

# West Virginia Redistricting Report

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Dr. Austin Buchanan  
Team Orange Operations  
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by:  
Cameron Groenteman,  
Judy Nguyenvo

# I. Executive Summary Letter

Congressional redistricting is the foundation for the entirety of a well represented, established nation. In 2021, the redistricting process started for West Virginia with intentions to redistribute the district to compensate for any societal changes. Aka population shift, new developments of communities and updates to possible compactness of these districts. The true intention is to make sure each district is correctly defined to the majority opinions. Our work provided is an attempt to replicate those same intentions.

Team Orange Operations chose to redistrict West Virginia and the following is our collected results summed up.

Our code allowed us to account for district compactness, allotting each district to have less than a 1% difference, and contained the intended districts to 2, from the original 3. We were able to do this by setting constraints. It is required that each county is assigned to one district and restricting the district centers to a certain value while also neighboring other counties that are in the same district. Our findings are later referred to below.

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## II. Introduction

The United States makes it a constitutional right for every citizen to have a vote that guarantees equal voting power. This is supported by redistricting, which gives the opportunity to confirm that our map accurately represents the growing diversity of each district. Redistricting is redrawing district boundaries, where our public officials are voted from. Boundaries are redrawn every 10 years and there are a lot of constraints in order to truly represent a community. There are many ways that public opinions can be threatened. Politicians have tried to manipulate the result to stay in office, silence a specific (or maybe all) minority, and sway the weight of a group to all live in one area so they don't have more representation. Whatever the reason for rigging equal representation is, any form of redistricting that doesn't simply focus on the federal and state criteria will lead to a skewed portrayal of the society's morals and values and in turn, will be represented by the public official's opinions instead.

Our focus here is to divide West Virginia into two districts with no political information or bias over the districts. All criteria are accounted for to the greatest potential by using both personal judgment and code, using Python.

## III. Criteria

### **Federal Criteria**

- States and their legislatures have primary authority in determining the “times, places and manner” of congressional elections, but Congress may pass laws regulating congressional elections. (U.S. Const., Art. I, § 4)
- States are allotted a portion of the 435 seats from the House of Representatives based on the size of their state's population compared to the other states. (U.S. Const., Art. I, § 2)  
This is why West Virginia has two congressional districts.
- Congressional districts must share nearly equivalent populations. The population deviance of the districts should be no more than 1%. This is required by a Supreme Court ruling in the Wesberry v. Sanders case.

- It is required that states do not draw district maps that negatively impact minority voting nor can they change laws to negatively impact a minority's ability to vote. This was included in the Voting Rights Act of 1965.

### **State Criteria**

- Contiguity: It is required that all counties within a congressional district should be physically adjacent to each other. (W. Va. Const., Art. I, § 4)
- Compactness: It is required that the population of a congressional district should live as near to one another as probable. (W. Va. Const., Art. I, § 4)
- Communities of Interest: It is required that communities of interest are considered when redistricting. (W. Va. Const., Art. I, § 4)

Every 10 years, redistricting occurs to keep up with the constant change in society. By doing this, it updates any massive change in a population which may require the acquisition or removal of a state representative. This ensures the population gets an adequate amount of representation in relation to their population. Provided that each district has the same population assures that everyone's vote is heard equally. If one district had a higher population than another, the latter would have a stronger influence because there's less resistance to their community's opinions. Yet, they would have just as much power to their voice as an area with double their population.

The state-based requirements support local communities to live amongst those with common interests, whether they be social, economic, or political. Containing everyone to live in close proximity to one another pushes for societal exchanges and overall community upbringing. It's much harder for a society to survive when everyone is secluded. Collaboration delivers more insight, energy, and power for a community to improve in all aspects. With areas that pertain to a certain interest, these communities should be considered when redistricting.

## IV. Problem Statement

The objective here is to create a program that organizes West Virginia's counties into two congressional districts, following federal and state criteria. We must take into consideration communities of interest and district contiguity while minimizing the difference in district populations with the use of operational research methods.

## V. OR Model (in words and math)

Sets:

$$N(i) = \{j \in V \mid \{i,j\} \in F\}$$

Indices:

$i$  is a county

$j$  is a district

Parameters:

$L$  is lower population bound

$U$  is upper population bound

$k$  is the number of districts

$p_i$  = population of a parcel

$n$  = number of land parcels (where  $n = |V|$ )

$v$  = district center

$$w_{ij} = p_i * d_{ij}^2$$

$$x_{ij} = \begin{cases} 1 & \text{if vertex } i \text{ is assigned to (the district centered at) vertex } j \\ 0 & \text{otherwise.} \end{cases}$$

Variables:

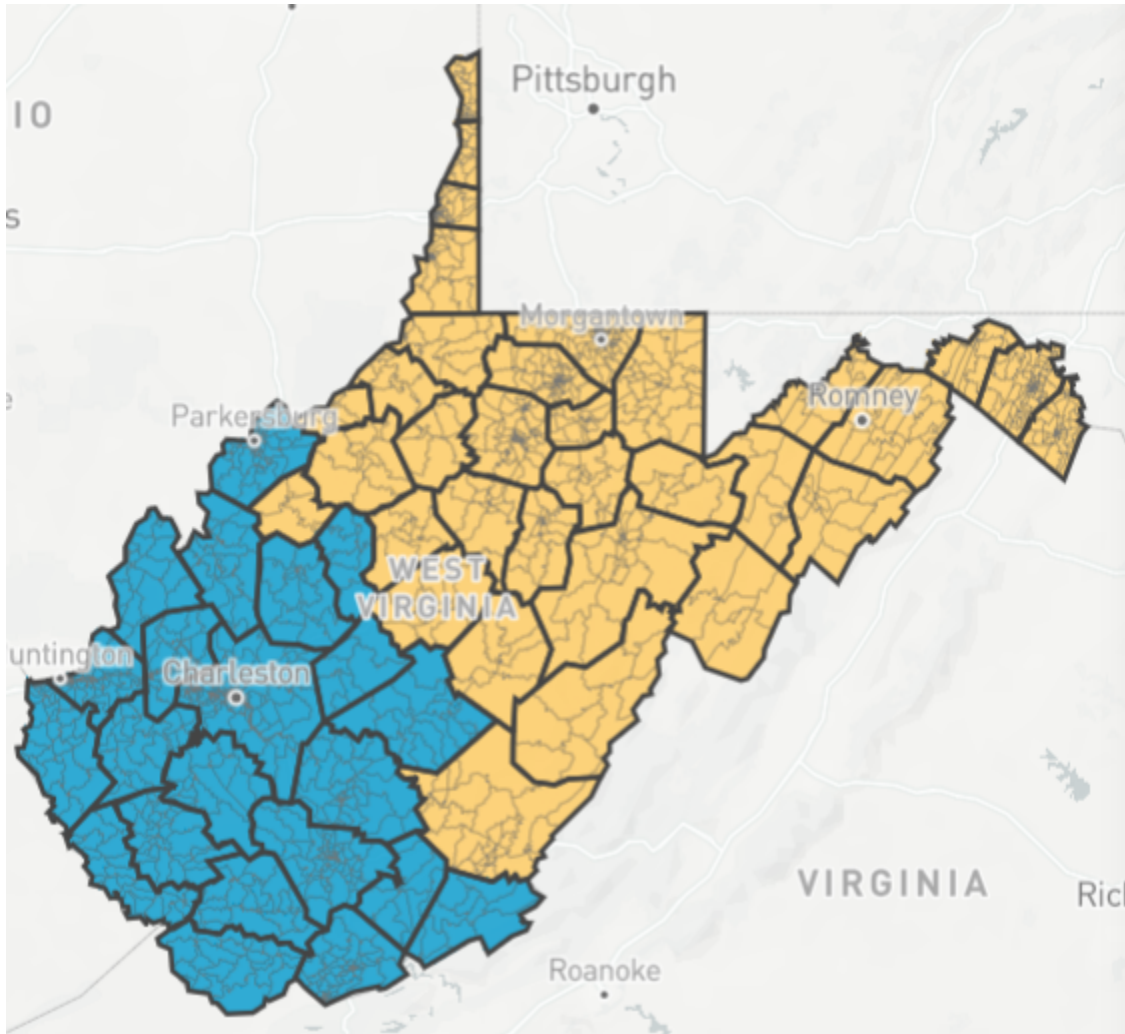
$f_{ij}^v$  = the amount of flow, originating at district center  $v$ ,  
that is sent across edge  $\{i,j\}$  (from  $i$  to  $j$ ).

Minimize the moment of inertia	$\min \sum_{i \in V} \sum_{j \in V} w_{ij} x_{ij}$
	s.t
Assign each county to one district	$\sum_{j \in V} x_{ij} = 1 \quad \forall i \in V$
Choose $k$ district centers	$\sum_{j \in V} x_{jj} = k$
The population of each district must be between $L$ and $U$	$Lx_{jj} \leq \sum_{i \in V} p_i x_{ij} \leq Ux_{jj} \quad \forall j \in V$
If $i$ is assigned to $j$ , then $j$ is a center	$x_{ij} \leq x_{jj} \quad \forall i, j \in V$
Binary restriction; each county is either assigned or not assigned to a district	$x_{ij} \in \{0, 1\} \quad \forall i, j \in V.$
If vertex $i$ is assigned to center $j$ , then $i$ consumes one unit of flow of type $i$ ; otherwise, it consumes none	$\sum_{u \in N(i)} (f_{ui}^j - f_{iu}^j) = x_{ij} \quad \forall i \in V \setminus \{j\}, \forall j \in V$
Vertex $i$ can receive flow of type $j$ only if $i$ is assigned to center $j$	$\sum_{u \in N(i)} f_{ui}^j \leq (n-1)x_{ij} \quad \forall i \in V \setminus \{j\}, \forall j \in V$
Prevents flow circulation	$\sum_{u \in N(i)} f_{uj}^j = 0 \quad \forall j \in V$
Variables must be positive	$f_{ij}^v, f_{ji}^v \geq 0 \quad \forall \{i, j\} \in E, \forall v \in V.$

## VI. Experiments

The model was coded and solved using Gurobi Optimizer Version 9.5.0. The model was run on an MSI GS65 Stealth Laptop, containing an Intel i7-9750H CPU @ 2.60 GHz and 32 GB DDR4 @ 2666 MHz. The model that we ran had contiguity, moment of inertia, and deviation constraints. It found an optimal solution in 0.67 seconds.

## VII. Maps



Our plan meets all of the federal and state criteria. **District 0 (blue)** has a population of 899,947, while **District 1 (yellow)** has a population of 893,769. This gives a population difference of 6,178 and a population deviation of 0.34%.

**District 0, population of 899,947** : Wyoming, Roane, Monroe, Summers, Raleigh, Nicholas, Mason, Calhoun, Lincoln, Kanawha, Mingo, Wayne, Putnam, Boone, Cabell, Jackson, Wood, McDowell, Clay, Logan, Fayette, Mercer

**District 1, population of 893,769**: Braxton, Grant, Doddridge, Wirt, Tyler, Greenbrier, Ritchie, Randolph, Marion, Pendleton, Berkeley, Upshur, Taylor, Gilmer, Brooke, Ohio, Morgan, Lewis,



Pocahontas, Wetzel, Marshall, Monongalia, Mineral, Hancock, Preston, Hardy, Webster, Hampshire, Harrison, Barbour, Tucker, Pleasants, Jefferson

Here is the link to view the map: <https://districtr.org/plan/124639>

## VIII. Evaluation of Plan

The map exhibited a 0.34% population deviation, ensuring the difference is below 1%. This shows that the districts are both compact and contiguous. Our downside is the code could not take into account any communities of interest. Therefore this process could not contain these groups into the same period districts.

## IX. Conclusion

Using a minimizing moment of inertia and contiguity program, we found an optimal congressional district plan in 0.67 seconds. District 0 has a population of 899,947 and District 1 has a population of 893,769 with a population deviation of 6,178 people or 0.34%. Our program meets all state and federal criteria, excluding the communities of interest requirement. We found this to be out of the scope of our knowledge and we lack the information required to be imported into the code.

Provided is the link to all of our files in Github:

<https://github.com/CGroenteman/OperationsResearchProject-West-Virginia->

## Work Cited

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