Proposed Solution to the Problem of Inequitable Taxation in Whitman County 2024/2025

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1 Executive Summary

This document proposes a solution to address inequitable taxation in Whitman County due to historical non-compliance with state laws on annual property revaluation and physical inspections. The solution involves a whole-county mathematical optimization to adjust the "percent of actual value" (POAV) for each property in each remaining year of the cycle, ensuring fair taxation over a 6-year cycle. Immediate implementation of the data collection and optimization using numerical algorithms will correct past discrepancies and establish equitable taxation moving forward. Through empirical simulations, this approach is demonstrated to achieve fair taxation within 0.3% of true equitable taxation over the cycle. The simulations also demonstrate the imperative to begin the correction as quickly as possible, as the equalization through this kind of optimization becomes impossible if it commences too late in the 6-year cycle.

2 Introduction

This document contains a proposed solution to the problem of inequitable taxation that has occurred as a results of both historical failure to follow state law regarding annual revaluation and a lack of a systematic approach to regular physical inspection. Annual revaluation of all properties in the county has not been taking place since at least as far back as 2010 (the oldest assessment records we have public access to). Furthermore, even the attempt to do physical inspections on 6 year intervals has not been systematic and uniform, as we have found several properties that hadn't had physical inspection and/or revaluation since at least 2010.

Furthermore, even in the newly proposed plan of 6 defined "areas", we have discovered that there were even pockets of the south side of Pullman that didn't receive physical inspection and revaluation in 2023 (for the 2024 tax year) even though that was done for the vast majority of properties in that "area". Those same homes were again not revalued in 2024 (for the 2025 tax year), or at least that is what is indicated in TaxSifter.

The purpose of this plan is to perform a whole-county mathematical optimization problem, in which a fair taxation amount is calculated for each property in the county, and then a per-property "percent of actual value" (POAV) is provided for each year, such that the property owner pays the amount that is equitable over the 6-year cycle. As 1-2 years of the 6-year cycle have already passed without a solution being provided, this proposed solution applies an optimized POAV to each property so that equitable taxes are achieved over the course of the first 6 year cycle. It is assumed that even as early as next year that Whitman County will be following state law and conducting annual revaluations so that this problem won't occur again.

3 Assumed Available Information

For this optimization problem to work, it requires several necessary inputs.

1. The true market value of every property in the county, which we will call $T_{y,k}$, where y is the year and k represents the k-th property in the county. The collection of this information is required by state law and must begin immediately, as pointed out by the recent DOR audit of the Whitman County assessment procedures.

2. The assessed value of every property in the county in the years of the cycle prior to the implementation of this optimization, which we will call $A_{y,k}$, where y is the year and k represents the index in the list of the k-th property in the county.

3. The amount of taxes that will be collected by a given tax district in each year of the cycle, C_y.

4. A list of which tax districts each property is part of, which we will call $D_{y,k}$, where y is the year and k represents the k-th property in the county.

There are a few critical facts/assumptions to realize involving the information above.

- Because the county hasn't been following state law and revaluating all properties in the county each year, the first year that full county revaluation occurs will have to be used as a basis to back-calculate the "true value", $T_{y,j}$, for all the prior years in the 6 year cycle. A broad market analysis by zip code or general area should be sufficient to apply a gross annual percentage adjustment to find the "true value" for prior years with fairly high accuracy.

- During the optimization, the assessed values, $A_{y,k}$, of the years that have already elapsed in the 6-year cycle are fixed. Thus the optimization only provides the target assessed values, or the analogous POAV, for the remaining years of the 6-year cycle.

- For simplification of the optimization process, it would be ideal to have this list of actual and assessed values in a spreadsheet or CSV file with matched columns for each year, so that the historical data is easy to parse by the optimization software.
- Each year the list of properties will grow, as new properties are added to the rolls. There will need to be some way to indicate which properties are added and in which year. This is critical when doing the back-calculations of true value and updating the 100%-of-actual-value levy rate, which is a key intermediate result in the optimization process.

The outputs of the optimization process is "percent of actual value" (POAV) that should be applied to each property in the county for the remaining years in the cycle, which we will call $P_{y,k}$, where y is the year and k represents the k-th property in the county.

4 Proposed Solution

This sections goes into great detail of the process of optimizing the POAV for each property to ensure that equitable taxation is achieved over the 6 year cycle. I am not going to decrease the mathematical rigor with which I explain the process, but I will intersperse the math with explanations of what is going on in terms that should make sense to those with some finance/accounting experience.

We will divide the optimization problem into two computations: (1) past tax years where we are calculating how much a property owner has overpaid/underpaid compared to an equitable tax, and (2) future years where the POAV are adjusted relatively to achieve equitable taxation for all. Some of the the optimization math below is only shown for a single tax district, but the exact same computation can easily be conducted for each tax district individually, and our final equation describes how the optimization is conducted across all tax districts.

In any given year, we are going to conduct two different computations. One is based on the assessed values and the other is based on the true values.

1. The total tax district assessed property values, tax district levy rate based on assessed values, and individual property taxes for each property in the tax district based on assessed values.

$$\begin{aligned} P_{A,y} &= \sum A_{y,k} \text{ - the total tax district assessed property value} \\ L_{A,y} &= \frac{C_y}{P_{A,y}} \text{ - the levy rate based on the assessed values} \\ V_{A,y,k} &= L_{A,y} A_{y,k} \text{ - the tax due by the k-th property owner, based on assessed values} \end{aligned} \tag{1}$$

2. The total tax district 100% actual property values, tax district levy rate based on 100% actual property values, and what truly equitable individual

property taxes would be for each property in the tax district if revaluation had been following state law.

$$\begin{aligned}
P_{T,y} &= \sum T_{y,k} \text{ - the total tax district true property value}\\
L_{T,y} &= \frac{C_y}{P_{T,y}} \text{ - the levy rate based on the true values}\\
V_{T,y,k} &= L_{T,y} T_{y,k} \text{ - the tax due by the k-th property owner, based on true values}
\end{aligned} \tag{2}$$

The way these two sets of computations can be interpreted is that the first set of computations tells us what each taxpayer paid based on the tax district assessments in a given year, and the second set of computations tells us what fair taxation would be if everyone's assessed value was correct.

But, because the first year or two of the faulty process will have already passed before this type of correction can occur, then the goal is to achieve equitable taxation over the 6-year cycle. So, if we sum the difference between the equitable taxation and the taxation based on assessments over the 6-year cycle, the desirable outcome would be that this sum is equal to zero.

$$J_k = \sum_{y=2024}^{2029} (V_{A,y,k} - V_{T,y,k})^2 \tag{3}$$

This value J_k can be interpreted as the squared error of taxed paid from and equitable amount over the cycle, which we will call the "taxation discrepancy". It may look strange that I am choosing to take the squared value of the difference, but this is simply a mathematically-sound choice because it makes the algorithms that conduct the optimization perform better and always have a positive discrepancy. In the mathematics field of optimization, this is called the "cost" or "cost function", but to avoid confusion with more commonplace usage of the term "cost", we are going to use the term "taxation discrepancy". This value gives a measure of how far a given set of assessment values over the 6-year cycle are from being an equitable taxation. When this value is zero, then an equitable taxation over the 6-year cycle has been achieved.

If we expand this summation to show all 6 years, really the only values that the optimization problem can "wiggle" to achieve fair taxation are the assessed values of properties in the remaining years in the 6-year cycle. This is because the first year (and possibly second year) has already been set in stone and people have paid (or are paying) those taxes already. This expansion of the taxation discrepancy is shown below with the variables that can be adjusted in bold (assuming that only the first year of the cycle is set in stone):

$$\begin{aligned}
J_k =& (V_{A,2024,k} - V_{T,2024,k})^2 + (\boldsymbol{V_{A,2025,k}} - V_{T,2025,k})^2 + (\boldsymbol{V_{A,2026,k}} - V_{T,2026,k})^2 + \\
& (\boldsymbol{V_{A,2027,k}} - V_{T,2027,k})^2 + (\boldsymbol{V_{A,2028,k}} - V_{T,2028,k})^2 + (\boldsymbol{V_{A,2029,k}} - V_{T,2029,k})^2
\end{aligned} \tag{4}$$

In other words, we can say that the taxation discrepancy for any individual property is a function of how we decide to assign an assessed value over the remaining years of the cycle.

$$J_k = f(V_{A,2025,k}, V_{A,2026,k}, V_{A,2027,k}, V_{A,2028,k}, V_{A,2029,k}) \tag{5}$$

Furthermore, we can compute a total taxation discrepancy for the entire tax district by summing the individual property taxation discrepancies for all the properties in the tax district.

$$J_{\text{district}} = \sum_{k=1}^{n} J_k = \sum_{k=1}^{n} \sum_{y=2024}^{2029} (V_{A,y,k} - V_{T,y,k})^2 \tag{6}$$

Extending even further, we can sum the taxation discrepancy over all the districts to get a total "taxation discrepancy", which we will call J_{county}. In the end, the variable input to this taxation discrepancy function, X, is a very large array of all the assessed values over the remaining years of the cycle. In the form below, the $\cdots$ represent all the other properties and years in the county.

$$X = [A_{2024,1}, \cdots, A_{2029,1}, A_{2024,2}, \cdots, A_{2029,2}, \cdots, A_{2024,n}, \cdots, A_{2029,n}] \tag{7}$$

One important note is that not all properties in the county will have entries for every year. New properties will only have as many years as the property has existed as a separate entity on the tax rolls. This doesn't have an effect on the success of the optimization, but must be taken into account to ensure that the new property owners are also treated equitably.

The optimization algorithm can also be modified ensure that by the fourth year of the cycle that all properties are assessed at 100% of fair market value and to try and ensure that the assessment value for each successive year is the same or higher than the previous year, by adding additional terms to the taxation discrepancy equation.

$$\begin{aligned} J_{\text{district}} = \sum_{k=1}^{n} \sum_{y=2024}^{2029} (V_{A,y,k} - V_{T,y,k})^2 + \alpha_1 \sum_{k=1}^{n} (T_{2027,k} - A_{2027,k})^2 \\ + \alpha_2 \sum_{k=1}^{n} \sum_{y=2025}^{2029} |A_{y,k} - A_{y-1,k}| \end{aligned} \tag{8}$$

The first extra term causes the optimization process to try and ensure that in the fourth year of the 6-year cycle that the assessed value is equal to the fair market value and the second extra term causes the optimization process to work to ensure that each year's assessment is higher than the previous year.

4.1 Optimization Methods

The optimizations were conducted using the numerical optimization algorithms provided by the Python-based SciPy Optimization library (see `https://docs.scipy.org/doc/scipy/tutorial/optimize.html`). I tried the following approaches with nearly identical results, achieving approximately anequitable taxation to within 0.3% of a true fair taxation over the 6-year cycle. The optimization algorithms used during experimentation were:

- Powell's conjugate gradient method.
- Sequential Least Squares Programming (SLSQP).
- Dual annealing

The dual annealing approach and Powell's method both performed the best, achieving the 0.3% results. SLSQP was near 1.0%. Dual annealing often is computationally more efficient for large numbers of variable, which will occur when applying this optimization process to the entire county.

4.2 Experiments

I conducted experiments with a set of 6 proposed properties. I did experiments where the faulty assessment procedures were in effect for either the first year or the first two years of the 6 year cycle.

I also conducted variation where the initial property values were across a large range of $\$250,000 - \$1,000,000$ and where the initial two years had disparate percentages of POAV in the range $30\% - 80\%$.

In all experiments, the result was fair taxation to within 0.3% of a true fair taxation over the 6-year cycle.

Table 1 provides an example of the results of this optimization. It uses different values for each property and differing starting POAV for the first year. The algorithm is allowed to adjust the POAV in years 2 through 6. In this simulation, there are several assumptions:

1. True property values increase by 5% each year.
2. Property 1 was increased to 80% in the first year of the 6-year cycle. Its assessed value is then held fixed over the remaining years of the cycle.
3. Properties 2 through 6 are allowed to have their POAV adjusted annually for years 2 though 6 of the 6-year cycle.

Though not shown in this example for the sake of presenting a simplified table, this doesn't include that addition of new properties in the later years. This doesn't present a problem for the optimization methodology presented.

5 Conclusion

The described method of optimization is able to achieve equitable taxation over the 6-year assessment cycle, despite the first area (and maybe the second) being treated unfairly under the current procedures. This is done by computing the percent-of-actual-value (POAV) that should be applied to each property on a yearly basis going forward. The plain-English end result is that the first properties that have been over-taxed are held near the same POAV over the remaining years of the cycle, while the other property's POAV is adjusted year-over-year to arrive at the equitable taxation.

Year	Property 1	Property 2	Property 3	Property 4	Property 5	Property 6
2023						
True Market Value	800,000	500,000	400,000	400,000	300,000	400,000
Assessed Value	500,000	450,000	200,000	300,000	100,000	200,000
Tax Due (Assessed)	285.71	257.14	114.29	171.43	57.14	114.29
Tax Due (True)	285.71	178.57	142.86	142.86	107.14	142.86
2024						
True Market Value	840,000	525,000	420,000	420,000	315,000	420,000
Assessed Value	672,000	450,000	200,000	300,000	100,000	200,000
Tax Due (Assessed)	353.13	236.47	105.10	157.65	52.55	105.10
Tax Due (True)	288.57	180.36	144.29	144.29	108.21	144.29
2025						
True Market Value	882,000	551,250	441,000	441,000	330,750	441,000
Assessed Value	702,219.03	450,025.96	303,050.04	353,424.15	282,089.65	392,373.44
Tax Due (Assessed)	288.47	184.87	124.49	145.19	115.88	161.19
Tax Due (True)	291.46	182.16	145.73	145.73	109.30	145.73
2026						
True Market Value	926,100	578,812.5	463,050	463,050	347,287.5	463,050
Assessed Value	725,586.23	450,050.11	426,719.71	386,422.59	326,424.64	402,238.96
Tax Due (Assessed)	275.10	170.63	161.79	146.51	123.76	152.51
Tax Due (True)	294.37	183.98	147.19	147.19	110.39	147.19
2027						
True Market Value	972,405	607,753.13	486,202.5	486,202.5	364,651.88	486,202.5
Assessed Value	758,243.71	450,477.20	464,923.32	387,190.13	333,952.89	428,577.48
Tax Due (Assessed)	279.46	166.03	171.36	142.71	123.08	157.96
Tax Due (True)	297.32	185.82	148.66	148.66	111.49	148.66
2028						
True Market Value	1,021,025.25	638,140.78	510,512.63	510,512.63	382,884.47	510,512.63
Assessed Value	767,066.84	450,478.26	481,830.04	400,308.02	380,218.75	442,846.66
Tax Due (Assessed)	275.83	161.99	173.26	143.95	136.73	159.25
Tax Due (True)	300.29	187.68	150.14	150.14	112.61	150.14
2029						
True Market Value	1,072,076.51	670,047.82	536,038.26	536,038.26	402,028.69	536,038.26
Assessed Value	1,072,076.47	670,047.82	536,038.26	536,038.26	402,028.66	536,038.26
Tax Due (Assessed)	303.29	189.56	151.65	151.65	113.73	151.65
Tax Due (True)	303.29	189.56	151.65	151.65	113.73	151.65
Taxes Paid Through the First Cycle						
Actual Tax	1,775.30	1,109.56	887.65	887.65	665.74	887.65
Equitable Tax	1,775.30	1,109.56	887.65	887.65	665.74	887.65

Table 1: Tax Data from 2023 to 2029

The other thing to consider is that I have been conducting the example problems on a few handfuls of simulated properties. This optimization computation is essentially instantaneous. The real optimization computation will be tens of thousands of properties and the computation could take many hours or even days. This fundamentally isn't a problem, but just a note about how many variables are involved in the true problem. I can conduct a larger scale "toy problem" to verify exactly how the computation time scales with the number of properties.