)

The sprawl conjecture for convex bodies
Experimental Mathematics, Volume 22, Issue 2 (2013), 113–122. (with Samuel Lelièvre and Christopher Mooney)

Filling loops at infinity in the mapping class group
Michigan Math. Journal, Volume 61, Issue 4 (2012), 867–874.
(with Aaron Abrams, Noel Brady, Pallavi Dani, and Robert Young)

The geometry of spheres in free abelian groups
Geometriae Dedicata, Volume 161, Issue 1 (2012), 169–187. (with Samuel Lelièvre and Christopher Mooney)

Statistical hyperbolicity in groups
Algebraic and Geometric Topology **12** (2012) 1–18. (with Samuel Lelièvre and Christopher Mooney)

Length spectra and degeneration of flat metrics
Inventiones Mathematicae, Volume 182, Issue 2 (2010), 231–277. (with Christopher Leininger and Kasra Rafi)

Divergence of geodesics in Teichmüller space and the mapping class group
Geometric and Functional Analysis, Volume 19, Issue 3 (2009), 722–742. (with Kasra Rafi)

Curvature, stretchiness, and dynamics
In the Tradition of Ahlfors and Bers IV, Contemp. Math. **432** (2007), 19–30.

Geodesics track random walks in Teichmüller space
PhD Dissertation, University of Chicago 2005.

Selected Talks and Lectures

Gerald and Judith Porter Public Lecture
AMS-MAA-SIAM, Joint Mathematics Meetings, San Diego, CA — January 2018

AMS Invited Address
Eastern Sectional Meeting, Brunswick, ME — September 2016

MAA Distinguished Lecture
Carriage House, Washington, DC — October 2016

Named University Lectures

- School of Science Colloquium Series | The College of New Jersey
- Kieval Lecture | Cornell University
- G. Milton Wing Lectures | University of Rochester
- Norman Johnson Lecture | Wheaton College
- Constitution Day Lecture | Nelson A. Rockefeller Center for Public Policy, Dartmouth College
- Dan E. Christie Lecture | Bowdoin College

Recent Minicourses

- Workshop in geometric topology (main speaker, three talks) | Provo, UT — June 2017
- Growth in groups (two talks) | MSRI, Berkeley, CA — August 2016
- Hyperbolicity in Teichmüller space (three talks) | Université de Grenoble — May 2016
- Counting and growth (four talks) | IAS Women's Program, Princeton — May 2016
- Nilpotent groups (three talks) | Seoul National University — October 2014
- Sub-Finsler geometry of nilpotent groups (five talks) | Galatasaray Univ., Istanbul — April 2014

Department colloquia

- Northwestern University Oct 2017
- University of Illinois Sept 2017
- University of Utah Aug 2017
- Wesleyan Dec 2016
- Worcester Polytechnic Dec 2016
- Université de Neuchâtel Jun 2016
- Brandeis University Mar 2016
- Swarthmore College Oct 2015
- Bowling Green May 2015
- City College of New York Feb 2015
- Indiana University Nov 2014
- the Technion Oct 2014
- Wisconsin–Madison Sept 2014
- Stony Brook Mar 2013
- Bradley University Feb 2013
- Colby College Nov 2012
- Wentworth Tech Nov 2012
- NYU Poly Oct 2012
- Cornell University Sept 2012
- University of Ghana July 2012
- Wellesley College Oct 2011
- University of Hawaii Feb 2011
- University of Southern California Jan 2011
- Central Connecticut State May 2010
- Dartmouth College Jan 2010
- San Jose State Sept 2008
- University of Oklahoma Apr 2008
- Wesleyan University Nov 2007
- Reed College Nov 2005

Interdisciplinary seminars

- Quantitative Social Science | Dartmouth College September 2017
- Clough Center for the Study of Constitutional Democracy | Boston College November 2017
- Data for Black Lives conference | MIT November 2017
- Tech/Law Colloquium Series | Cornell Tech November 2017

Graduate Advising

Mai Mansouri (MS 2014), Kevin Buckles (PhD 2015), Ayla Sánchez (PhD 2017),
Sunrose Shrestha (PhD expected 2019), Nate Fisher (candidacy 2017)

Selected Professional Service

Committee on the Human Rights of Mathematicians
American Mathematical Society since 2016

Committee on The Future of Voting: Accessible, Reliable, Verifiable Technology
National Academies of Science, Engineering, and Medicine since 2017

EXHIBIT C

Outlier analysis for Pennsylvania congressional redistricting

Moon Duchin

February 15, 2018

The Pennsylvania redistricting plan submitted by Speaker Turzai and President Pro Tem Scarnati is an *extreme outlier* among redistricting plans, according to detailed analysis and rigorous calculations of partisan skew detailed in this report.

This was assessed by a series of tests that were set up and validated independently of the Governor's counter-proposal. I have studied the Governor's proposed map using the same tests and have determined that it behaves squarely in accordance with the traditional districting principles. On the other hand, the Turzai-Scarnati plan is overwhelmingly likely to have been drawn to increase partisan advantage, since traditional districting principles alone do not explain its partisan skew. I produced over three billion maps similar to the Turzai-Scarnati proposal that are at least as compact, preserve at least as many counties, and keep population deviation to within the 1% threshold, so that a mapmaker can tune them to 1-person deviation while maintaining county preservation and compactness. The fraction of maps that were more Republican-skewed in this sample was less than one in 2 million. This means that even with conservative assumptions, there is less than a 0.1% chance that the Turzai-Scarnati plan was drawn in a non-partisan way.

1 Introduction

I have been asked to use best practices from mathematics and statistics to assess whether a variety of newly proposed redistricting plans for Pennsylvania congressional districts are or are not *extreme outliers* along partisan lines. I have set up this analysis using a method that itself is symmetrical with respect to the two parties, by comparing a proposed plan to a large ensemble of alternatives produced by random changes that only take recognized and traditional districting principles into account. The principles encoded in the random walk are the ones named in the court order: respect for political boundaries, compactness, and population parity.

The method employed here is to run Markov chains to understand whether partisan scores of districting plans exhibit sensitive dependence on unstated priorities used in constructing the plan. Using modifications to two open-source packages (markovchain and redist [2, 4]), our runs characterize the Turzai-Scarnati plan (henceforth TS) as a partisan outlier at a very high level of statistical significance. By contrast, the Governor's counter-proposed plan (henceforth GOV) is not an outlier in chains initiated there.

I regard this analysis to be as robust as possible given the available data and the timeframe, and I have high confidence in the findings. I found that the TS plan is an extreme outlier under the local $\sqrt{2\epsilon}$ test from [1] at a very high level of statistical significance, while GOV showed no significant effects, i.e., there is no reason to believe that it was drawn to achieve partisan ends.

I will continue to investigate this topic and will extend this analysis with a variety of tests and approaches in the future. At the Court's request, I will gladly furnish further details and analysis.

2 Design and justification

2.1 Question to study

The basic question we are attempting to answer is:

Does a newly-proposed plan represent an extreme outlier among available alternatives?

The approach described here takes seriously the question of available alternatives; we need to control for the effects of the districting rules and for the underlying "political geography" of the state, i.e., where the voters live. Both of these factors may cause it to be the case that there is a systematic structural advantage for one party or the other, so it is only legitimate to compare a plan against alternative plans designed according to the same rules and with the same political geography.

2.2 Geographical distribution of voters

When assessing partisan skew, you must pick both a plan and a distribution of voters—the locations where voters live—against which to evaluate it. This is precisely the strength of the algorithmic sampling approach to studying gerrymandering: *the partisan properties of districting plans can only be understood when compared to other plans that hold constant the geography of where voters are located.*

I have studied the TS plan, the currently enacted plan, and the governor's proposed plan with respect to many available election returns and am focusing this analysis on two races for which I believe the answers give most reliable and most easily interpretable results: Senate 2010 (R 51–D 49) and Senate 2016 (R 50.7–D 49.3). These are state-level, statewide races that have two nice features: incumbency effects do not vary across the state, and we don't have to use any interpolation techniques to model uncontested races. (These are both sources of uncertainty when using returns from U.S. Congressional races or State Legislative races.) It is common practice to prefer state-level election results over presidential races for modeling future state-level elections, because presidential races often have voter preference patterns that are quite different.[1] Senate10 has the advantage of having no incumbent in the race, but Senate16 has the advantage of being more recent. I've also considered SenW, which is defined a weighted average of those two (weighted to equalize turnout)—I consider this to be the best and most reliable snapshot of the underlying political geography in Pennsylvania right now.

In other words, we hold constant the distribution of voters—with high concentrations of Democrats in Philadelphia and Pittsburgh and all the rest of the Pennsylvania political geography—and vary only the way the state is cut up into districts. This completely controls for voter distribution effects on any partisan outcomes described in this report.

2.3 Building an ensemble of alternatives

In order to assess the qualities of a proposed plan, we consider its evolution under random transformations. This procedure is called a *Markov chain*, which moves between *states* which represent redistricting plans built out of fixed units, via *transitions* that change the district assignment of a single unit at a time. (Here, the units are voting precincts.[2]) I used two different kinds of Markov chains in conducting this study: a simple random walk and a weighted random walk. In simple random walk, the changes are made through the following process: randomly select a precinct on the boundary between two districts; check whether the new plan is contiguous and has acceptable levels of adherence to traditional districting principles, and move there. In weighted random walk, a penalty score is used for every plan to measure its failure to achieve optimality (perfect compactness, zero splits, and zero population deviation). Now when a random new plan is proposed by the chain, it is accepted according to a probability distribution: definitely accept the new plan if it is better, and accept it with a lower probability derived from its penalty score if it is worse.

The precise formulation of the ways to measure traditional districting principles is described below in an Appendix. We will devote most of the description to the simple random walk implemented in markovchain, but have also explored the space of plans with the Metropolis-Hastings MCMC implementation in redist.

As the chain runs, an *ensemble* is built that accumulates all of the plans encountered by the random walk. This becomes a pool of available alternatives that are comparable to the plan under consideration. I will present data collected by comparing TS to several ensembles of alternatives, and will do the same for the current plan and the Governor's proposed plan.

[1] Nonetheless I have also considered weighted voter distributions that combine all available election returns, and the results are noisier but not qualitatively different.

[2] These are 2011 Census VTDs, straightforwardly "cleaned" by merging zero-population precincts into their neighbors, by merging precincts when one completely surrounds the other, etc.

2.4 Evaluating partisan performance against the ensemble

We need to select several indicators of partisan performance, given a vote distribution and a districting plan. There are many metrics for partisan skew that can be found in the literature on redistricting. Two of the most popular are the well-established *mean-median score* and the relatively new *efficiency gap*. Each of these measures the amount of advantage enjoyed by one of the political parties. These scores and several others are defined and discussed in an Appendix.

3 Findings

I will give several levels of analysis on the three plans discussed here (TS, Current, and GOV) against three voter geographies (Sen10, Sen16, and SenW).

3.1 General analysis

Given the voter geography recently observed in Pennsylvania, a plan that follows traditional districting principles in a politically neutral way will likely exhibit a tilt toward Republicans relative to the voter proportions. This analysis aims in part to quantify that effect. The full range of possibilities I encountered in trillions of trials against recent Senate vote geography was 4 to 10 seats for Democrats, but the 5-seat outcome is relatively rare and the 4-seat outcome is vanishingly rare.[3] Both the currently enacted plan and the TS plan give 5 seats to Democrats under the Senate 2010 and the averaged Senate distribution and only 4 seats to Democrats under the Senate 2016 distribution. **This immediately suggests that problem with these plans is that they are expressly designed to minimize the Democratic representation.**

3.2 Detailed analysis

The TS plan does improve on the currently enacted plan in terms of several traditional districting principles, especially compactness, but also county and municipality splits. However, it can be seen to be carefully designed to minimize Democratic representation even within those constraints.

In simple seat share, I have algorithmically generated many billions of plans that are similar to the TS plan while improving on compactness. We even find the same result *while keeping intact all of the same counties that are not split by the plan.* To handle population deviation, we note that maps are typically balanced at the end of the production process, and plans with population deviation of 1%, while they would never be enacted into law as-is, are easily *balanceable* by a mapmaker: any such plan can be "zeroed out" (reduced to one-person deviation) without any impact at all on county splits or compactness. All algorithmically generated plans considered in this analysis stay within 1% population deviation, in order to remain easily balanceable. Therefore, the traditional districting principles do not explain the skew in the number of seats obtained by each party.

However, the simple number of seats does not totally capture the partisan dynamics of a plan. An extremely well-established metric that gives a more detailed view of partisan skew is the *mean-median* statistic, which essentially describes how much the party that controls the district lines can fall short of half of the vote while still capturing half of the representation. (Since this analysis is set up to count Democratic seats, a positive mean-median score indicates a systematic advantage for Republicans that is present in the districting plan.)

The figures below that show how extreme the TS and the currently enacted plan are in terms of mean-median and efficiency gap scores. Each depicts 2^{30}—over 1 billion—steps in a random walk. By contrast, the GOV plan is frequently right in the middle of the curve for the plans with its compactness constraints. In addition, the GOV plan is more slightly compact than TS to begin with.

[3]Note that this analysis does not directly address the frequency of districts that are competitive enough to have been winnable by the losing side.

3.3 Rigorous calculations

If a plan is in the worst $1/n$ fraction of the plans encountered in a random walk chain, then it has less than $p = \sqrt{2/n}$ probability of being chosen by chance among the other ones that meet the constraints, according to a recent theorem of Chikina-Frieze-Pegden (see Appendix). In this case, the constraints are just adherence to traditional districting principles. Therefore, neither the distribution of voters nor the traditional districting principles can explain the extreme skew.

A billion districting plans, at least as compact as initial plan

10^{30} steps	D seats	MM	fraction with higher MM than plan	p-value
Turzai-Scarnati/Sen10	5	4.7%	.00067	.037
Turzai-Scarnati/Sen16	4	4.6%	.013	.16
Turzai-Scarnati/SenW	5	4.6%	.023	.21
currently enacted/Sen10	5	6.2%	.000000006	.00011
currently enacted/Sen16	4	4.3%	.015	.17
currently enacted/SenW	5	6.2%	.000000021	.0002
GOV/Sen10	6	2.5%	.74	1.2
GOV/Sen16	7	3.5%	.15	.54
GOV/SenW	7	3%	.55	1.0

A billion districting plans, at least as compact as initial plan, with no more county splits

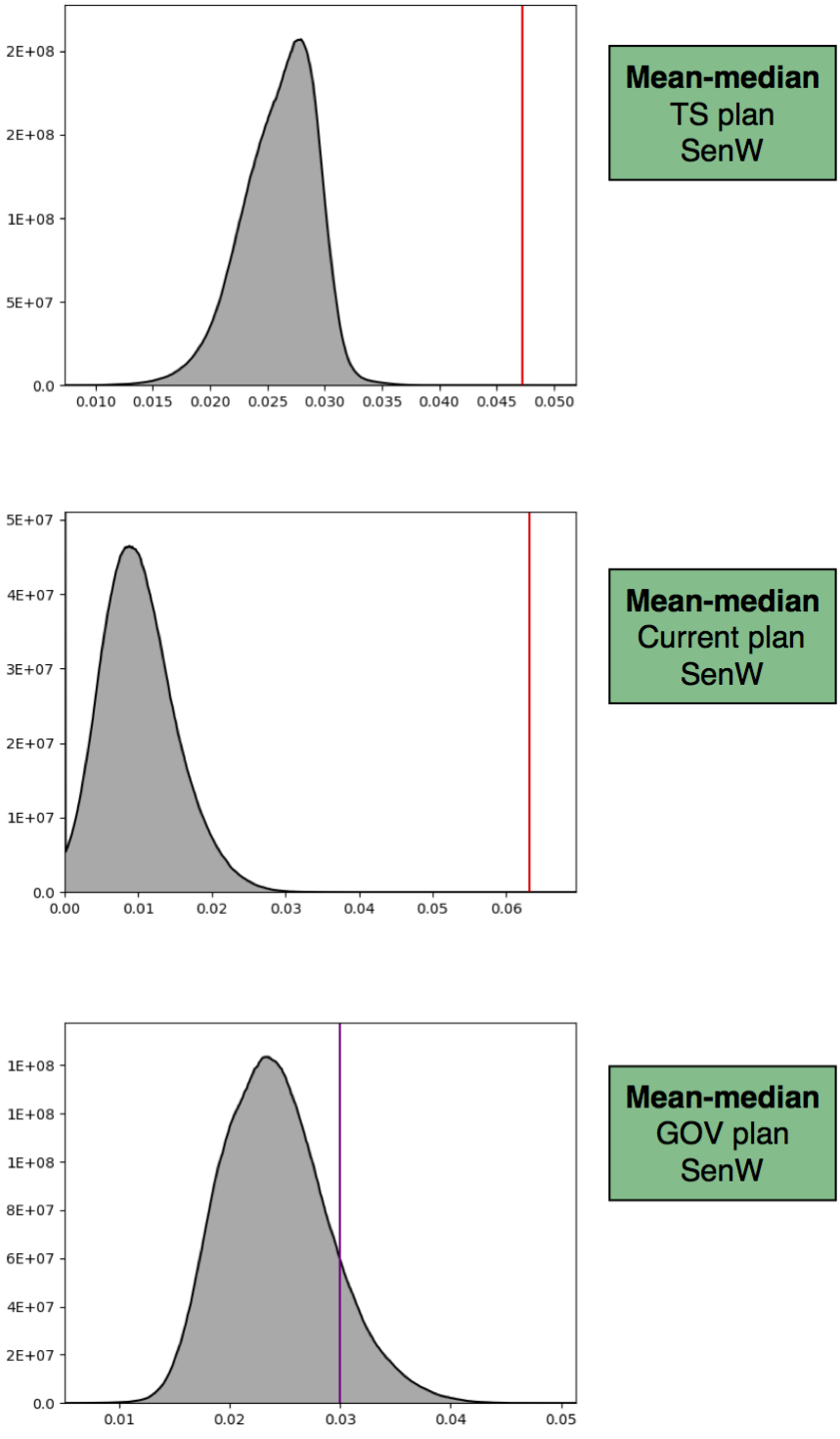
10^{30} steps	D seats	MM	fraction with higher MM than plan	p-value
Turzai-Scarnati/Sen10	5	4.7%	.0000005	.00099
Turzai-Scarnati/Sen16	4	4.6%	.00000031	.00078
Turzai-Scarnati/SenW	5	4.6%	.0000004	.0009
currently enacted/Sen10	5	6.2%	.000000014	.00017
currently enacted/Sen16	4	4.3%	.000049	.0099
currently enacted/SenW	5	6.2%	.00000049	.00099
GOV/Sen10	6	2.5%	.065	.36
GOV/Sen16	7	3.5%	.12	.5
GOV/SenW	7	3%	.12	.49

Recall that Sen10 and Sen16 are the 2010 and 2016 U.S. Senate races, and SenW is the combination of the two (weighted to equalize turnout). Note that $p \leq .05$ is the usual standard for statistical significance, though some prefer the tighter standard of $p \leq .01$. This means that both Turzai-Scarnati and the currently enacted plan show highly significant levels of partisan gerrymandering.

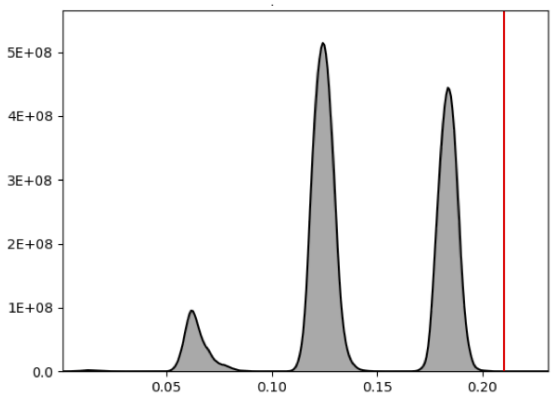
By contrast, the GOV plan does not meet even the looser standard for statistical significance, and in fact *when it exhibits any partisan skew, it is not skewed in the Democratic-favoring direction.*

We note that p-values are upper bounds for the probability of an event occurring under the null hypothesis (here, the hypothesis that a districting plan was generated only by traditional districting principles). This means that when you see a p-value greater than 1, you may conclude not only that there is no statistical significance, but that there is *literally no evidence at all* of partisan skew.

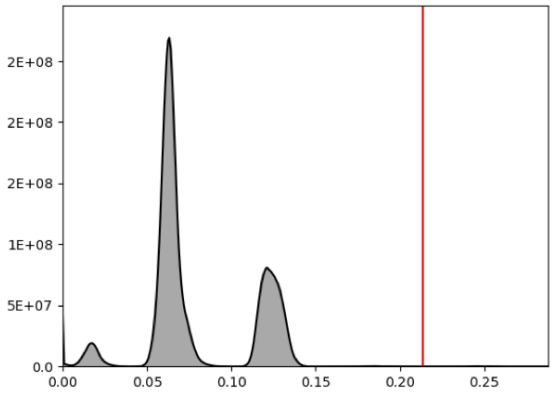
3.4 Images



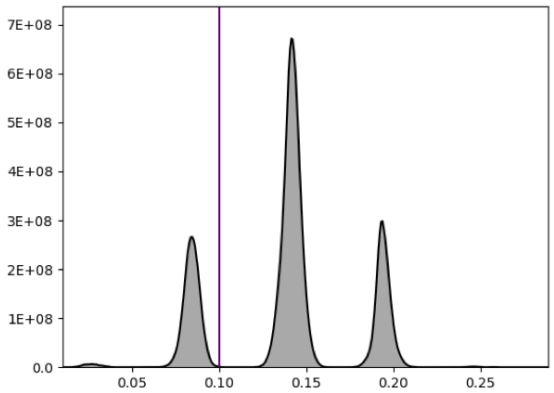
The plots in this group are histograms from the mean-median scores for the TS, currently enacted, and GOV plans, respectively. The positive direction is more systematically favorable to Republicans across a range of vote assumptions. Of these districting plans, only the GOV plan falls within reasonable parameters among similar maps.



Efficiency gap
TS plan
SenW



Efficiency gap
Current plan
SenW



Efficiency gap
GOV plan
SenW

The plots in this group are efficiency gap. The positive direction is more systematically favorable to Republicans. This means that all three plans pass up on drawing maps that are otherwise similar, but would be more favorable to Democrats.

Note that the *EG* values divided up into individual bell curves that shift as the number of Democratic seats grows. This is because of the close relationship of *EG* to seat share (see §7.2). The TS plan is visibly extreme, both for minimizing the number of Democratic seats and even compared to other plans with the same number of Democratic seats awarded.

These pictures all have all of the cited districting principles turned ON, and each plot has over a billion maps in it. Images of this kind for all calculations discussed here are available to the court upon request.

4 Conclusion

The TS plan is shown to be an extreme outlier in the partisan advantage afforded to the Republican party. This is true even when it is compared only to plans that closely resemble it which were found by algorithmic search in which only the stated principles set out by the Court were encoded.

The GOV plan, by contrast, falls squarely within the ensemble of similar plans created using nonpartisan criteria, and therefore gives no reason at all to believe that it was drawn with Democratic-favoring partisan intent.

5 Appendix: Rigorous bounds for statistical significance

We appeal above to the theorem of Chikina-Frieze-Pegden which assesses the likelihood that a given plan appears to be an extreme outlier by chance rather than by careful design. This can be applied to either the simple random walk, whose stationary distribution is uniform, or to the Metropolis-Hastings algorithm, which has the Gibbs distribution (more heavily weighting plans that better conform to traditional districting principles) as a stationary distribution.

The simple random walk is heavily constrained by traditional districting principles at the level of the starting map, so in effect the Markov chain is searching a much smaller state space that is a single connected component of a disconnected space, making it likelier to achieve mixing. The weighted random walk is preferentially seeking plans that more closely adhere to traditional districting principles. In either case, the null hypothesis ($X_0 \sim \pi$) is that the plan was chosen by the stated principles laid out by the Court. For such a plan to be an ϵ-outlier after k steps of the chain could occur with probability at most $\sqrt{2\epsilon}$.

Theorem 1 ([1]) *Let $M = X_0, X_1, \ldots$ be a reversible Markov chain with a stationary distribution π on its state space Ω, and consider a labeling function $G : \Omega \to \mathbb{R}$. If $X_0 \sim \pi$, then for any fixed k, the probability that $G(X_0)$ is an ϵ-outlier from among the list of values observed in the trajectory $X_0, X_1, X_2, \ldots, X_k$ is at most $\sqrt{2\epsilon}$.*

In statistical science, results are often reported with a p-value which indicates the fit of the observed data with the null hypothesis. A frequent standard for journal publication is to have a p-value below .05, which has traditionally represented adequate statistical significance to reject the null hypothesis. Note that $\epsilon = .00125$ gives $p = \sqrt{2\epsilon} = .05$, so to meet that standard of significance we would need an assessed map to fall in the worst one-eighth of a percent of the values encountered in a chain.

6 Appendix: Quantifying traditional districting principles

The Court has asked for a plan that reports on splits of political boundaries; population parity; and compactness. In this appendix I discuss metrics that measure adherence to these traditional districting principles.

6.1 Splitting

6.1.1 How much do the districts split the counties?

Suppose the 67 counties of Pennsylvania are labeled $\mathcal{C} = \{C_1, \ldots, C_{67}\}$. Let w_j be the population of C_j divided by the population of the state, and let $p_i^{C_j}$ be the population of $C_i \cap D_j$ over the population of C_j (that is, the fraction of county i that is contained in district j). Then we define $SqEnt(D|C_j) = \sum_i \sqrt{p_i^{(C_j)}}$ and $SqEnt(D|C) = \sum_j w_j \sum_i \sqrt{p_i^{(C_j)}}$.

This is a modification of the classical Shannon entropy which measures how much two different partitions cut each other into pieces; if for a function f you consider

$$Ent_f(D|C) = \sum_j \left[w_j \sum_i p_i^{C_j} \cdot f\left(1/p_i^{(C_j)}\right) \right],$$

then Shannon entropy uses $f(x) = \ln x$ and ours uses $f(x) = \sqrt{x}$. The reason to use square roots instead of logs is that we want to substantially penalize small "nibbles" that cut off the corner of a county, whereas Shannon entropy considers a 99–1 split to be negligibly worse than an intact county.

To illustrate how this works, consider the following choices of how to split county j.

	A	B	C	D	E	F	G	H
Splitting	97–3	88–12	50–50	96–2–2	50–25–25	33.3–33.3–33.3	25–25–25–25	25–20–1–1–. . . –1
Score	1.16	1.28	1.41	1.26	1.7	1.73	2	6.45

Note that these scores behave well under refinement: if one piece is broken down into two or more parts while leaving the other pieces alone (such as in moving from C to E to G above) then the score always goes up.

6.1.2 How much do the counties split the districts?

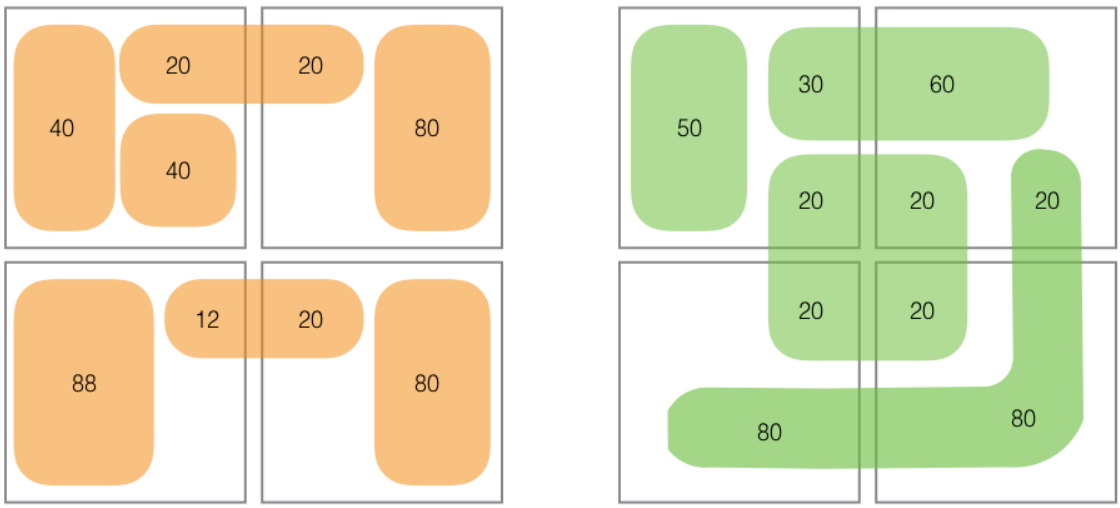
Typically, districts are much bigger than counties, so we try to keep small and medium-sized counties intact in a good districting plan. However, in the case of large counties (Philadelphia, Montgomery, Allegheny), the counties are larger than the ideal district size. In this case, we should try to keep the districts intact within the counties, to enact respect for political boundaries. The score $SqEnt(\mathcal{C}|\mathcal{D})$ looks at each district in turn and measures how much the districts are cut up by the counties, as opposed to $SqEnt(\mathcal{D}|\mathcal{C})$ which looks at each county and scores how much it is cut up by the districts.

Therefore our overall splitting penalty will be $\mathsf{Split}(\mathcal{D}) = SqEnt(\mathcal{D}|\mathcal{C}) + SqEnt(\mathcal{C}|\mathcal{D})$.

The definition is precisely the same for municipality splits rather than county splits, replacing $\mathcal{C}$ with $\mathcal{M}$.

6.1.3 Example

The images depict two districting plans, where the four squares are districts, the colored regions are counties, and the numbers are populations.



In the first plan (with counties in orange), $SqEnt(\mathcal{C}|\mathcal{D}) = 5.67$, while the second (with counties in green) has $SqEnt(\mathcal{C}|\mathcal{D}) = 6.05$. That means the first one is a little bit better at keeping districts from being overly cut up.

On the other hand, the first plan has $SqEnt(\mathcal{D}|\mathcal{C}) = 1.008$ while the second has $SqEnt(\mathcal{D}|\mathcal{C}) = 2.065$ That means that the first one does a significantly better job of keeping large counties from being chopped up too badly.

Taken together, our penalties read $\mathsf{Split}(\mathcal{D}) = 6.68$ for the first plan and $\mathsf{Split}(\mathcal{D}) = 8.12$ for the second, so a proposed transition from green to orange would automatically be accepted by the algorithm, while a transition in the other direction would occur less often.

6.1.4 Communities of interest and voting rights

Our algorithmic treatment of the problem can activate a feature that labels identified communities of interest as *geoclusters* and treats them like counties within counties. This has the effect that the algorithm can either enact a light preference for steps that do not create a split within these zones, or can require that they be kept intact.

For instance, the city of Philadelphia has two long-recognized historical Black neighborhoods, generally known as West Philadelphia and Southwest Philadelphia, each with several hundred thousand people. We can designate precincts covering those areas to be geoclusters in our algorithms. By freezing them intact, we are able to study districts that are built around these cores. I regard this as substantially more flexible and more responsive to the language of the Voting Rights Act of 1965 than previous algorithmic alternatives, which either constrain minority percentages at previously observed levels or freeze majority-minority districts wholesale. Our algorithmic methods are able to consider any of these alternatives, however, and to confirm that none of these explains the partisan skew of the TS plan.

6.2 Compactness

The most-cited compactness score in the redistricting literature and in expert testimony is the **Polsby-Popper** score A/P^2, which compares area to perimeter. This is sometimes normalized as $4\pi A/P^2$ because the Isoperimetric Theorem guarantees that this quantity varies from 0 to 1 (for all measurable shapes with rectifiable boundaries).

Our primary constraint on compactness in the algorithmic treatment is derived from what mathematicians would call an L^{-1} average Polsby-Popper score: we average the reciprocals of the PP scores of the 18 districts. The reason to average reciprocals instead of the straight scores is to attach a heavier penalty to plans with one extremely low score among the districts. (This averaging is the sense in which I assert that the GOV plan is slightly more compact than the TS plan.)

The **Schwartzberg** score is similar. It is commonly defined as *the ratio of the perimeter of a district to the perimeter of a circle with the same area as the district*, which works out to $\frac{1}{2\sqrt{\pi}} \cdot \frac{P}{\sqrt{A}}$. As such, it is exactly equal to the Polsby-Popper score raised to the $-\frac{1}{2}$ power. That means that the way it ranks districts is completely redundant with the Polsby-Popper score—because exponentiation is order-preserving, *they rank districts exactly the same way.* This is sometimes obscured by the fact that Maptitude, the industry-leading software for redistricting, does not use this formulation to report its Schwartzberg scores. Instead of perimeter, Maptitude uses a notion of "gross perimeter" that was proposed by Schwartzberg himself in the 1960s, when computers were not yet able to report perimeters reliably.

We have additionally defined a discrete compactness score as follows: $\mathsf{Cpct}(D_i) = Pop/BPop^2$, where Pop is the population of the district and $BPop$ is the population of the precincts of the district that are on the boundary with other districts or on the edge of the state. This is a population-based version of the classical Polsby-Popper and Schwartzberg scores, which both compare the area A of a district to the perimeter P of a district via A/P^2, and it is available as a feature in our algorithms.

6.3 Population parity

If Pop_i is the population of district i and I is the ideal district population (i.e., the population of the state divided by 18), then there are several reasonable ways to evaluate the deviation from population parity. For the simple random walk trials I constrained population deviation to 1%, meaning that the only maps considered were those that satisfied

$$.99I \leq Pop_i \leq 1.01I \quad \forall i.$$

When creating a penalty energy, I considered the population deviation score

$$\mathsf{PopDev}(\mathcal{D}) = \sqrt{\left(\frac{Pop_1 - I}{Pop_1}\right)^2 + \cdots + \left(\frac{Pop_{18} - I}{Pop_{18}}\right)^2},$$

which is just the (L^2) distance of the populations from ideal. An L^∞ distance, taking into account only the worst deviation from ideal, is a reasonable alternative.

6.4 Combinations and tuning

For defining an energy to use in a Metropolis-Hastings search, an overall penalty score of a districting plan D can be defined as a linear combination of a county-splitting penalty, a compactness penalty, and a population deviation penalty:

$$\alpha \cdot \mathsf{Split}(D) + \beta \cdot \mathsf{Cpct}(D) + \gamma \cdot \mathsf{PopDev}(D),$$

The weights α, β, γ are arrived at by a tuning protocol: initial runs are made with fixed values for those parameters, compared against runs with other relative weights, until a steady level with a high acceptance ratio is found. This is a standard protocol for tuning parameters in MCMC. We used this combined penalty to explore the space of possible districting plans with the redist package developed by Fifield et al. [3, 4]

7 Appendix: Quantifying partisan skew

There are many metrics for partisan skew that can be found in the literature on redistricting. Two of the most popular are the well-established *mean-median score* and the relatively new *efficiency gap*. Each of these measures the amount of advantage enjoyed by one of the political parties.

To compute each of these scores, we fix a districting plan $\mathcal{D}$ and a geographic distribution of votes Ω. (For instance, $\mathcal{D}$ = the TS plan, and Ω = the Senate16 vote distribution.) Writing V_i^D for the Democratic vote total in district i (and likewise V_i^R for Republicans), we then have $V_i = V_i^E + V_i^R$ for the total major party vote. Let $X_i = V_i^D/V_i$, which is the Democratic percentage of the head-to-head vote.

Then the number of seats awarded to Democrats in plan $\mathcal{D}$ and voting pattern Ω is simply $\#\{i : X_i > \frac{1}{2}\}$.

7.1 Mean-Median score

This is just the mean of the $\{X_i\}$ minus the median. The interpretation is this: the mean Democratic vote share over districts is a proxy for the statewide Democratic vote share. The median is the vote level for which half of the districts have less and half have more than that. A gap of m means that Republicans could earn half of the representation with $\frac{1}{2} - m$ of the statewide vote share. For instance, a mean-median score of .05 means that for Republicans to be awarded half of the representatives, they only need 45% of the vote.

This is the main score relied on in this report. It is the longest-standing and most well established of all the partisan scores. It has many features that make it well-suited to this analysis, such as varying very continuously. I do not intend to endorse it as the most meaningful of partisan scores, but I have selected it as a reliable and uncontroversial score with a long pedigree.

7.2 Efficiency gap

The efficiency gap formula relies on a definition of wasted votes. Suppose that party A loses district i. Then its wasted votes in that district are V_i^A, i.e., all votes were wasted. On the other hand, suppose A wins the district. Then its wasted votes are $V_i^A - \dfrac{V_i}{2}$, the votes cast for that party in excess of what was needed to win. With these definitions, we calculate W^D and W^R, the total wasted votes for each party summed over the districts. Then the efficiency gap is defined as $EG = \dfrac{W^D - W^R}{V}$, which measures the wastage for Democrats minus the wastage for Republicans as a proportion of the total vote in the state.

When this is positive, it means that the map is keyed to waste more Democratic votes. This effect is more exaggerated as EG grows higher. A rule of thumb that was proposed by the creators of the EG score is that magnitudes over .08 should be presumptively disallowed.

As is well-documented in the growing literature on efficiency gap, it is closely tied to the number of seats won by each party. If the voting turnout were equal across districts, then EG would precisely equal $2v - s - \frac{1}{2}$, where v is party A's statewide vote share (head-to-head) and s is party A's fraction of the representation.

However, when turnouts are unequal, the effect of EG is similar, but with different weights to different districts according to their turnout. This is why holding Ω constant it is possible to see different values of EG with the same proportion s of the representation.

7.3 Duke Gerrymandering Index

Finally, the *gerrymandering index* of Mattingly et al can be computed as follows: for a given distribution of voters and a given districting plan $\mathcal{D}$, re-index the

We then adopt the convention that the districts of $\mathcal{D}$ are re-indexed so that D_1 has the lowest Republican head-to-head share against Democrats, with the Republican share increasing up to its highest value D_{18}.

That is, $V_1^R \leq \cdots \leq V_{18}^R$. Then let $V_i^R(\mathbf{E}_\mathcal{D})$ be the median value of V_i^R over the local ensemble based on a districting plan $\mathcal{D}$, and let $V_i^R(\mathcal{D})$ be the value of the initial districting plan. The Duke index is

$$G(\mathcal{D}) = \sqrt{\sum \left(V_i^R(\mathbf{E}_\mathcal{D}) - V_i^R(\mathcal{D})\right)^2}.$$

The simple random walk used here can also report this score, giving yet another piece of persuasive evidence that a plan is a gerrymander.

References

[1] Maria Chikina, Alan Frieze, and Wesley Pegden, *Assessing Significance in a Markov Chain without Mixing*, Proceedings of the National Academy of Sciences, March 14, 2017, vol. 114 no. 11, 2860–2864.

[2] Chikina et al, markovchain package: http://www.math.cmu.edu/∼wes/files/markovchain.tgz

[3] Ben Fifield, Michael Higgins, Kosuke Imai, and Alexander Tarr, *A New Automated Redistricting Simulator Using Markov Chain Monte Carlo*, preprint.

[4] Fifield et al, redist package: https://cran.r-project.org/web/packages/redist/index.html

[5] Greg Herschlag, Robert Ravier, and Jonathan Mattingly, *Evaluating Partisan Gerrymandering in Wisconsin*, preprint. https://arxiv.org/pdf/1709.01596.pdf

8 Appendix: Compactness scores

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
Polsby-Popper	.27	.35	.34	.45	.44	.26	.39	.27	.33
Schwartzberg	1.92	1.7	1.7	1.49	1.5	1.95	1.6	1.93	1.75
Schwartzberg*	1.85	1.68	1.53	1.41	1.47	1.82	1.56	1.85	1.64
Reock	.32	.33	.33	.39	.47	.47	.47	.29	.44
Minimum convex polygon	.7	.69	.66	.91	.81	.71	.88	.82	.78
Population polygon	.88	.75	.84	.9	.7	.71	.77	.7	.86

	D_{10}	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}	D_{16}	D_{17}	D_{18}
Polsby-Popper	.35	.31	.16	.37	.31	.19	.28	.35	.38
Schwartzberg	1.68	1.8	2.49	1.64	1.8	2.29	1.88	1.69	1.62
Schwartzberg*	1.64	1.68	2.29	1.62	1.67	2.21	1.73	1.54	1.54
Reock	.53	.54	.26	.46	.6	.27	.52	.52	.51
Minimum convex polygon	.82	.79	.61	.78	.81	.74	.78	.78	.86
Population polygon	.54	.76	.34	.81	.84	.77	.71	.93	.63

All compactness scores were computed in Maptitude except for *minimum convex polygon*, which was computed in ArcGIS. As noted in §6.2, the built-in Maptitude functionality uses a slightly different definition of the Schwartzberg score than the one commonly defined in expert reports. We use Schwartzberg* to denote the Maptitude Schwartzberg score.

9 Appendix: County and municipality splits

Political Subdivisions Split Between Districts

Thursday February 15, 2018 2:29 PM

Number of subdivisions not split:

County 51

Number of subdivisions split into more than one district:

County 16

Number of subdivision splits which affect *no* population:

County 0

Split Counts

County

Cases where a County is split among 2 Districts: 13

Cases where a County is split among 3 Districts: 3

Number of times a County has been split into more than one district: 19

Total of County splits: 35

County	District	Population
Split Counties :		
ALLEGHENY	12	195,085
ALLEGHENY	14	705,688
ALLEGHENY	18	322,575
BEAVER	3	86,795
BEAVER	12	83,744
BERKS	6	64,981
BERKS	15	218,608
BERKS	16	127,853
BUCKS	8	545,535
BUCKS	13	79,714
CENTRE	5	84,293
CENTRE	9	69,697
CUMBERLAND	4	169,309
CUMBERLAND	11	66,097
DELAWARE	1	417,158
DELAWARE	6	141,821
LEBANON	11	75,179
LEBANON	16	58,389
LEHIGH	8	113,428
LEHIGH	15	236,069
LUZERNE	10	109,700
LUZERNE	17	211,218
MIFFLIN	9	152
MIFFLIN	11	46,530

Page 1

County	District	Population
Split Counties (continued):		
MONTGOMERY	7	705,688
MONTGOMERY	13	94,186
NORTHAMPTON	8	46,725
NORTHAMPTON	15	251,010
PHILADELPHIA	1	288,530
PHILADELPHIA	2	705,687
PHILADELPHIA	13	531,789
SOMERSET	9	16,053
SOMERSET	12	61,689
TIOGA	5	1,886
TIOGA	10	40,095

The count of municipality splits is very sensitive to the precise data source used. We identified municipalities from the US Census place dataset (TIGER files), including all incorporated cities and boroughs.

With these definitions there are 14 municipality splits, though 5 of them are due to the fact that the municipalities themselves cross county lines. By contrast, the currently enacted plan splits 20 municipalities by this definition, with 5 due to municipality/county crosses.

Split municipalities, with districts intersected

Adamstown borough – 6,16
Baldwin borough – 14,18
Bristol borough – 8,13
Carnegie borough – 14,18
Central City borough – 9,12
Clairton city – 14,18
Jefferson Hills borough – 14,18
Philadelphia city – 1,2,13
Plum borough – 12,14
Seven Springs borough 12,18
Shippensburg borough – 4,9
Telford borough – 7,8
Trafford borough – 12,14
Whitehall borough – 14,18

Split precincts, with districts intersected

Split VTDs			
ALLEGHENY	CARNEGIE WD 01 DIST 03	14	237
ALLEGHENY	CARNEGIE WD 01 DIST 03	18	933
ALLEGHENY	INDIANA TWP DIST 04	12	1,250
ALLEGHENY	INDIANA TWP DIST 04	14	104
ALLEGHENY	INDIANA TWP DIST 05	12	875
ALLEGHENY	INDIANA TWP DIST 05	14	402
BEAVER	NEW SEWICKLEY TWP VTD FREEDOM	3	1,942
BEAVER	NEW SEWICKLEY TWP VTD FREEDOM	12	352
BERKS	ONTELAUNEE TWP DIST 01	15	241
BERKS	ONTELAUNEE TWP DIST 01	16	1,405
BERKS	SOUTH HEIDELBERG TWP PCT 01	6	28
BERKS	SOUTH HEIDELBERG TWP PCT 01	16	2,215
BUCKS	BRISTOL VTD WEST ED 01	8	538
BUCKS	BRISTOL VTD WEST ED 01	13	0
BUCKS	BRISTOL VTD WEST ED 03	8	854
BUCKS	BRISTOL VTD WEST ED 03	13	3
CENTRE	PATTON TWP VTD NORTH ED 02	5	2,708
CENTRE	PATTON TWP VTD NORTH ED 02	9	217
CENTRE	PATTON TWP VTD SOUTH ED 03	5	12
CENTRE	PATTON TWP VTD SOUTH ED 03	9	2,578
CUMBERLAND	HAMPDEN TWP PCT 02	4	2,253
CUMBERLAND	HAMPDEN TWP PCT 02	11	12
CUMBERLAND	HAMPDEN TWP PCT 10	4	4,403
CUMBERLAND	HAMPDEN TWP PCT 10	11	0
CUMBERLAND	HAMPDEN TWP PCT 12	4	2,005
CUMBERLAND	HAMPDEN TWP PCT 12	11	645
DELAWARE	HAVERFORD TWP WD 03 PCT 03	1	625
DELAWARE	HAVERFORD TWP WD 03 PCT 03	6	608
DELAWARE	MARPLE TWP WD 03 PCT 03	1	25
DELAWARE	MARPLE TWP WD 03 PCT 03	6	825
LEBANON	WEST CORNWALL TWP	11	938
LEBANON	WEST CORNWALL TWP	16	1,038
LEHIGH	SOUTH WHITEHALL TWP DIST	8	322
LEHIGH	SOUTH WHITEHALL TWP DIST 04	15	1,457
LEHIGH	SOUTH WHITEHALL TWP DIST 05	8	1,661
LEHIGH	SOUTH WHITEHALL TWP DIST 05	15	937
LUZERNE	NEWPORT TWP WD 03	10	495
LUZERNE	NEWPORT TWP WD 03	17	366
MIFFLIN	MENNO TWP Voting District	9	152
MIFFLIN	MENNO TWP Voting District	11	1,731
MONTGOMERY	UPPER MORELAND TWP VTD 02 ED 02	7	1,374
MONTGOMERY	UPPER MORELAND TWP VTD 02 ED 02	13	91
MONTGOMERY	UPPER MORELAND TWP VTD 05 ED 01	7	968
MONTGOMERY	UPPER MORELAND TWP VTD 05 ED 01	13	286
NORTHAMPTON	BETHLEHEM TWP WD 04 DIST 01	8	2,495
NORTHAMPTON	BETHLEHEM TWP WD 04 DIST 01	15	387
NORTHAMPTON	BETHLEHEM TWP WD 04 DIST 02	8	1,043
NORTHAMPTON	BETHLEHEM TWP WD 04 DIST 02	15	921
NORTHAMPTON	PALMER TWP VTD MIDDLE ED 02	8	862
NORTHAMPTON	PALMER TWP VTD MIDDLE ED 02	15	1,309
PHILADELPHIA	PHILADELPHIA WD 31 PCT 10	2	437
PHILADELPHIA	PHILADELPHIA WD 31 PCT 10	13	147
PHILADELPHIA	PHILADELPHIA WD 36 PCT 07	1	29
PHILADELPHIA	PHILADELPHIA WD 36 PCT 07	2	567
SOMERSET	CENTRAL CITY	9	1,124
SOMERSET	CENTRAL CITY	12	0
SOMERSET	CONEMAUGH TWP VTD 03	9	859
SOMERSET	CONEMAUGH TWP VTD 03	12	675
TIOGA	WESTFIELD TWP VTD 01	5	401
TIOGA	WESTFIELD TWP VTD 01	10	646