Findings on the City of Lowell's Election Systems
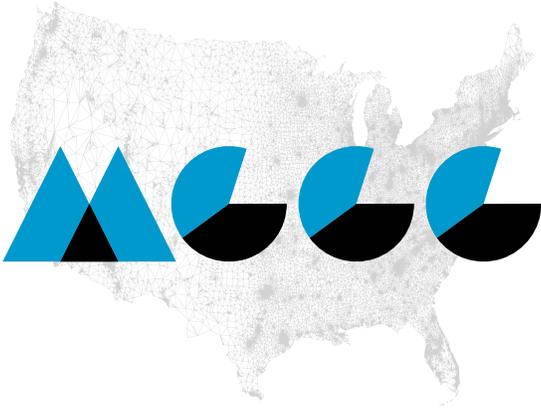
MGGG Redistricting Lab

Contents

Contributors

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1   Introduction

1.1   Background

In May 2017, a coalition of Latinx and Asian-American Lowell residents sued the City of Lowell, challenging the city's at-large plurality election system as being in violation of Section 2 of the Voting Rights Act. At the time of the lawsuit, an at-large plurality system was in use to elect the 9-member City Council and 6-member School Committee. Although Latinx and Asian-American residents comprised about 40% of Lowell's population as of 2017, the City Council and School Committee have historically been all-White with few exceptions. This is due to racially polarized voting coupled with an election system that structurally excludes minorities.

The Defendants agreed to a Consent Decree in May 2019 which outlined four categories of possible remedial election systems for the City Council and School Committee, which we can call Districted, Ranked Choice, Hybrid and Combination systems. (In fact, there were three sub-categories of Hybrid system, making six choices in all.) The decree also specified a process for selecting and implementing a new system, including a popular vote.

On November 5th, Lowell residents will be voting on choices narrowed down from six to two by the City Council: a Hybrid "8+3" system that would have 8 single-member districts and 3 at-large seats, and a city-wide Ranked Choice Voting (RCV) "1×9" system that would elect 9 members at once. The results of this vote are non-binding, and in December the City Council will exercise its authority and decide on the final election system.

Although the city will be voting on just these two options, we analyze all the systems proposed in the Consent Decree in this report. We focus on the City Council, but provide a brief analysis of School Committee outcomes in an Appendix.

1.2   Study Goals

The goal of the present study is to analyze the election systems outlined in the May 2019 Consent Decree, paying particular attention to the opportunity of Coalition voters to elect candidates of their choice under each system. To analyze these voting systems, we have used Markov chain sampling algorithms to produce district maps for single-member City Council districts. We have also designed a stochastic (i.e., randomized) voter model for Ranked Choice Voting with single transferable vote (STV) methods like the one currently employed in Cambridge, MA. The analysis incorporates sensitivity testing to assess the robustness of the predictions for Coalition representation under RCV.

Additionally, we have provided four customized modules on Districtr, our web tool for districting and community identification. The Lowell modules allow users to make and evaluate 3-, 7-, 8-, and 9-district plans out of Lowell census blocks. Visit the Lowell landing page, districtr.org/lowell, to try for yourself.

1.3   Basic Statistics

The following demographic statistics are from the 2010 Census except for Citizen Voting Age Population (CVAP) data, which is drawn from the American Community Survey (ACS). Here and throughout the report, "Hispanic" denotes all respondents of any race who indicated Hispanic ethnicity; "White" denotes non-Hispanic White; "Asian" denotes non-Hispanic Asian, and so on. The case was brought as a Coalition claim and the term "Coalition" will be used to refer to the combined population of Hispanic and Asian voters.

City of Lowell total population: 106,519
Hispanic population: 18,396 or 17.3%
Asian population: 22,459 or 21.1%
Coalition population: 40,855 or 38.4%
White population: 56,280 or 52.8%

City of Lowell total Voting Age Population (VAP): 81,259
Hispanic VAP: 11,600 or 14.3%
Asian VAP: 15,270 or 18.8%
Coalition VAP: 26,870 or 33.1%
White VAP: 47,187 or 58.1%

City of Lowell total CVAP: 72,750
Hispanic CVAP: 12,615[1] or 17.3%
Asian CVAP: 12,629 or 17.4%
Coalition CVAP: 25,244 or 34.7%
White CVAP: 42,645 or 58.6%

2   Remedial Election System Options for City Council

In this section we review all four systems outlined in the Consent Decree, including a description, study methodology, and analysis for each.

2.1   Districted

2.1.1   9 × 1 Districted

The Districted electoral system would consist of nine single-member districts, one for each member of the City Council. Two districts would be required to be majority-Coalition districts—that is, each of the two must have over 50% of Citizen Voting Age Population (CVAP) comprised of Latinx or Asian-American voters.

We used a mathematical technique—a randomized algorithm called a Markov chain—to build thousands of sample plans out of census blocks while ensuring compliance with the majority-Coalition district stipulations of the Consent Decree. The code to generate plans, which is fully public and open-source, is available at github.com/mggg/GerryChain.

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[1]The higher number of Hispanic CVAP than Hispanic VAP could be due to a combination of population growth between 2010 Census data collection and the 2017 ACS data and errors in ACS data sampling/reporting.

To visualize the possible demographic statistics in plans that comply with the Decree, we started by ranking the districts within each plan in order of their Coalition share of population. We can then form a boxplot of the district-by-district Coalition population share.
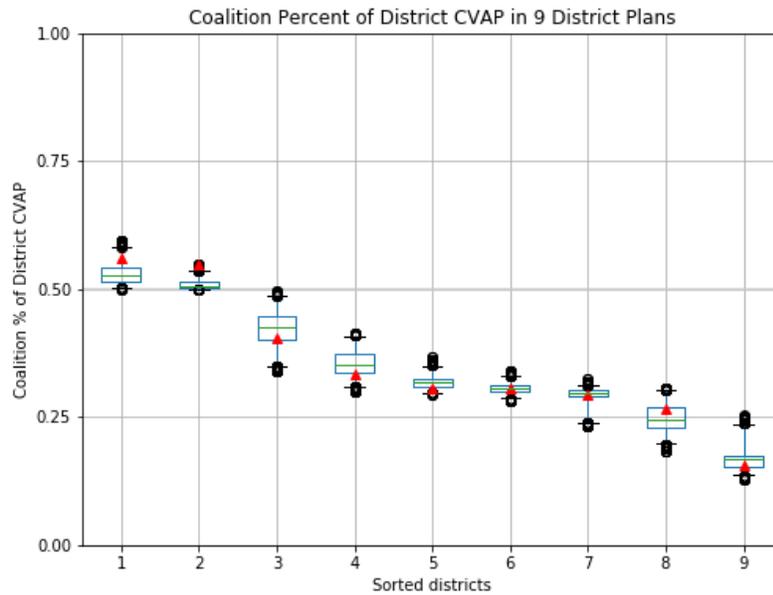

Coalition Percent of District CVAP in 9 District Plans

Figure 1. Boxplot of Coalition share of CVAP ("CCVAP") by district, over an ensemble of 9-district plans. The procedure only accepted plans with two districts having CCVAP $\geq 50\%$. The boxes represent the 25th-75th percentiles over the 10,000-step ensembles, the whiskers bracket the 1st-99th percentiles, and the dots show the outlying values.

In Figure 1, the district number is on the x-axis, and the Coalition share of CVAP (CCVAP%) is on the y-axis.[2] The District 1 data, for instance, shows the range in the highest-concentration Coalition district from every map we made. This plot shows that it is very difficult to find a third district with CCVAP$> 50\%$.

In our ensemble, we found a variety of ways to comply with the majority-minority requirements of the Consent Decree. Some maps have two districts that are very narrowly above 50% CCVAP with a third in the high 40s, while others have more comfortable margins in the top two and drop below 40% in District 3.

The red triangles in Figure 1 show statistics from the plan with the highest District 2 CCVAP value, illustrating a choice that favors greater certainty of securing two Coalition seats. Because of wide variation in turnout in past municipal elections with markedly low turnout in the city's more diverse precincts, there is a reasonable concern that even districts with a Coalition majority of CVAP may not suffice to secure representation. This plan is highlighted as an option emphasizing the performance of Districts 1 and 2. It is depicted in Figure 2 (after some slight modifications to smooth the boundaries). Thousands more 9-district plans are available upon request.

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[2]Throughout the report we order districts in a plan by their Coalition share of CVAP, or CCVAP. That is, we take the numbering convention that District 1 has the highest Coalition CVAP share, District 2 has the second highest, and so on.
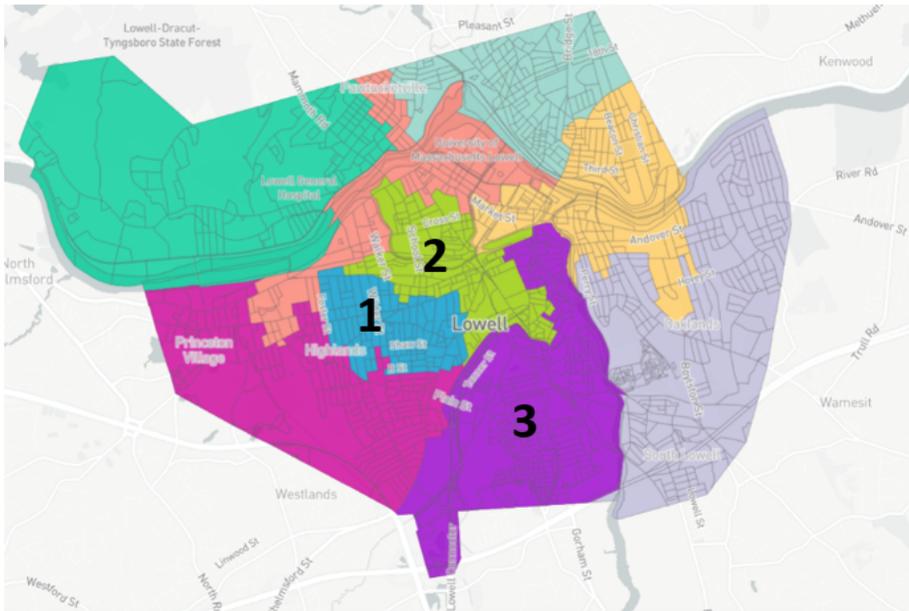
Figure 2. Sample 9-district plan with two highly concentrated Coalition districts. (Link) District 1 CCVAP - 55.5%, District 2 CCVAP - 53.4%, District 3 CCVAP - 39.0%.

2.2   Ranked Choice

2.2.1 1×9 RCV - On the Ballot

This electoral system would have no districts; instead all nine members of the City Council (and six members of the School Committee) would be elected in one city-wide vote. Voters would rank candidates in order of preference, with the opportunity to rank every candidate.

To select the nine members of the City Council, ballots would be tallied in a method similar to that used in Cambridge, MA City Council Elections. This process is done by one of the standard transferable vote algorithms.

1. Ballots are sorted by their first choice candidate;

2. Any candidate whose number of first choice ballots exceeds 10% of cast votes is elected[3];

3. If an elected candidate had a surplus of first-place votes (say k votes above the threshold), then k ballots supporting that candidate are randomly selected and reallocated to the next preferred candidate;

4. If not enough candidates have been elected, the candidate with the fewest number of first-choice votes is then eliminated, and all the ballots supporting that candidate are reallocated to the next preferred candidate;

5. This process repeats until all City Council spots are filled.

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[3]In general, when a single transferable vote election is used to select m candidates, the threshold is $1/(m+1)$.

To assess the likely outcomes under this system, we built a Stochastic RCV Model. A "stochastic model" is one that employs some randomized steps. If such a model is run many times and results are compared, we can be more confident that the outcomes are robust. In this case, randomness is present in two places: the order in which certain voters rank candidates of each racial group, and the way that votes are transferred when the results are tallied. For simplicity, we assume in all RCV modeling reported here that when there are m seats to be filled, there are m White candidates and m Coalition candidates. All voters rank all $2m$ candidates according to the voter scenarios explained below in the Explanation of Terms. The results that we report use varying turnout data and varying rates of voter "crossover" data.

Instead of simply using standard statistical techniques like King's Ecological Inference to estimate turnout and crossover once and for all, we ran a sensitivity analysis that varied both. For each combination of turnout and crossover inputs, we ran the RCV simulation model 200 times and averaged the results to get the expected Coalition representation on the City Council for the fixed combination of inputs. Each model run simulates 5000 cast votes. The model is coded in Python and is available in our RCV github repo.

Expected outcomes (average number of Coalition candidates elected out of 9 City Council members) are reported in Table 1. Each row is a different scenario, determined by the crossover and turnout vector columns.

Explanation of Terms in Stochastic RCV Model

Relative turnout: Relative turnout rates by race for White, Hispanic, Asian, Other as a share of CVAP (which tracks with eligible voters). For instance, Run 13 has a turnout vector of $[1, .25, .75, 1]$, meaning that White and Other voters turn out at the highest rate of eligible voters, while Hispanic turnout is 25% of that level and Asian turnout is 75% of that level. This is a relative turnout only and is meant to address worries about the possibility of low Coalition participation in the election.

Total polarization (no crossover): All White voters vote WWWCCC and non-White voters vote CCCWWW.

Crossover vector: This records the share of members of each group whose first-choice vote is a "crossover." For instance, Run 13 has crossover vector $[.1, .3, .3, .3]$, meaning that 10% of White voters prefer a Coalition candidate most, while 30% of Asian, Hispanic, and Other voters prefer a White candidate most. These are values that are typically computed in a racially polarized voting analysis such as that used in the current lawsuit. However, the current sensitivity analysis is used to verify that the findings are not completely dependent on the empirical RPV data.

Crossover: A crossover White voter votes CWCWCW and a crossover Coalition voter votes WCWCWC. In crossover scenarios not all voters are crossover voters, only the percentage of each population specified by the crossover vector.

Voter Scenarios: These refer to different possibilities of how much agreement voters have on the order to rank candidates within a racial group.

A Unanimous order: Voters always rank White candidates W1W2W3 and Coalition-candidates C1C2C3. This simulates community agreement or coordination about which are the preferred candidates.

Run	Relative Turnout [W,H,A,O]	Voter Scenarios (No Crossover)				Crossover Rates [W,H,A,O]	Voter Scenarios With Crossover			
		A	B	C	D		A	B	C	D
1	[1, 1, 1, 1]	4	4	4	4	[.1, .3, .3, .3]	4	4	3	3
2						[.3, .3, .3, .3]	5	5	4	3
3						[.1, .5, .5, .1]	4	4	2	2
4						[.1, .1, .1, .1]	4	4	4	3
5						[.1, .1, .5, .1]	4	4	3	3
6						[.1, .5, .1, .1]	4	4	3	3
7	[1, .5, .5, 1]	2	2	2	2	[.1, .3, .3, .3]	3	3	2	2
8						[.3, .3, .3, .3]	4	4	2.2	2
9						[.1, .5, .5, .1]	3	3	1.6	2
10						[.1, .1, .1, .1]	3	3	2	2
11						[.1, .1, .5, .1]	3	3	2	2
12						[.1, .5, .1, .1]	3	3	2	2
13	[1, .25, .75, 1]	2	2	2	2	[.1, .3, .3, .3]	3	3	2	2
14						[.3, .3, .3, .3]	4	4	2.2	2
15						[.1, .5, .5, .1]	3	3	1.6	2
16						[.1, .1, .1, .1]	3	3	2	2
17						[.1, .1, .5, .1]	3	3	2	2
18						[.1, .5, .1, .1]	3	3	2	2
19	[1, .75, .25, 1]	2	2	2	2	[.1, .3, .3, .3]	3	3	2	2
20						[.3, .3, .3, .3]	4	4	2.2	2
21						[.1, .5, .5, .1]	3	3	1.5	2
22						[.1, .1, .1, .1]	3	3	2	2
23						[.1, .1, .5, .1]	3	3	2	2
24						[.1, .5, .1, .1]	3	3	2	2
25	[1, .33, .33, 1]	2	2	2	2	[.1, .3, .3, .3]	3	2.6	1	1
26						[.3, .3, .3, .3]	4	4	2	2
27						[.1, .5, .5, .1]	3	2.1	1	1
28						[.1, .1, .1, .1]	3	3	2	2
29						[.1, .1, .5, .1]	3	3	2	2
30						[.1, .5, .1, .1]	3	3	2	2
31	[1, .1, .9, 1]	2	2	2	2	[.1, .3, .3, .3]	3	3	2	2
32						[.3, .3, .3, .3]	4	4	2.2	2
33						[.1, .5, .5, .1]	3	3	1.6	2
34						[.1, .1, .1, .1]	3	3	2	2
35						[.1, .1, .5, .1]	3	3	2	2
36						[.1, .5, .1, .1]	3	3	2	2
37	[1, .9, .1, 1]	2	2	2	2	[.1, .3, .3, .3]	3	3	2	2
38						[.3, .3, .3, .3]	4	4	2.2	2
39						[.1, .5, .5, .1]	3	3	1.6	2
40						[.1, .1, .1, .1]	3	3	2	2
41						[.1, .1, .5, .1]	3	3	2	2
42						[.1, .5, .1, .1]	3	3	2	2
43	[1, .8, .8, 1]	3	3	3	3	[.1, .3, .3, .3]	4	4	2	2
44						[.3, .3, .3, .3]	5	5	3	3
45						[.1, .5, .5, .1]	4	4	2	2
46						[.1, .1, .1, .1]	4	4	3	3
47						[.1, .1, .5, .1]	4	4	2.9	2.5
48						[.1, .5, .1, .1]	4	4	2.9	2.5

Table 1. RCV Stochastic Model output, designed to stress-test predictions under "worst-case" Coalition turnout and a variety of crossover voting scenarios. Scenarios A-D are options for how unanimously or randomly the voters rank the candidates of each racial grouping (see Explanation of Terms).

B Coalition vary coalition: In this scenario each Coalition voter is equally likely to rank C1C2C3, C2C1C3, C1C3C2, etc, while White voters are unanimous in their preference order.

C All vary all: All votes choose a preference order randomly within each racial group.

D White vary all: White voters choose a random order for Coalition candidates and for White candidates, while Coalition voters are coordinated in their preferences.

From this sensitivity analysis we can see that an RCV system can afford Coalition communities opportunity to elect candidates of choice in near proportion to (and sometimes even exceeding) their share of the overall Lowell population. We see 2-4 Coalition candidates elected in almost all $48 \cdot 8 = 384$ scenarios in the table, with 2 candidates occurring in the most extreme low-turnout/high-crossover scenarios for Coalition voters.

2.3 Hybrid

A Hybrid electoral system would consist of both single-member districts and at-large seats. The at-large seats are not required to use RCV, and most watchers of the legal situation expect that they would be done by multi-member plurality (that is, the system that has now been successfully challenged for excluding minorities). The Consent Decree describes three Hybrid-system variants.

2.3.1 8 + 3 Hybrid - On the Ballot

The $8 + 3$ Hybrid system consists of eight single-member districts and three at-large seats for the City Council, expanding its size from nine to eleven members. Within this 8-district plan, two districts would be required to be majority-Coalition by CVAP. We used Markov chains to generate compliant 8-district plans. See Figure 3.

As we would expect, it is harder to find plans with a third near-majority Coalition district in the 8-district system than in the 9-district system. The red triangles show statistics from the plan with the highest District 2 CCVAP value (the Coalition share of CVAP in the second most concentrated Coalition district). Such a plan may have a better chance of securing two districts that are likely to elect Coalition-preferred candidates. We note again that because of Lowell's high variation in turnout, these districts cannot guarantee Coalition representation. This plan is pictured in Figure 4, after some minor modifications to smooth boundary lines.

If the at-large seats are elected via plurality voting and there are White candidates running for each of them, we predict they will win every seat (under reasonable assumptions for turnout and crossover voting in Lowell). See §2.3.4 for outcomes if the at-large seats were to use RCV.

2.3.2 8 + 1 Hybrid

The $8 + 1$ Hybrid system consists of eight single-member districts and one at-large seat for the City Council. Two districts are required to be majority-Coalition by CVAP. The 8-district plan analysis is identical to the previous section, and the one at-large seat is unlikely to go to a Coalition-preferred candidate regardless of the system of election.
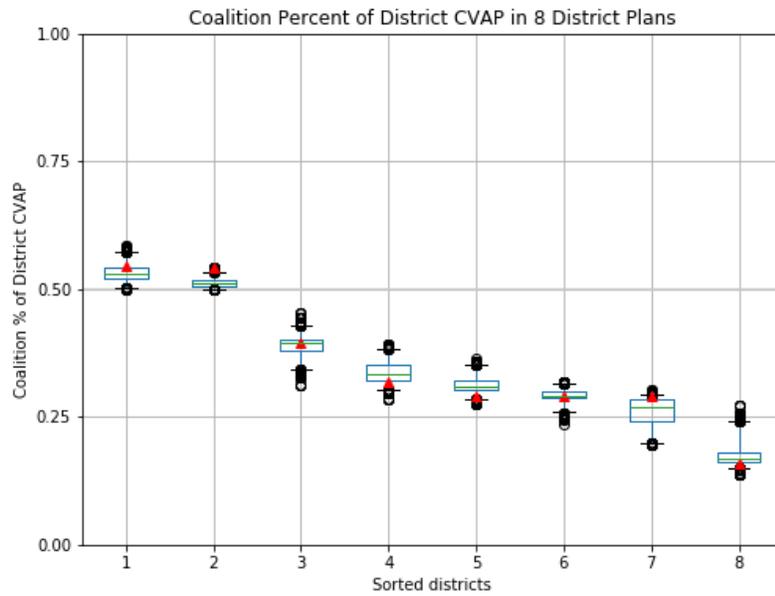
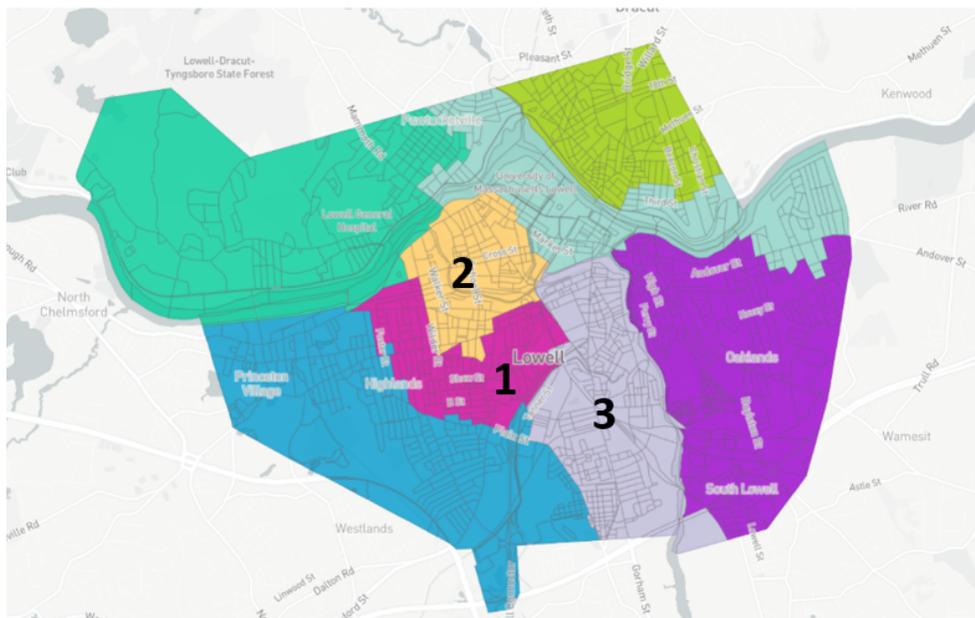**Figure 3.** Boxplot of Coalition population share by district in ensemble of 8-district plans.

Figure 4. Sample 8-district plan with two highly concentrated Coalition districts. (Link)
District 1 CCVAP - 54.9%, District 2 CCVAP - 53.9%, District 3 CCVAP - 40.3%.

2.3.3   7 + 2 Hybrid

The 7 + 2 Hybrid system consists of seven single-member districts and two at-large seats for the City Council, with two districts required to be majority-Coalition by CVAP. Plots and sample plans are available upon request.

2.3.4   At-Large Analysis with RCV

In the event of using a hybrid system with at-large seats, we expect the City to select the plurality system for electing those at-large members. If they do, then recent voting patterns would indicate that all 1, 2, or 3 seats would go to White candidates.

However, the city could adopt a ranked choice system for its at-large seats, which would give a stronger chance of Coalition representation. The stochastic RCV model was used to analyze 1, 2 and 3 at-large seats by RCV. The model assumptions, number of runs and votes were the same as described in Section 2.2. The values in the table below are the number of Coalition candidates elected to the at-large seats averaged across simulation runs and across sensitivity inputs (so fractional outputs are attributable to averaging). Results broken out by crossover and turnout inputs are available upon request.

Crossover	Preference Order	1 Seat	2 Seats	3 Seats
Total polarization	**A** Unanimous order	0	.25	.88
Total polarization	**B** Coalition vary coalition	0	.25	.88
Total polarization	**C** All vary all	0	.25	.88
Total polarization	**D** White vary all	0	.25	.88
Crossover	**A** Unanimous order	0	.56	1.00
Crossover	**B** Coalition vary coalition	0	.46	1.02
Crossover	**C** All vary all	0	.09	.53
Crossover	**D** White vary all	0	.24	.65

Table 2. Expected number of Coalition candidates elected in stochastic model if 1, 2, or 3 at-large seats were filled by RCV.

2.4   Combination

2.4.1   3 × 3 RCV

Under a Combination system, three districts would be drawn, each of which would elect three City Council members (and two School Committee members) via the same RCV method described in Section 2.2. Below is an example of a three-district plan with approximately equal Coalition CVAP in each district. (Thousands more 3-district plans are available upon request.)

To analyze how this plan would perform, we used our stochastic RCV model to predict 3-member outcomes in each of the three districts, by the methods reported above. The results for each district are summarized in Table 3.

We used all voter scenarios in Table 1, which includes some scenarios with extremely low Coalition turnout relative to White turnout. Bearing this in mind in interpreting the results reported in
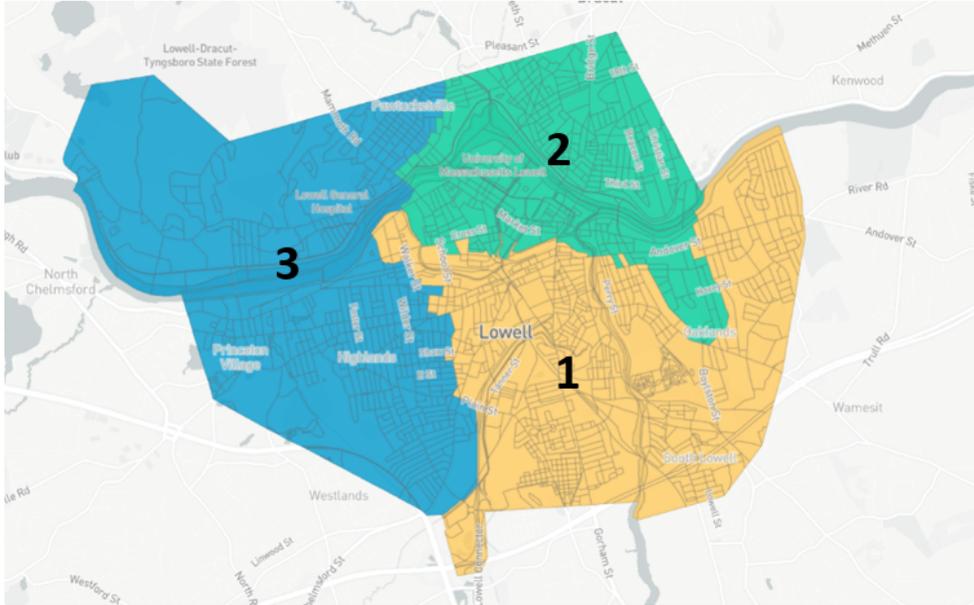
Figure 5. Sample 3-district plan with approximately equal Coalition CVAP in each district. (Link)
District 1 CCVAP - 35.9%, District 2 CCVAP - 34.7%, District 3 CCVAP - 33.6%.

Crossover	Preference Order	District 1	District 2	District 3	Total
	District CVAP [W,H,A,O]	[.58, .13, .23,.06]	[.59, .16, .18, .07]	[.59, .23, .11, .08]	
Total pol.	**A** Unanimous order	.88	.88	.75	2.51
Total pol.	**B** Coalition vary coalition	.88	.88	.75	2.51
Total pol.	**C** All vary all	.88	.88	.75	2.51
Total pol.	**D** White vary all	.88	.88	.75	2.51
Crossover	**A** Unanimous order	1.00	1.00	1.00	3.00
Crossover	**B** Coalition vary coalition	1.02	1.02	1.02	3.06
Crossover	**C** All vary all	.51	.54	.52	1.57
Crossover	**D** White vary all	.67	.70	.71	2.08

Table 3. Expected number of Coalition candidates elected in stochastic model from sample 3-district plan, out of 3 seats per district and 9 overall.

Table 3, RCV 3×3 is likely to produce a Coalition candidate in each of these 3 districts, resulting in 3 out of 9 on the City Council, if enough high-quality Coalition candidates run for office. Importantly, these results are specific to this sample plan, and we see up to 4/9 Coalition-preferred representatives with other map configurations. As before, 2/9 Coalition-preferred candidates might be elected in extremely low-turnout scenarios.

In addition to having comparable results for Coalition representation to the city-wide RCV (1×9) option, the 3×3 has the benefit of guaranteeing a degree of geographic diversity and neighborhood representation that is important to many residents; it will have members of the City Council elected from three regions of the City, and will prevent the representatives from affluent Belvidere from numerically dominating the council. Candidates only have to campaign in their district, and voters can still show preferences for many candidates without having to become familiar with a large slate. We therefore think the Combination 3×3 system combines key attractive features of the other proposed election options for both candidates and voters.

3 Conclusion

This report provides supporting detail for our public-facing publication, Community-Centered Redistricting in Lowell, Massachusetts, which can be found at mggg.org/Lowell-Report. Above, we have analyzed not only the two election systems on the ballot this November, but all of the systems outlined in the Consent Decree. We have aimed to provide a comprehensive overview of model outputs, calling particular attention to an option not on the ballot that combines some benefits of districts and RCV (Combination, 3×3). The public report more fully discusses the tradeoffs between districts and ranked-choice systems in human terms, while this detailed report focuses on expected representation for the Coalition population of Lowell, which was the subject of the lawsuit.

In those terms, the findings can be summarized in this final table.

Election System	Coalition Representation	(*if Hybrid conducted with RCV)
District, 9 x 1	1 - 2 out of 9 (11 - 22%)	
RCV, 1 x 9	2 - 4 out of 9 (22 - 44%)	
Hybrid, 8 + 3	1 - 2 out of 11 (9 - 18%)	2 - 3 out of 11 (18 - 27%)
Hybrid, 8 + 1	1 - 2 out of 9 (11 - 22%)	1 - 2 out of 9 (11 - 22%)
Hybrid, 7 + 2	0 - 2 out of 9 (0 - 22%)	1 - 3 out of 9 (11 - 33%)
Combination, 3 x 3	2 - 4 out of 9 (22 - 44%)	

Table 4. Summary results for expected Coalition representation under election system alternatives. The shaded cells mark the options that are on the November municipal ballot in Lowell.

On grounds of Coalition representation alone, the RCV 1×9 option is far preferable to the Hybrid $8 + 3$. However, there are other reasons that residents indicate for desiring a districted system. The Combination 3×3 model retains the best prospects for Coalition representation while offering some of the benefits of districts at the same time, and would therefore be an excellent compromise solution for Lowell, should the City and the Plaintiffs choose to revisit their options.

Appendix A: Summary of Citizen Voting Age Population (CVAP) for Demonstration Maps

The Lowell landing page of our Districtr web tool (districtr.org/lowell) links to eight sample districting plans: two each containing 3, 7, 8 and 9 districts. The White CVAP / non-White CVAP in the three most concentrated Coalition districts are shown here.

City-wide CVAP values are: White - 58.6 %, Asian - 17.4 %, Hispanic - 17.3 %, Other - 7 %

Plan	District 1 White/non-White	District 2 White/non-White	District 3 White/non-White
3 Districts - Plan A	42.9% / 57.1%	64.6% / 35.4%	68.0% / 32.0%
3 Districts - Plan B	58.4% / 41.6%	58.5% / 41.5%	59.0% / 41.0%
7 Districts - Plan A	41.2% / 58.8%	44.0% / 56.0%	51.0% / 49.0%
7 Districts - Plan B	41.4% / 58.6%	43.4% / 56.6%	53.1% / 46.9%
8 Districts - Plan A	42.4% / 57.6%	42.7% / 57.3%	46.3% / 53.7%
8 Districts - Plan B	38.5% / 61.5%	39.3% / 60.7%	50.6% / 49.4%
9 Districts - Plan A	39.0% / 61.0%	42.3% / 57.7%	44.9% / 55.1%
9 Districts - Plan B	38.4% / 61.6%	39.0% / 61.0%	51.9% / 48.1%

Table 5. Population statistics for the sample plans shown on Lowell landing page.

Appendix B: School Committee

For each proposed election system, the Consent Decree also specifies how members of Lowell's 6-member School Committee are to be elected. Here we provide a brief note on Coalition representation on the School Committee under the two systems on the November ballot.

Under the $8 + 3$ City Council option, the decree calls for Lowell's eight City Council districts to be paired to form four School Committee districts, one of which has to be majority-Coalition by CVAP. Two additional seats will be elected at-large. While it's not specified if RCV or plurality will be used for the at-large seats, we expect plurality to be chosen, as for the Council. With this assumption we expect one member of the 6-member School Committee to be Coalition-preferred.

On the other hand, if the RCV (1×9) City Council system is adopted, all six School Committee members will also be elected via RCV. Stochastic RCV Model results predict two Coalition-preferred candidates out of six in this case.