Arizona Criteria

Adjustments to the grid shall then be made as necessary to accommodate the goals as set forth below:

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b. Congressional districts shall have equal population to the extent practicable, and state legislative districts shall have equal population to the extent practicable;

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e. To the extent practicable, district lines shall use visible geographic features, city, town and county boundaries, and undivided census tracts;

f. To the extent practicable, competitive districts should be favored where to do so would create no significant detriment to the other goals.

Today's Presentation

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NDC
National Demographics Corporation

TIMMONS GROUP
ENGINEERING | DESIGN | TECHNOLOGY

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Contiguity

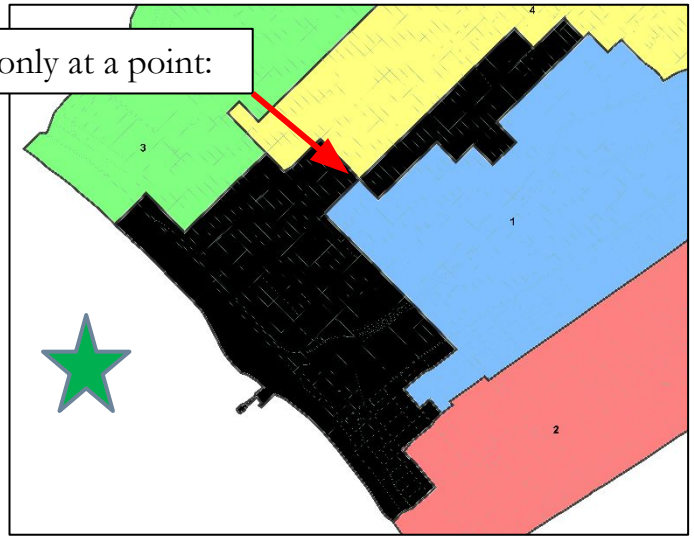
c. Districts shall be geographically compact and contiguous to the extent practicable;

Three Definitions of Contiguity

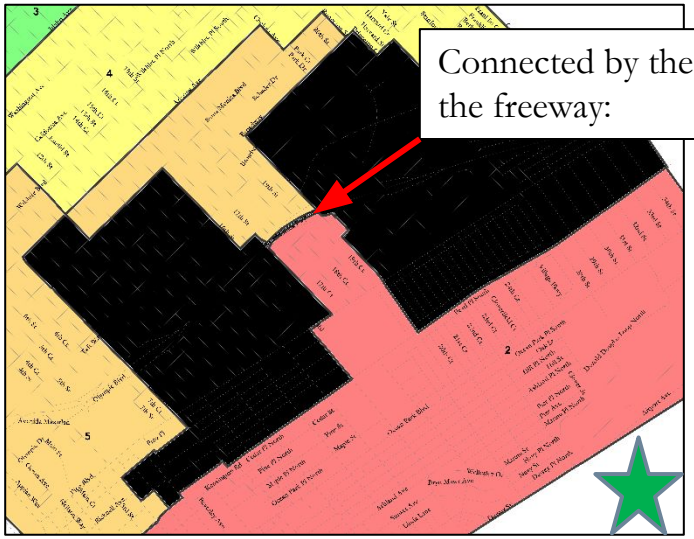
1. "Any part touching" connection
2. "More than a point" connection
3. "Able to Travel" connection

1. Any Part Touching

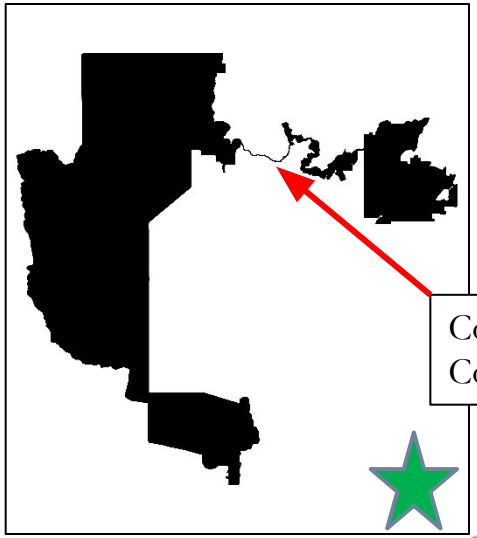
Connected only at a point:



Connected by the width of the freeway:

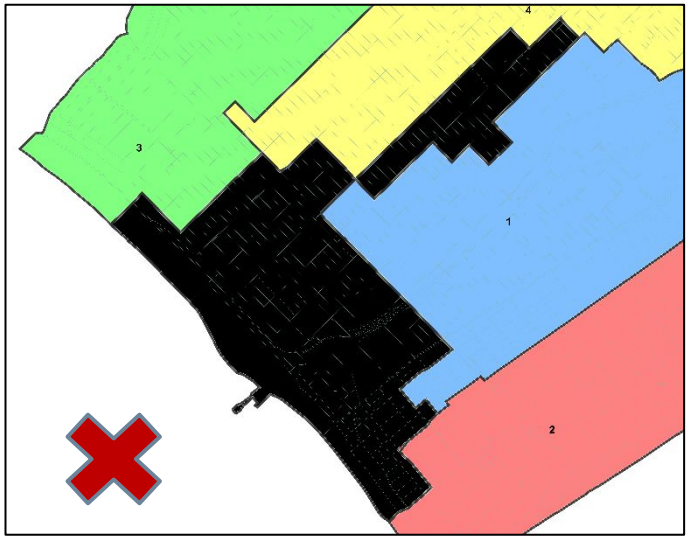


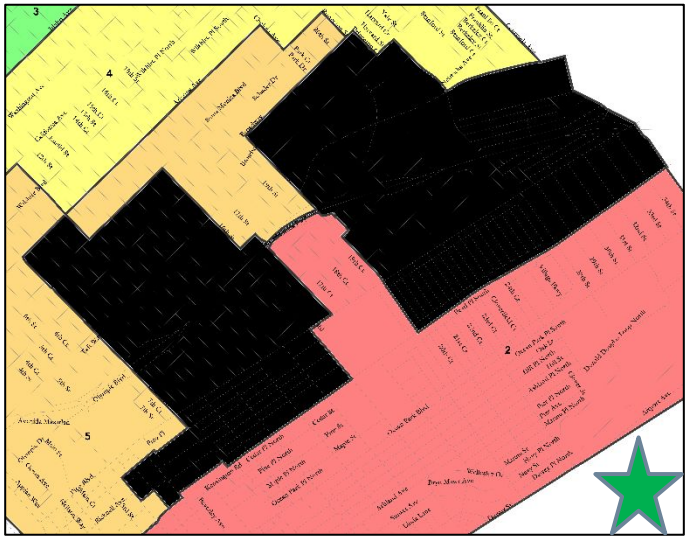
Connected by hiking trails:

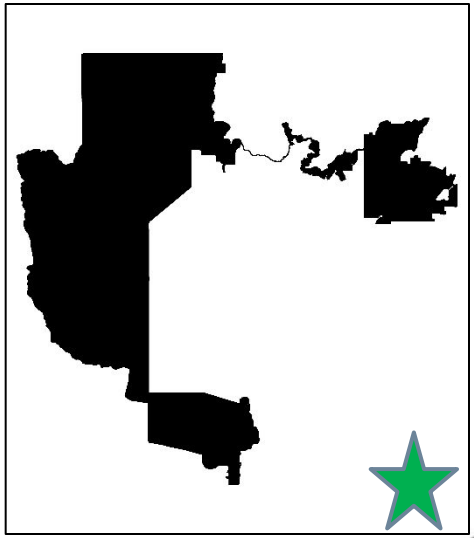


Connected by the Colorado River:

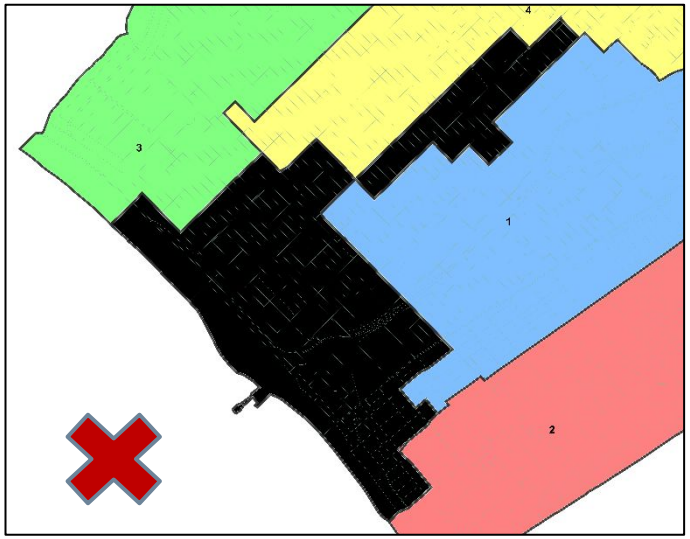
2. More than a Point

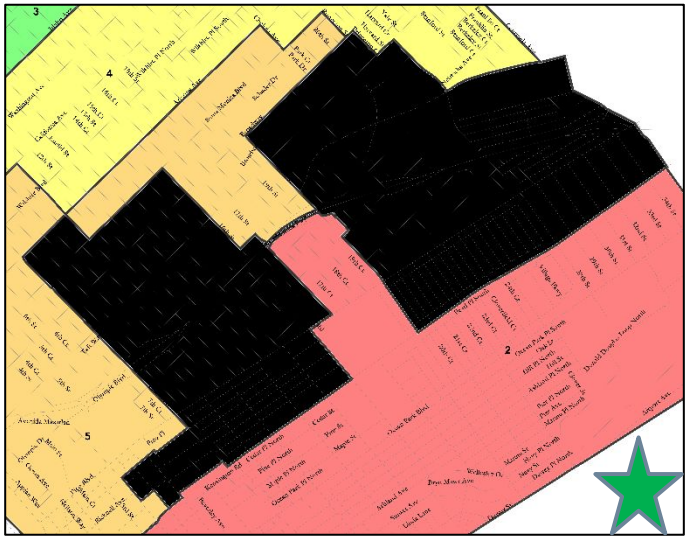


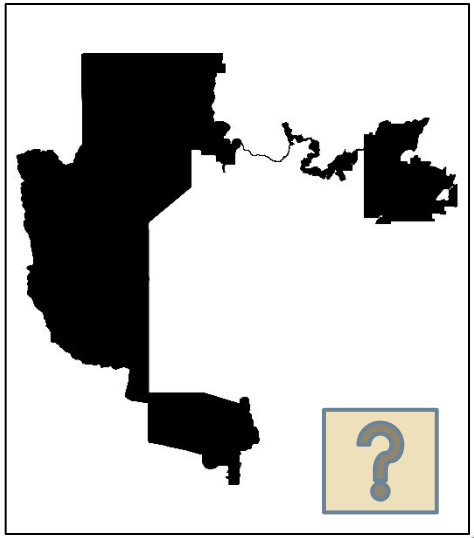




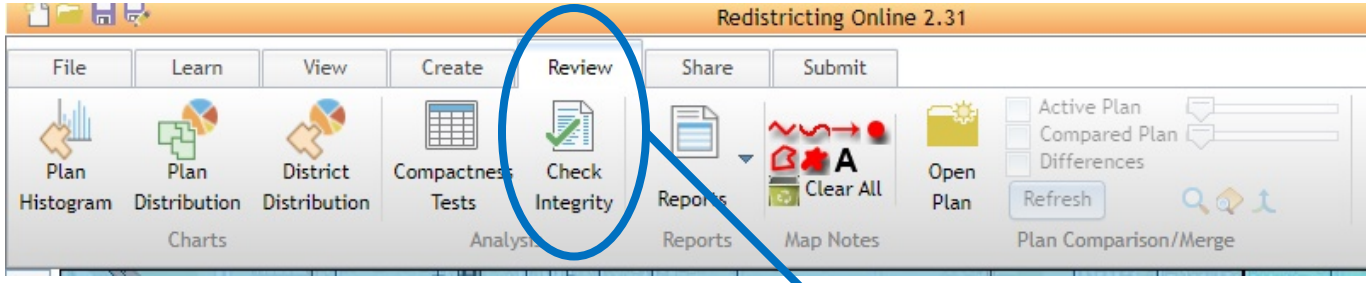
3. Able to Travel

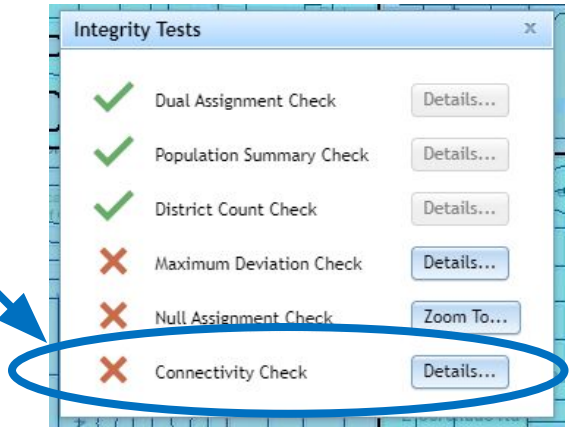






ESRI Contiguity Reporting





1. "Any part touching" connection
   - *Point contiguity fails ESRI Connectivity Check*
2. "More than a point" connection
   - *Approved by ESRI Connectivity Check*
3. "Able to Travel" connection
   - *Approved by ESRI Connectivity Check*

Compactness

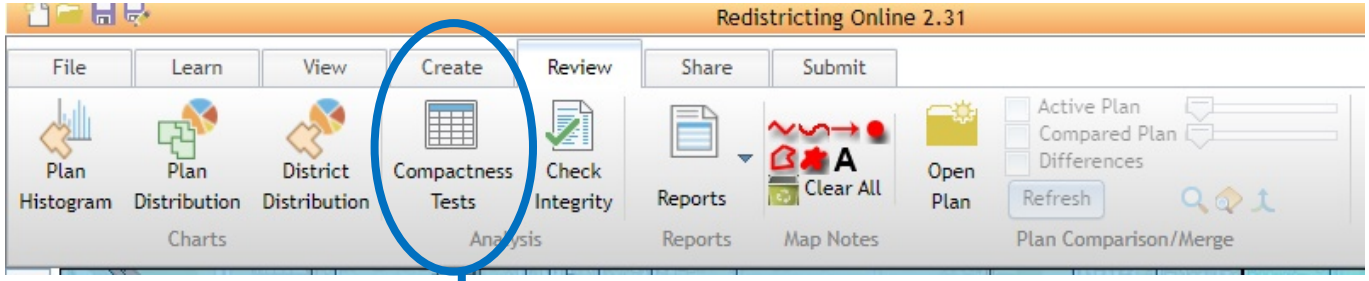
c. Districts shall be geographically compact and contiguous to the extent practicable;

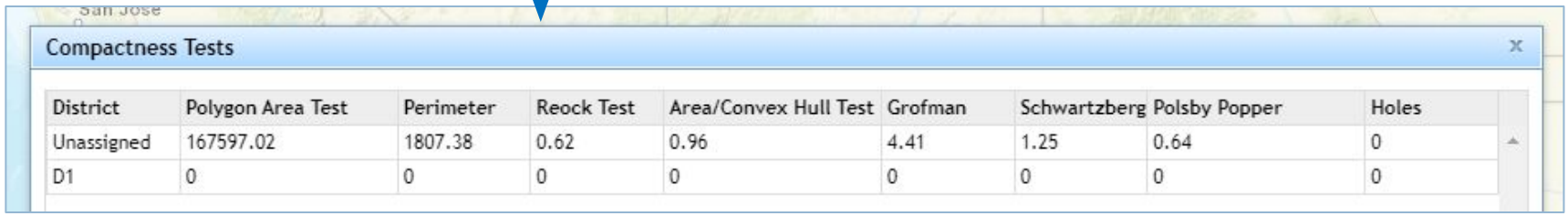
Standard Idea of Compactness

- A compact district does not bypass nearby areas of population to take in more distant populations.

Compactness Measures

- There are LOTS of compactness measures
  - *ESRI contains seven different mathematical measures of compactness.*
  - *In the software, click "Review" and "Compactness Tests":*





Compactness Tests

District	Polygon Area Test	Perimeter	Reock Test	Area/Convex Hull Test	Grofman	Schwartzberg	Polsby Popper	Holes
Unassigned	167597.02	1807.38	0.62	0.96	4.41	1.25	0.64	0
D1	0	0	0	0	0	0	0	0

Compactness Comparisons

- No consensus on a best measure

Compactness Tests

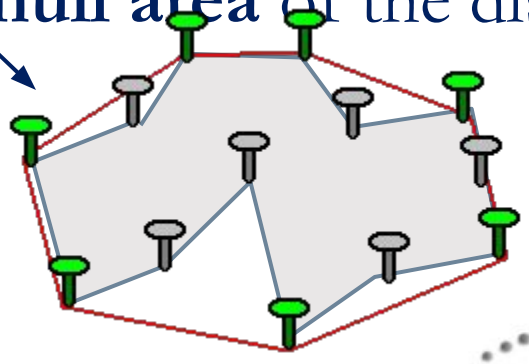
District	Polygon Area Test	Perimeter	Reock Test	Area/Convex Hull Test	Grofman	Schwartzberg	Polsby Popper	Holes
Unassigned	0	0	0	0	0	0	0	0
D1	39030.8	1424	0.37	0.67	7.21	2.03	0.24	0
D2	60417.34	1360.02	0.57	0.92	5.53	1.56	0.41	0
D3	20670.42	876.67	0.27	0.71	6.1	1.72	0.34	0
D4	14608.15	908.64	0.48	0.73	7.52	2.12	0.22	0
D5	9254.83	466.45	0.54	0.95	4.85	1.37	0.53	0
D6	10359.79	493.44	0.41	0.87	4.85	1.37	0.53	0
D7	3120.18	353.82	0.37	0.84	6.33	1.79	0.31	0
D8	9392.61	481.93	0.56	0.91	4.97	1.4	0.51	0
D9	742.9	134.55	0.6	0.93	4.94	1.39	0.52	0

  - Some create values. Others create ratios.
  - Varying opinions whether the "average," "median," "total" or "extreme" results matter more.
  - Used properly, the measures are helpful though imperfect.
  - Polsby-Popper and perimeter are the most commonly used, but only because it is very fast to calculate and easy to understand (not because they are better).

Definitions I

- **Polygon Area Test** simply reports the total **area** of each district in square miles.
- **Perimeter** measures the **perimeter** of the district in miles.
- **Grofman Test** calculates the ratio of the district perimeter to the square root of the area.
- **Area / Convex Hull Test** determines the ratio of the area of the district to the **convex hull area** of the district.

The set of green nails are the convex hull of the collection of the points:



(Text and base image courtesy of the "Brilliant" math and science knowledge base.)

Definitions II

- **Reock Test** calculates the ratio of district area to the **smallest circle** containing the district.
- **Schwartzberg Test** is the ratio of the perimeter of the district to the perimeter of a circle of an equal area to that of the district.
- **Polsby Popper Test** calculates the ratio of the same area of the district to the area of a circle with the same perimeter.

Tangent

Compactness Tests

District	Polygon Area Test	Perimeter	Reock Test	Area/Convex Hull Test	Grofman	Schwartzberg	Polsby Popper	Holes
Unassigned	167597.02	1807.38	0.62	0.96	4.41	1.25	0.64	0
D1	0	0	0	0	0	0	0	0

- **Holes** reports the number of holes (geography clusters that are fully enclosed) within each district.
  - *This is not a compactness test. It alerts the user to encircled unassigned areas and encircled other districts, both of which could significantly impact compactness.*

Summary of ESRI Compactness Measures

Measure	Approach	Scale
Area	Simple measure	Measured in square miles
Perimeter	Simple measure	Measured in miles
Grofman	Perimeter / sq. root of area	Greater than 1, and 1 is most compact.
Area / Convex Hull	Area / convex hull area	0 to 1 (1 is best, 0 is worst)
Reock	Area / area of smallest enclosing circle	0 to 1 (1 is best, 0 is worst)
Schwartzberg	Perimeter / Perimeter of equal area circle	Greater than 1, and 1 is most compact.
Polsby Popper	Area / Area of equal perimeter circle	0 to 1 (1 is best, 0 is worst)

Different Measures Often Disagree

Table 2: Illustrations of agreements (in the first two columns) and disagreements (in the last two columns) about the degree of compactness.

Copied from "How to Measure Legislative District Compactness If You Only Know it When You See it," by Aaron Kaufman, Gary King and Mayya Komisarchik,

https://gking.harvard.edu/files/gking/files/compact.pdf.

Districts should be evaluated against those in a similar geographic area. Natural and man-made features like coasts and city boundaries may distort results.

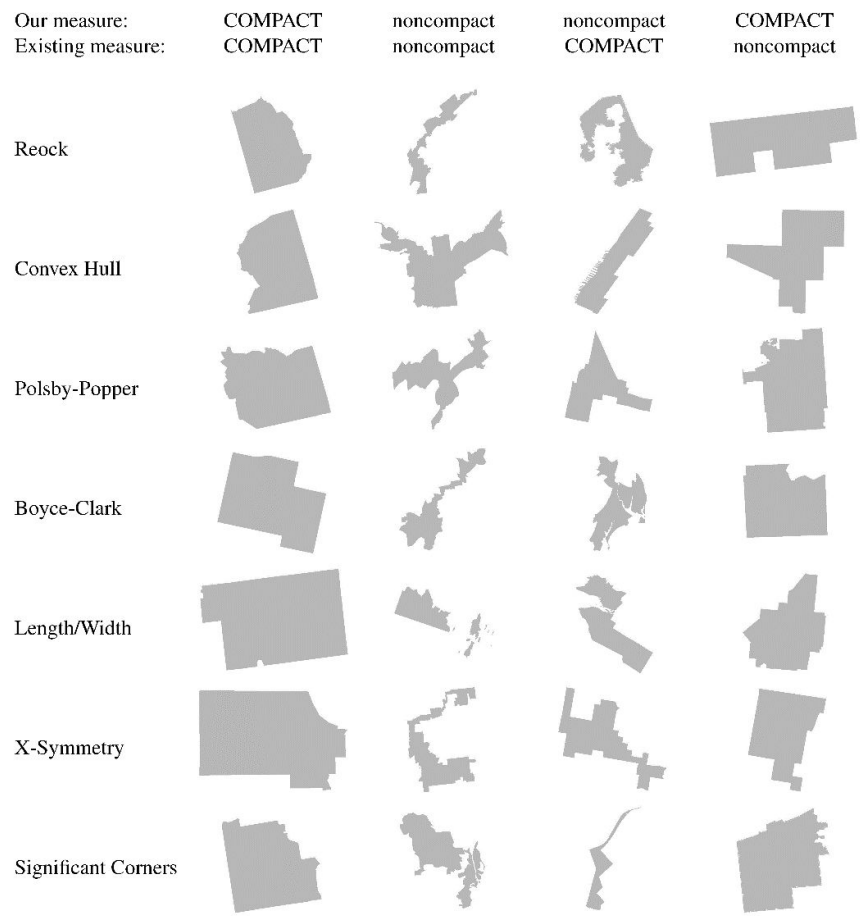
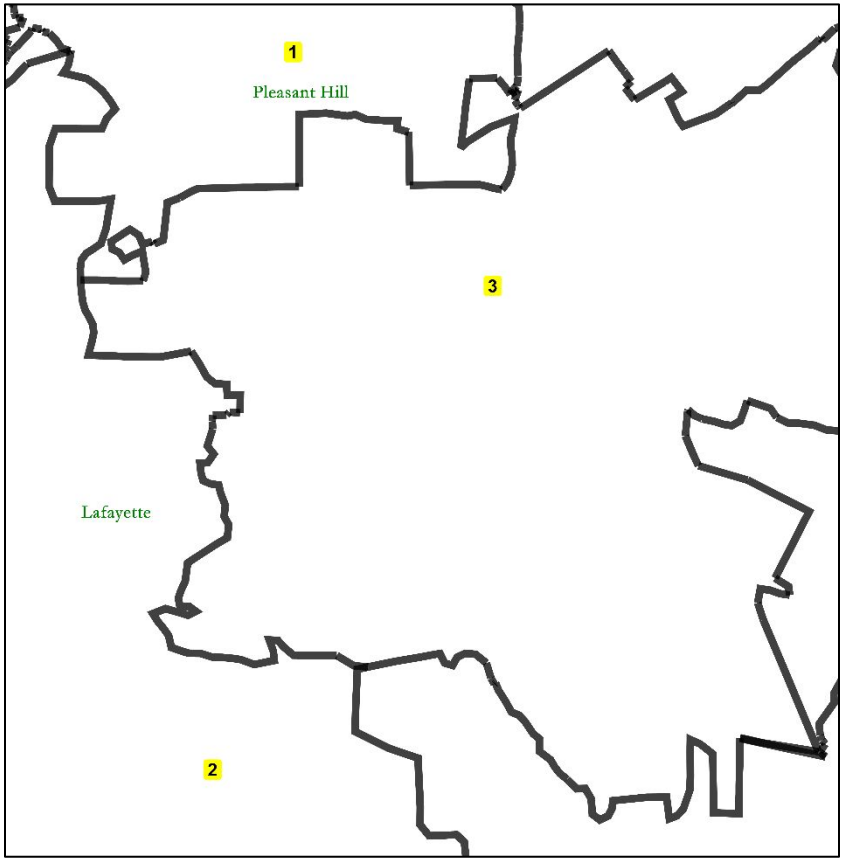


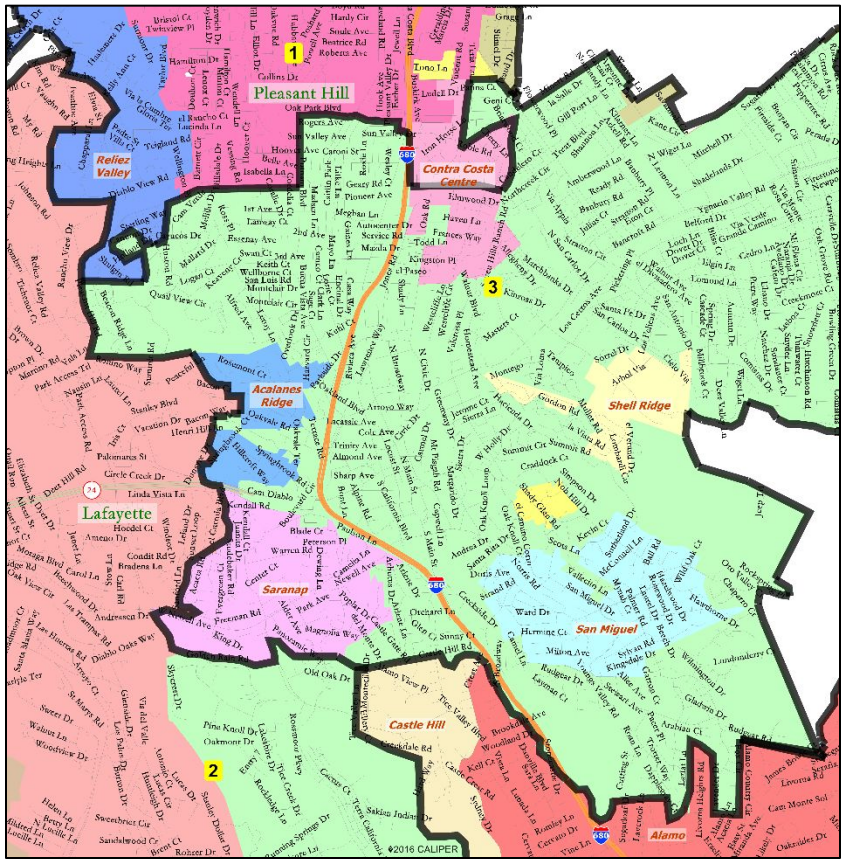
Table 2: Illustrations of agreements (in the first two columns) and disagreements (in the last two columns) about the degree of compactness between each of seven existing measures and our measure. Each row represents a 2×2 table of our measure by an existing measure, with a dichotomized compactness summary, displaying one example district in each cell arbitrarily chosen via alphabetical order.

Not all odd shapes are bad



Not all odd shapes are bad

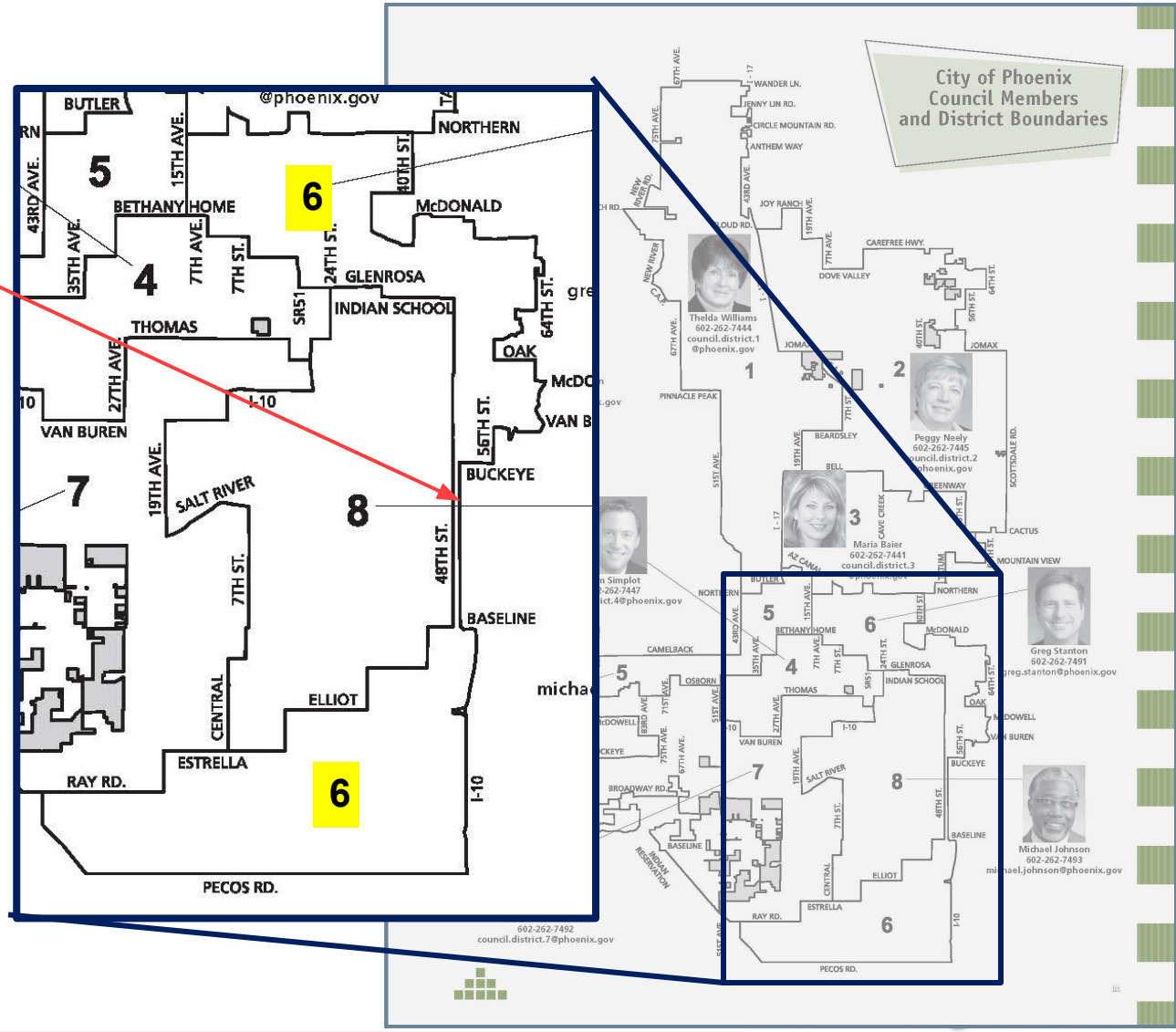
Odd shapes may be needed to meet the other Prop. 106 goals.



(Colors are cities and Census-Designated Places.) Following odd-shaped city borders may result in odd district shapes.

Not all odd shapes are bad

Phoenix Council District 6 has a "barbell" shape to pair Arcadia and Ahwatukee separate from South Phoenix.



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Miscellaneous

e. To the extent practicable, district lines shall use visible geographic features, city, town and county boundaries, and undivided census tracts;

Easily Understood Borders

- **"district lines shall use visible geographic features,"**

- This definition commonly includes rivers, canals, hills/mountains, major roads, railroad tracks, and similarly visible and easily understood borders.
- Following such boundaries makes it easy for voters to understand what district they live in.
- For voters, it also simplifies knocking on doors and talking to neighbors during campaigns and knowing which legislator to go to for help when needed.

Definition of Census Tracts

- **"district lines shall use . . . undivided census tracts"**

- "The primary purpose of census tracts is to provide a stable set of geographic units for the presentation of statistical data. . . . Census tracts generally have a population size between 1,200 and 8,000 people, with an optimum size of 4,000 people."
  - *Official Census Bureau* *Glossary Entry*
  - *Official Census Bureau* *History of Census Tracts*

Cities, Towns and Counties

- "e. To the extent practicable, **district lines shall use** visible geographic features, **city, town and county boundaries,** and undivided census tracts;"

- This direction from Prop. 106 is unclear:
  - Should cities, towns and counties be kept undivided?
  - Or is this language more limited: should district boundaries should simply follow city, town and county boundaries where the lines otherwise end up close together?
  - Is keeping cities, towns and counties undivided (when practicable) part of this criterion?
    - *If the answer is no, then individual cities, towns and counties could be evaluated as potential "communities of interest" under criterion (d).*

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