STATE OF MINNESOTA

SPECIAL REDISTRICTING PANEL

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Peter S. Wattson, Joseph Mansky, Nancy B. Greenwood, Mary E. Kupper, Douglas W. Backstrom, and James E. Hougas, III, individually and on behalf of all citizens and voting residents of Minnesota similarly situated, and League of Women Voters Minnesota,

Plaintiffs,

and

Paul Anderson, Ida Lano, Chuck Brusven, Karen Lane, Joel Hineman, Carol Wegner, and Daniel Schonhardt,

Plaintiff-Intervenors,

vs.

Steve Simon, Secretary of State of Minnesota; and Kendra Olson, Carver County Elections and Licensing Manager, individually and on behalf of all Minnesota county chief election officers,

Defendants,

Frank Sachs, Dagny Heimisdottir, Michael Arulfo, Tanwi Prigge, Jennifer Guertin, Garrison O'Keith McMurtrey, Mara Lee Glubka, Jeffrey Strand, Danielle Main, and Wayne Grimmer,

Plaintiffs,

and

Dr. Bruce Corrie, Shelly Diaz, Alberder Gillespie, Xiongpao Lee, Abdirazak Mahboub, Aida Simon, Beatriz Winters, Common Cause, OneMinnesota.org, and Voices for Racial Justice,

Plaintiff-Intervenors,

vs.

Steve Simon, Secretary of State of Minnesota,

Defendant.

BRIEF SUBMITTED BY

AMICI CURIAE

CITIZEN DATA SCIENTISTS

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INTRODUCTION

Amici are professors, practitioners, and researchers in data science, computer science, mathematics, statistics, and engineering at some of Minnesota's leading institutions of higher education.[1] These "Citizen Data Scientists" are also Minnesota voters who care about a data-driven, nonpartisan, scientific approach to redistricting.[2] They believe such an approach will provide transparency to the redistricting process and lead to redistricting plans that are fair to all Minnesotans. The Panel has permitted the Citizen Data Scientists to submit an *amicus curiae* brief to "describ[e] how mathematical balancing of redistricting principles yields maps that best apply the panel's redistricting principles." (Dec. 6, 2021 Order at 3.)

This brief provides that information, which was derived through the use of *computational redistricting*. Computational redistricting is a relatively new field that uses high-performance computers and optimization algorithms to systematically search through millions of possible combinations of district boundaries and find maps that best effectuate

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[1] No counsel for a party to this proceeding authored this brief in whole or in part. No person or entity, other than counsel for *amici curiae*, made a monetary contribution to the preparation or submission of this brief. *See* MINN. R. APP. P. 129.03. The preparation and submission of this *amicus* brief has been a separate endeavor from the preparation and submission of the redistricting plans that the Citizen Data Scientists provided to the Panel, as members of the public, on November 29, 2021.

[2] The Citizen Data Scientists are Karen Saxe, Paul Zorn, Deanna Haunsperger, Stephen Kennedy, Stephen Polasky, Victor Reiner, Brianna Heggeseth, Lisa Lendway, Shilad Sen, David Van Riper, Jonathan Schroeder, and Tracy Kugler. Among them are two Past Presidents of the Mathematical Association of America, an Associate Executive Director of the American Mathematical Society, a Member of the National Academy of Sciences, and three research scientists from the Minnesota Population Center at the University of Minnesota.

a set of neutral redistricting principles. The Citizen Data Scientists' experts used computational redistricting to develop proposed redistricting plans (separately submitted to this Panel on November 29th), but this brief focuses instead on the broader findings that the computational-redistricting process yielded. Those findings, set out below, are "benchmarks" providing a baseline against which the Panel can evaluate—quickly, efficiently, and transparently—any map submitted to it or drawn by the Panel itself.

ARGUMENT

I. By Systematically Assessing Millions of Potential Maps, Computational Redistricting Provides Benchmarks for Effectuating the Panel's Redistricting Principles.

A. Computational Redistricting Provides Data About Necessary and Unnecessary Tradeoffs Among Redistricting Principles.

Redistricting is a challenging task. It "involves balancing the satisfaction of various criteria, from the mandatory (contiguity) to the discretionary (splitting some cities and counties but not others), and from the quantifiable (equipopulous districts) to the more ineffable (preserving communities of interest)."[3] At some point, each criterion comes into conflict with the others, so improving on one criterion creates "downstream consequences" for other criteria.[4] For example, "[d]eciding to keep a county whole instead of splitting it across two districts changes at least the boundaries of all neighboring districts, and could come at the cost of other redistricting criteria, such as making the map as a whole less compact."[5] Similarly, optimizing population balance often comes at the price of

[3] Emily Rong Zhang, *Bolstering Faith with Facts: Supporting Independent Redistricting Commissions with Redistricting Algorithms*, 109 CAL. L. REV. 987, 1013 (2021).
[4] *Id.*
[5] *Id.*

diminished respect for political subdivisions. Or compactness might need to be de-emphasized to keep communities of interest together, or vice versa.

The traditional way to try to find maps with the right balance among competing redistricting principles has been through trial and error, with a mapmaker using commercial software like Maptitude to move district lines one at a time. But drawing maps by hand is both time-consuming and fundamentally limited, putting actual optimization out of reach. Indeed, "[a] single decision" in the map-drawing process can have "implications for the rest of the map that even seasoned line-drawers cannot always fully account for or predict."[6] "[A] data point of one [map] can be highly unreliable and idiosyncratic, especially in an enterprise as complex as redistricting."[7] And having 10 or 20, or even 100, data points is not much better when the challenge is identifying not just a "good" or "very good" map, but an "excellent" one.

The field of computational redistricting that has developed over the past decade is a game-changer. The high-performance computing and algorithmic optimization techniques involved in computational redistricting take the Census Bureau's latest demographic and geographic data, systematically construct a sample of "the astronomical number of ways in which a state can be partitioned," and then sort through millions of alternatives to "zero in on the maps that best meet the redistricting criteria."[8] In this way, a "computer program

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[6] *Id.*

[7] Bruce E. Cain, *et al.*, *A Reasonable Bias Approach to Gerrymandering: Using Automated Plan Generation to Evaluate Redistricting Proposals*, 59 WM. & MARY L. REV. 1521, 1536 (2018).

[8] Zhang, *supra*, at 1013; *see also, e.g.*, Siobhan Roberts, *Mathematicians Are Deploying Algorithms to Stop Gerrymandering*, MIT TECHNOLOGY REVIEW (Aug. 12, 2021),

essentially substitutes for a very large body of neutral experts and the viable, neutral maps they draw. By programming neutral redistricting criteria, such as the preservation of extant communities, compactness, contiguity, and adherence to one-person, one-vote guidelines, a computer algorithm can generate a very large set of neutral redistricting plans that by design are not influenced by partisanship, and take as given the natural gerrymandering effect—if any—of the underlying demographics."[9]

This approach is particularly valuable in a dynamic state like Minnesota, where a decade-old map is about as useful as a decade-old phonebook. Minnesota's population has grown and shifted, and its makeup has changed substantially in the ten years since the Panel's predecessor adopted the current redistricting plans. Thus, one cannot possibly sort out the tradeoffs among criteria and find maps presenting the right balance merely by tinkering with the 2012 maps, or by comparing this year's proposed maps to the 2012 maps. Given Minnesota's population changes, a "good" or even "excellent" score on a given redistricting principle in 2012 may—or may not—be "good" or "excellent" now.

Exploring millions of map iterations not only can identify high-quality maps, but also can yield information that is valuable to the redistricting process more generally. By systematically sorting through a very large number of plans, computational redistricting

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https://www.technologyreview.com/2021/08/12/1031567/mathematicians-algorithms-stop-gerrymandering/; Moon Duchin, *Geometry Versus Gerrymandering: Mathematicians Are Developing Statistical Forensics to Identify Districts that Disenfranchise Voters*, SCIENTIFIC AMERICAN, Nov. 2018, https://www.scientificamerican.com/article/geometry-versus-gerrymandering/; Amariah Becker, Moon Duchin, Dara Gold & Sam Hirsch, *Computational Redistricting and the Voting Rights Act*, 20 ELECTION L.J. (forthcoming 2022), https://www.liebertpub.com/doi/10.1089/elj.2020.0704.

[9] Cain, *et al.*, *supra*, at 1536–37.

reveals the tradeoffs between the redistricting criteria and the levels at which specific criteria can be attained in balance with other criteria.[10]

This is the information set forth in this brief: benchmarks to help the Panel separate those maps that do well on all criteria, given Minnesota's current demography and geography, from maps that unnecessarily fall short on one or more criteria. A map that meets (or exceeds) not just one of the benchmarks described below but *all* of them approaches what scholars call "Pareto optimality"—where no single principle can be further improved without worsening the map as to one or more other principles. That is the gold standard to which the Panel can aspire.

B. The Panel Can Use Empirically Derived Benchmarks to Effectuate Its Redistricting Principles.

Before cataloguing the benchmarks, a bit of terminology will be helpful. As used in this brief, a redistricting *principle* (or criterion) articulates a goal or aim, such as those featured in the Panel's November 18 Order: population equality, minority electoral opportunity, contiguity, respect for political subdivisions, respect for communities of interest, and reasonable compactness.

A *metric* is a precise, quantifiable measure of how well a district, or an entire map, pursues the goal set forth in a redistricting principle. For example, population equality is a principle, and maximum population deviation (the difference between a plan's largest and smallest districts) is a metric. This top-to-bottom deviation metric can be expressed either as a number of persons (so a map in which all districts contain either 713,311 or

[10] *Id.* at 1537; Zhang, *supra*, at 1013–15.

713,312 residents has a maximum population deviation of one person) or as a percentage of the population of an ideal district (for example, 1 person divided by 713,312 persons is 0.00014%). Most of the metrics described below, including the metric for the principle of population equality, are like golf scores: the lower, the better. A few, however, like the metrics used to measure compactness, are like hockey scores: the higher, the better.

Every metric can be improved up to a certain point without doing significant harm to competing metrics so long as the mapmaker explores a very broad range of possibilities (as a computational redistricter does). But at some point, the possibilities narrow, so that one cannot improve any particular metric any further without doing significant damage to some other metric, and thus to some other redistricting principle. By carefully considering the tradeoffs and the historical priorities of Minnesota redistricting, *Amici* have identified a *benchmark* for each metric—a "standard of excellence." These standards can be simultaneously satisfied in numerous and varied ways; but once a benchmark is reached for any given metric, it may become difficult or impossible to meaningfully improve on the principle associated with that metric without doing harm to other principles and metrics.

Good mapmaking (which, again, is far more likely when assisted by high-performance computers) should strive to improve any metric *at least* up to the point where the benchmark is attained. Indeed, because these standards are in line with Minnesota's historical priorities and are simultaneously achievable but are difficult to simultaneously improve further, any redistricting plan that falls short of any of these benchmarks on any metric should be rejected.

Whether to push *beyond* the benchmark on any particular metric is a question the Panel, exercising its equitable discretion, is free to consider. But improving one metric beyond its benchmark level typically will cause a map to suffer, at least marginally, on another metric and thus make the map as a whole stronger on the first principle at the expense of making it somewhat weaker on one or more other principles. That is the sort of tradeoff that may or may not be acceptable under the circumstances; evaluation of these tradeoffs is part of what has been entrusted to this Panel's sound judgment.

By contrast, deciding to forgo any of these standards of excellence would be an avoidable error. Because these benchmarks closely reflect the Panel's priorities, have been optimized with the full power of computational redistricting, and are demonstrably achievable, there is no valid reason to settle for less. A map that is truly fair to all Minnesotans will achieve all of the below standards of excellence.

II. Redistricting Plans Should Achieve Each of the Benchmarks Identified Through Computational Redistricting.

With this framework as background—and with the terms *principle* (or criterion), *metric*, and *benchmark* now defined—this brief next identifies the key benchmarks for Minnesota congressional, senate, and house redistricting plans under the 2020 Census redistricting data. The Panel can use these benchmarks to identify, and discard, plans that do not actually achieve all the Panel's stated redistricting principles to a reasonable degree. The Citizen Data Scientists recommend that the Panel refuse to consider such maps and instead focus on maps that do satisfy all the benchmarks. There should be no shortage of

the latter, as there are many alternative maps—for all three offices (congressional, senate, and house)—that comply with every single one of these benchmarks.

The following sections provide thorough explanations of what each benchmark means. And for the Panel's convenience, *Amici* have summarized all their numerical benchmarks in a Table of Standards of Excellence at the end of this section.

A. Population Equality

The Panel's first redistricting principle is population equality. The best metric for the principle of population equality is the plan's *maximum population deviation*, which the U.S. Supreme Court has defined as "the sum of the percentage deviations from perfect population equality of the most- and least-populated districts." *Evenwel v. Abbott*, 136 S. Ct. 1120, 1124 n.2 (2016). "For example, if the largest district is 4.5% overpopulated, and the smallest district is 2.3% underpopulated, the map's maximum population deviation is 6.8%." *Id.*

For a court-ordered congressional redistricting plan, the Panel is requiring a one-person maximum population deviation, with either 713,311 or 713,312 people residing in each of Minnesota's eight districts. (Nov. 18, 2021 Order ["Principles Order"] at 5.) This standard is simple to articulate, and it is easy to determine whether a map satisfies it. But this level of strict population equality has tradeoffs for virtually every other redistricting principle. As a result, the key question is the level at which a congressional map that achieves one-person deviation *also* can achieve all other criteria. The benchmarks identified in the remaining sections for congressional maps all can be attained with a one-person population deviation.

For legislative districts, the Panel has concluded that it must achieve "a high standard of population equality." (*Id.* at 6.) Accordingly, "[s]ome deviation from perfect population equality is permissible," but only to "accommodate [the] state's clearly identified, legitimate policy objectives"—which presumably include the neutral redistricting principles the Panel has articulated. (*Id.*) As a result, the goal is "de minimis deviation," but a district may deviate by up to "two percent from the population of the ideal district"—that is, a 4% maximum population deviation—where doing so is necessary to accommodate the Panel's other principles. (*Id.*) The Panel also properly refused to set a level of population inequality "[below] which all population deviations will be presumed acceptable." (*Id.*)

Although this metric is straightforward to measure, it is difficult to identify the "right" level of population deviation within the Panel's plus-or-minus 2% limit. A legislative redistricting plan that has the best possible population balance (like a congressional plan must have) achieves that feat only by sacrificing better compliance with other redistricting principles, such as respect for counties, cities, townships, and communities of interest. After all, Minnesotans do not live in neat, compact, contiguous chunks of 85,172 people (in the case of senate districts) or 42,586 people (in the case of house districts).

The central question under the Panel's Order, then, is what level of population deviation is *necessary* to accommodate the Panel's other redistricting principles. (*See id.* at 6–7.) The Citizen Data Scientists' benchmarks, derived from millions of maps using demographic and geographic data from the 2020 Census, answer that precise question. The

Citizen Data Scientists have found that all the Panel's redistricting principles can be achieved without coming anywhere close to a 4% maximum population deviation (plus or minus 2%). Specifically, the Citizen Data Scientists have found that a maximum population deviation of 1.40% (plus-or-minus 0.70%) in a state house map is always compatible with high scores on metrics for the Panel's other redistricting principles. Sometimes population deviations significantly better than that level also can be compatible. But it is unnecessary to accept—and *Amici* recommend that the Panel flatly reject—any house map with a maximum population deviation that *exceeds* 1.40%.

Because house districts are nested in senate districts, the maximum population deviation is almost always larger for a house plan than for a senate plan. Accordingly, the benchmark for a senate map is 1.22% (plus-or-minus 0.61%). Again, *Amici* see no valid reason to accept any senate map with a maximum population deviation that exceeds this benchmark. Of course, house or senate maps with maximum population deviations *below* these 1.40% and 1.22% benchmarks are preferable (since the population-deviation metric is like a golf score—lower is better), so long as the map also satisfies the benchmarks for the Panel's other redistricting principles.

B. Contiguity

The Panel requires districts in both the legislative and congressional maps to "consist of contiguous territory," with contiguity by water generally sufficing but areas touching at only a single point being deemed non-contiguous. (Principles Order at 6–7.) Certainly, tradeoffs must be made to achieve contiguity, but contiguity is a state requirement (*see id.* at 6 (citing MINN. CONST. art. IV, § 3, and MINN. STAT. § 2.91, subd. 2)) and a nearly universal

requirement throughout the United States, *see* Redistricting Criteria, National Conference of State Legislatures (July 16, 2021), https://www.ncsl.org/research/redistricting/redistricting-criteria.aspx (last visited Dec. 7, 2021).

The Citizen Data Scientists' computational-redistricting process shows that it is entirely possible to keep all districts contiguous while satisfying all the benchmarks, set forth in this brief, that are tied to the Panel's other redistricting principles. The Panel should reject any proposed map that has non-contiguous districts.

C. Minority Electoral Opportunity

Consistent with the Voting Rights Act, the Panel has stated that "[d]istricts must not be drawn with either the purpose or effect of denying or abridging the voting rights of any United States citizen on account of race, ethnicity, or membership in a language minority group." (Principles Order at 6.) Accordingly, districts are to be "drawn to protect the equal opportunity of racial, ethnic, and language minorities to participate in the political process and elect candidates of their choice, whether alone or in alliance with others." (*Id.*) This principle is particularly important given how Minnesota's population has grown in the last decade, with the majority of that growth coming from individuals identifying as something other than "White alone." Although our state's overall population increased from 2010 to 2020 by 7.6%, the "White alone" category *decreased* by 2.2% over the same decade.[11]

[11] Written Statement to Special Redistricting Panel of Dr. Shilad Sen (a Citizen Data Scientist), at 1–2 (citing "Minnesota's Population at 5,706,494 in 2020, Up 7.6% Since 2010," Aug. 25, 2021, https://www.census.gov/library/stories/state-by-state/minnesota-population-change-between-census-decade.html).

In states with even larger minority percentages than Minnesota, the inquiry into whether a redistricting plan offers minority group members an equal opportunity to elect candidates of their choice can be extraordinarily complex. That inquiry typically turns on whether there are statistically significant patterns of racial polarization in voting. In Minnesota, however, *Amici*'s experts have found no statistical evidence suggesting such high levels of polarization. To the contrary, the available evidence suggests that members of Minnesota's larger racial, ethnic, and language minority groups typically coalesce and form political alliances, and those efforts often succeed.

In Minnesota, then, mapmakers have typically resorted to a rule of thumb that focuses on whether a district's voting-age population, or VAP, is more than 30% minority, defined as a combination of all racial, ethnic, and language minorities reported in the Census redistricting data. *E.g.*, Parties' Plan Submissions in *Hippert, available at* https://www.mncourts.gov/Media/Historic-High-Profile-Cases/Special-Redistricting-Panel-2011.aspx; 2021 Legislative Redistricting Proposals, *available at* https://gis.lcc.mn.gov/redist2020/plans.html. Although this rule of thumb alone would not suffice to resolve a litigated Voting Rights Act case, the Citizen Data Scientists have confirmed that it roughly tracks a set of districts, mostly in the Twin Cities, where minority-preferred candidates routinely prevail in both primary and general elections. This is a metric of the "hockey" variety where, all things equal, a plan with more minority opportunity districts is better.

The Citizen Data Scientists' computational-redistricting work has found that reasonable benchmarks for minority districts—defined here as districts having at least a

30% combined-minority VAP—are no fewer than two congressional districts (out of 8), 10 senate districts (out of 67), and 20 house districts (out of 134). Having computationally created millions of alternative maps, *Amici* see no reason to accept any plan that falls short of these minority-opportunity benchmarks.

D. Respect for American Indian Reservation Lands

The Panel has recognized the importance of "preserving the reservation lands of federally recognized American Indian tribes." (Principles Order at 14.) Out of "[r]espect for the inherent sovereignty of American Indian tribes," the Panel has ruled that maps must "avoid dividing reservation land more than necessary to meet constitutional requirements" (*id.* at 15), and that "[p]lacing discontiguous portions of reservation lands in separate districts does not constitute a division" (*id.* at 6).

The computational-redistricting process demonstrates that it is possible, for both legislative and congressional maps, to keep the contiguous, populated reservation lands of each tribe intact in a district. Indeed, for the congressional map, it is also possible, without unduly sacrificing any other redistricting principle, to keep in the same congressional district all people who live on the same reservation, even where the reservation has discontiguous portions. With respect to the legislative maps, the Citizen Data Scientists have found that it is possible not to split any contiguous reservation lands, as that can be accomplished while still achieving all other redistricting metrics at the levels described in this brief. The Citizen Data Scientists therefore see no good reason to adopt any map that splits contiguous portions of any tribe's reservation lands across separate districts.

E. Respect for Political Subdivisions

The Panel has held that "[p]olitical subdivisions must not be divided more than necessary to meet constitutional requirements." (Principles Order at 7.) Prior Special Redistricting Panels focused on counties and county subdivisions (in other words, a county's cities and townships), all of which are "political subdivisions" under Minnesota law. *Hippert v. Ritchie*, 813 N.W.2d 374, 379 (Minn. 2012) ["*Hippert* (Legislative)"] (citing MINN. STAT. § 2.91, subd. 2). This Panel also has asked for data concerning voting districts (in other words, precincts, or Census Bureau VTDs) (Principles Order at 11), which are not political subdivisions under Minnesota law.

The Citizen Data Scientists offer two types of metrics here. The first is the number of areas (counties, county subdivisions, or voting districts) divided across multiple districts. The second is the number of such areas divided across more than two (*i.e.*, three or more) districts, as well as the number divided across more than three districts. The focus is on reducing the number of divided areas (and the extent to which they are divided) at least until doing so might start significantly constraining the map's ability to accomplish the Panel's other redistricting principles.

For counties, there is no good reason, at our recommended population-deviation levels, to split more than 8 counties in an 8-district congressional plan, 38 counties in a 67-district senate plan, or 45 counties in a 134-district house plan.[12] Not surprisingly, as the

[12] *Amici*'s benchmarks for county, county-subdivision, and precinct splits are arguably inflated because they include splits that affect zero population. Comparing these benchmarks to numbers that (as is often done) exclude zero-population splits would be an "apples to oranges" comparison and thus should be avoided.

number of districts in a map increases, the number of split counties generally must increase, too. For the congressional plan, it is unnecessary to split more than one county across more than two districts, and that one county should not be split across more than three districts. The only county that might reasonably be divided across three congressional districts is Hennepin, Minnesota's most heavily populated county. For senate plans, it is unnecessary to split more than 31 counties across more than two districts, or more than 11 counties across more than three districts. For house plans, it is unnecessary to split more than 33 counties across more than two districts, or more than 26 counties across more than three districts.

As for cities and townships within a county (which the Census Bureau labels "county subdivisions"), *Amici*'s computational-redistricting work found no good reason to split more than 9 county subdivisions in an 8-district congressional plan, 55 in a 67-district senate plan, or 70 in a 134-district house plan. And there is no good reason to divide across more than two districts any more than 22 county subdivisions in a senate plan or 36 county subdivisions in a house plan. In a congressional plan, within a county there is no good reason to divide *any* city or township across more than two districts. After all, as discussed below in Part II.F, Minneapolis and Saint Paul each can easily be kept intact in its own congressional district, so there clearly is no reason to trisect either of them—or any other city or township—in a congressional plan.

As for voting districts (precincts or VTDs), which are not "political subdivisions" but still should not be needlessly fragmented, *Amici* found it was unnecessary to divide more than 9 precincts in a congressional plan, 120 precincts in a senate plan, or 180 precincts in a house plan.

F. Respect for Communities of Interest

The Panel has called for redistricting plans to preserve "[c]ommunities of people with shared interests" when possible to do so consistent with other redistricting principles. (Principles Order at 7.) Communities of interest "include, but are not limited to, groups of Minnesotans with clearly recognizable similarities of social, geographic, cultural, ethnic, economic, occupational, trade, transportation, or other interests." (*Id.*)

Determining whether a community is defined by actual shared interests, and identifying precise boundaries for that community, can be difficult. Genuine input from residents of certain communities, however, can be very helpful in defining their existence and geographic scope. Fortunately, testimony at the Panel's recent public hearings, as well as decisions from Panels in prior decades, can help to define communities that are widely acknowledged by Minnesotans.

One particularly clear example is the Iron Range, which encompasses Aitkin, Carlton, Cook, Itasca, Koochiching, Lake, and St. Louis Counties. The Iron Range is a meaningful regional community defined by actual shared interests that redistricters should respect. *Hippert* (Legislative), 813 N.W.2d at 385. And, with the occasional exception of Aitkin County, the Iron Range has been kept intact in a single district in every congressional plan since Minnesota became a state in 1858. *See* Historical Congressional Maps, Legis. Coordinating Comm'n Geographic Info. Servs., https://www.gis.lcc.mn.gov/html/maps/leg_districts.html (last visited Dec. 8, 2021). The Citizen Data Scientists found that it was unnecessary, while satisfying all the Panel's other

principles, to divide the Iron Range across more than 1 congressional district, 7 senate districts, or 13 house districts.

Another recognizable regional community of interest is the Twin Cities metropolitan area (an 11-county area precisely defined in Minnesota's election code), which is distinct from Greater Minnesota. *See Hippert v. Ritchie*, 813 N.W.2d 391, 397–99 (Minn. 2012) ["*Hippert* (Congressional)"]; *Hippert* (Legislative), 813 N.W.2d at 381–82, 385; MINN. STAT. § 200.02, subd. 24. *Amici* found that all the redistricting benchmarks can be achieved in maps that have no greater than 3 congressional districts, 4 senate districts, or 7 house districts that reach across this regional boundary to encompass parts of both the 11-county Metro area and Greater Minnesota.

Within the Metro area, it is unnecessary to combine any part of Minneapolis with any part of Saint Paul in any district, whether in a congressional or legislative map. And at the congressional-district level, there is never a need to split either of the Twin Cities, as each can be kept intact to anchor its own congressional district, while fully complying with the Panel's other redistricting principles. Although the same is not true for the much smaller senate and house districts, respect for the Panel's redistricting principles does not justify splitting Minneapolis or Saint Paul across more than 9 senate districts or 7 senate districts, respectively, or across more than 15 house districts or 11 house districts, respectively. (Minneapolis's population is larger than Saint Paul's, so it can reasonably absorb more legislative districts.)

And as the 2012 Panel noted, within these large urban areas, redistricters can take guidance from the officially designated "neighborhoods" of Minneapolis and "planning

districts" of Saint Paul. *See Hippert* (Congressional), 813 N.W.2d at 396; *Hippert* (Legislative), 813 N.W.2d at 380, 384–85. These official neighborhoods are truly communities defined by actual shared interests, as well understood by their respective city governments. *Amici* found that it was unnecessary to split more than 5 or 10 Minneapolis neighborhoods in a senate or house map, respectively, or to split more than 3 or 5 Saint Paul planning districts in a senate or house map, respectively.[13]

Of course, the benchmarks provided above do not come close to exhausting the possible universe of legitimate communities of interest in a state as large and diverse as Minnesota. The Panel can and should consider other communities of interest, like the ones following transportation routes, such as the Interstate-90 corridor that runs the full length of southern Minnesota or the Interstate-94 corridor that connects Moorhead to Fergus Falls to Alexandria to Saint Cloud and then to the Metro area. *See Hippert* (Congressional), 813 N.W.2d at 401. And as alluded to earlier, the Panel should be particularly attentive to Minnesota's diverse and growing communities of color, to the ways each of those communities identifies itself and its home territory, and to the social and political alliances they have been cultivating for the common good of all Minnesotans.

[13] Because neither city restricts itself to official Census geography when drawing these neighborhoods or planning districts, some of them contain a part of a single Census block, which is the smallest unit of geography that the Census uses. This is especially true along lakefronts. The neighborhood and planning-district benchmarks in this brief ignore partial blocks.

G. Compactness

This Panel has indicated that it will consider reasonable geographic compactness "[a]s a factor subordinate to all other redistricting principles." (Principles Order at 7.) The Panel correctly recognized that, although "[n]o federal or state law requires that districts be compact," compactness can be "a tool for ensuring districts have been drawn in accordance with neutral redistricting principles." (*Id.* at 15.)

The Panel has selected five compactness metrics: Polsby-Popper, Area/Convex Hull, Reock, Population Circles, and Population Polygon. (*Id.* at 11.) Each of these measures has different strengths and weaknesses, and no single compactness measure should be considered the most important.[14] And because it is best to consider the entire map and not just the map's worst feature, *Amici* focus here on each map's mean, or average, compactness score. The mean score weighs each district in the map equally.

Academics have rigorously debated the merits of the various compactness measures that the Panel has chosen (and others). But ultimately, these measures involve two key considerations. The first is whether the measure pays attention only to area or whether the measure also looks at the dispersion of population across that area.[15] And the second is what kind of noncompactness the measure focuses on: jaggedness, elongation, or concavity.[16]

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[14] *See, e.g.*, Written Statement to Special Redistricting Panel of Dr. Karen Saxe (a Citizen Data Scientist), at 1.

[15] *See* Carl Corcoran & Karen Saxe, *Redistricting and District Compactness*, 624 CONTEMPORARY MATHEMATICS 1, 3 (2014).

[16] *Id.*

Of the Panel's five measures, Polsby-Popper is the one that focuses only on area and especially on jaggedness. It would, for example, give a good score (a perfect 1, in fact) to a district that was circular, while giving a poor score to a district shaped like a gear, because, although roughly circular, its edge is quite jagged.[17] Two other measures that focus on area, without regard to where people reside, are Area/Convex Hull and Reock. For Area/Convex Hull, imagine a rubber band stretched around the boundary of a district, and then imagine calculating the fraction of the rubber-banded area that the district occupies.[18] This measure focuses on concavity, or inward curvature. So a crescent moon, which is neither jagged nor elongated, scores poorly because so much of the area that would be bounded by a rubber band stretched around a crescent-moon-shaped district would fall outside, rather than within, the district itself.[19] The Reock measure is also area-based but focuses on elongation rather than concavity or jaggedness.[20] Here, imagine placing a circular hoop, rather than a rubber band, around the district. A district shaped like a pencil might get a good Polsby-Popper score because its perimeter is not jagged, as well as a good Area/Convex Hull score because it is convex; but the same district would get a poor Reock score because it is elongated and occupies only a small fraction of the area encompassed by a circular hoop circumscribing the pencil-shaped district.[21]

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[17] Saxe Statement, *supra*, at 2.

[18] Anthony E. Pizzimenti, *Compactness: A Mathematical Introduction*, at 9 (Jan. 5, 2021), *available at* https://myweb.uiowa.edu/apizzimenti/files/documents/compactness.pdf.

[19] *Id.* at 9–10.

[20] *See id.* at 8.

[21] *See id.* at 8–9.

The Population Polygon and Population Circle measures focus on population rather than area. They are roughly analogous to the Area/Convex Hull and Reock measures, respectively, except that instead of treating every acre (or on a map, maybe every square inch) the same, the focus is now on how many people are within or outside the district.[22] So, the crescent moon-shaped district would score better on the Population Polygon measure if the area surrounded by the crescent were rural and sparsely populated, and it would score worse if the area surrounded by the district were urban and densely packed. This measure thus penalizes districts that were drawn to evade population centers. And an analogous concept would apply to the Population Circle measure if the half-circles on either side of the pencil-shaped district were lightly, or heavily, populated.[23]

Each of the five compactness measures described above runs from a score of 0 (bizarrely noncompact, like a "Rorschach test" district) to 1 (extremely compact, like a perfectly circular district). Thus, compactness is a "hockey" metric, where high scores are preferable. But the question is how high each score can go without diminishing the map's adherence to the Panel's other, more important redistricting principles. The answer depends, one would think, on both the type of metric and the type of map. As for the type of metric, the rubber-band scores—Area/Convex Hull and Population Polygon—tend to run much closer to 1 than the circular-hoop scores. That makes sense because the area encompassed by a circular hoop stretched around a shape will always be at least as large, and sometimes much larger, than the area encompassed by a rubber band stretched around

[22] Corcoran & Saxe, *supra*, at 4.

[23] *See id.*

the same shape. As a result, the circle-based scores have larger denominators and thus come out lower (*i.e.*, closer to 0 than to 1). However, as the computational-redistricting process revealed, the second factor, the type of map, has little impact on compactness scores, given Minnesota's geography.

The Citizen Data Scientists' computational-redistricting process revealed that the only metric that seems to vary consistently by type of map is the Polsby-Popper measure, where the smaller house districts tend to score a bit better than the larger senate or congressional districts. This may be because the perimeters of the smaller house districts are less dependent on features like rivers and other bodies of water that sometimes form Minnesota's state or county boundaries.

The Citizen Data Scientists' computational-redistricting process revealed that for Polsby-Popper (the jaggedness measure), the benchmarks are 0.30 for congressional and senate maps and 0.35 for house maps. The benchmarks for the circular-hoop (or elongation) metrics—Reock and Population Circle—are 0.40 for all three types of maps (congressional, senate, and house). And the benchmarks for the rubber-band (or concavity) metrics—Area/Convex Hull and Population Polygon—are 0.70 for all three types of maps. Because each of these benchmarks can be achieved in a map that also achieves the Panel's other redistricting principles, there is no good reason to consider, much less accept, any map that falls short on any of these compactness benchmarks.

H. Table of Standards of Excellence

At this point, we have listed the Panel's redistricting principles, developed one or more quantitative metrics for measuring adherence to each principle, and provided a

benchmark for each metric. Again, each benchmark is designed to serve as an absolute threshold. There is no reason to accept any map that falls short on any benchmark, because computational redistricting, the systematic creation and evaluation of millions of alternative maps based on Minnesota's geography and 2020 Census data, shows that there is simply nothing to be gained by falling short. Once the Panel confines itself to maps that meet each and every one of the benchmarks, the Panel can exercise its discretion to choose among those maps, as each one will be not only lawful but also highly respectful of the neutral redistricting principles that this Panel—after extensive briefing and oral argument by the parties—affirmatively selected.

For the Panel's convenience, *Amici* have summarized all the benchmarks in the following Table of Standards of Excellence. The handful of "hockey" metrics, like the number of minority opportunity districts and the five compactness scores, are italicized to show that a higher number is preferable—meaning the benchmarks are minimums, not maximums, and a good map will likely *exceed* these benchmarks. For all the metrics in regular typeface, the "golf" metrics, a lower number is preferable—meaning the benchmarks are maximums, not minimums, and a good map will have a lower score (just as a good golfer aspires to a "below par" score).

Redistricting Principle (all caps) & Metric(s)	Congressional Benchmarks	Senate Benchmarks	House Benchmarks
POPULATION EQUALITY: Maximum population deviation.	1 person, or 0.00014%.	1040persons, or 1.22%	596 persons, or 1.40%
MINORITY OPPORTUNITY: *Number of districts with at least a 30% minority voting-age population.*	2	10	20
INDIAN RESERVATIONS: Number of divisions of contiguous portions of a tribe's reservation lands.	0	0	0
CONTIGUITY: Number of districts containing more than one "distinct area."	0	0	0
POLITICAL SUBDIVISIONS:			
• Number of counties divided.	8	38	45
• Number of counties divided into > 2 districts.	1	31	33
• Number of counties divided into > 3 districts.	0	11	26
• Number of county subdivisions (cities and townships) divided.	9	55	70
• Number of county subdivisions (cities and townships) divided into >2 districts.	0	22	36
PRECINCTS: Number of voting districts divided.	9	120	180
COMMUNITIES OF INTEREST:			
• Number of districts with Minneapolis residents.	1	9	15
• Number of splits of Minneapolis neighborhoods.	0	5	10
• Number of districts with Saint Paul residents.	1	7	11
• Number of splits of St. Paul planning districts.	0	3	5
• Number of districts containing both Minneapolis and Saint Paul residents.	0	0	0
• Number of districts containing both Metro area and Greater Minnesota residents.	3	4	7
• Number of districts with Iron Range residents.	1	7	13
COMPACTNESS:			
• *Mean Polsby-Popper.*	0.30	0.30	0.35
• *Mean Area/Convex Hull.*	0.70	0.70	0.70
• *Mean Reock.*	0.40	0.40	0.40
• *Mean Population Polygon.*	0.70	0.70	0.70
• *Mean Population Circle.*	0.40	0.40	0.40

III. Congressional, Senate, and House Redistricting Plans Can Simultaneously Satisfy Every Single One of the Benchmarks.

Given the length of this Table of Standards of Excellence, one might ask whether it is actually possible to simultaneously satisfy all these benchmarks—and thus fulfill the promise of the neutral redistricting principles articulated by the Panel in its November 18 Order. The answer is a definitive "Yes." Indeed, that is the whole point of the Citizen Data Scientists' methodology: Computational redistricting and its systematic evaluation of millions of alternative maps ensure that each one of these benchmarks is attainable without rendering it impossible to attain the others.

Of course, it may be impossible for even a skilled mapmaker, armed with Maptitude for Redistricting or other standard software, to find a map that meets or exceeds all the benchmarks within a day, a week, or even a month. But a properly programmed high-performance computer can do it in a matter of hours. And there is no single unique solution to this problem of multi-objective optimization. So the Panel may find that it can choose among three or four or more maps that are all "excellent."

In their papers seeking leave to file this brief, the Citizen Data Scientists stated that they would not use this brief to describe the congressional, senate, and house maps that they submitted, as members of the public, on November 29 to the Panel, all parties to this proceeding, the Governor, and the Chairs of the Senate and House Redistricting Committees. *Amici* need not do that because it will be easy for the Panel to confirm that those maps collectively meet 20 of the benchmarks in the above Table, exceed the other 46 benchmarks in that Table, and fall short on zero benchmarks. It is *Amici*'s hope that the

maps that they provided (with block-equivalency files) more than a week ago to the Panel and the parties contain useful features that can be incorporated, modified, or even improved upon. Because of *Amici*'s maps submission, the benchmarks set forth in this brief should not come as a surprise to the parties—and that transparency was one of *Amici*'s goals.[24] The purpose of this brief is simply to give the Panel specific, objective, scientific bases on which to evenhandedly evaluate all plan submissions and any maps the Panel itself might create.

CONCLUSION

In the end, what matters most is that Minnesotans enjoy fair and effective representation in both Congress and the Legislature for the next decade. That depends in great part on having fair maps that are grounded in the neutral redistricting principles that this Panel articulated in its November 18 Order. The Citizen Data Scientists respectfully submit that the best way to be confident that any particular redistricting plan fulfills those principles is to satisfy the benchmarks presented in this *amicus* brief. *Amici* greatly appreciate the opportunity to provide this information to the Honorable members of this Panel and to our fellow citizens of the State of Minnesota.

[24] The Citizen Data Scientists distributed their plans to the parties eight days before the parties' own maps were due to the Panel—almost as long as the Citizen Data Scientists and their experts had to study and implement the redistricting principles from the Panel's November 18 Order.

Dated: December 8, 2021

Respectfully submitted,

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CERTIFICATION OF COMPLIANCE WITH MINN. R. APP. P. 132.02(3)(c)(1)

The undersigned hereby certifies that this Brief Submitted by *Amici Curiae* Citizen Data Scientists complies with the word count limitation set forth in Minnesota Rule of Appellate Procedure 132.02(3)(c)(1). Specifically, the Brief contains 6,917 words, calculated using the word-count feature in Microsoft Word 365, including all footnotes and the Table set forth on page 24, but excluding the case caption, the tables of contents and authorities, and the signature block.

Dated: December 8, 2021

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