

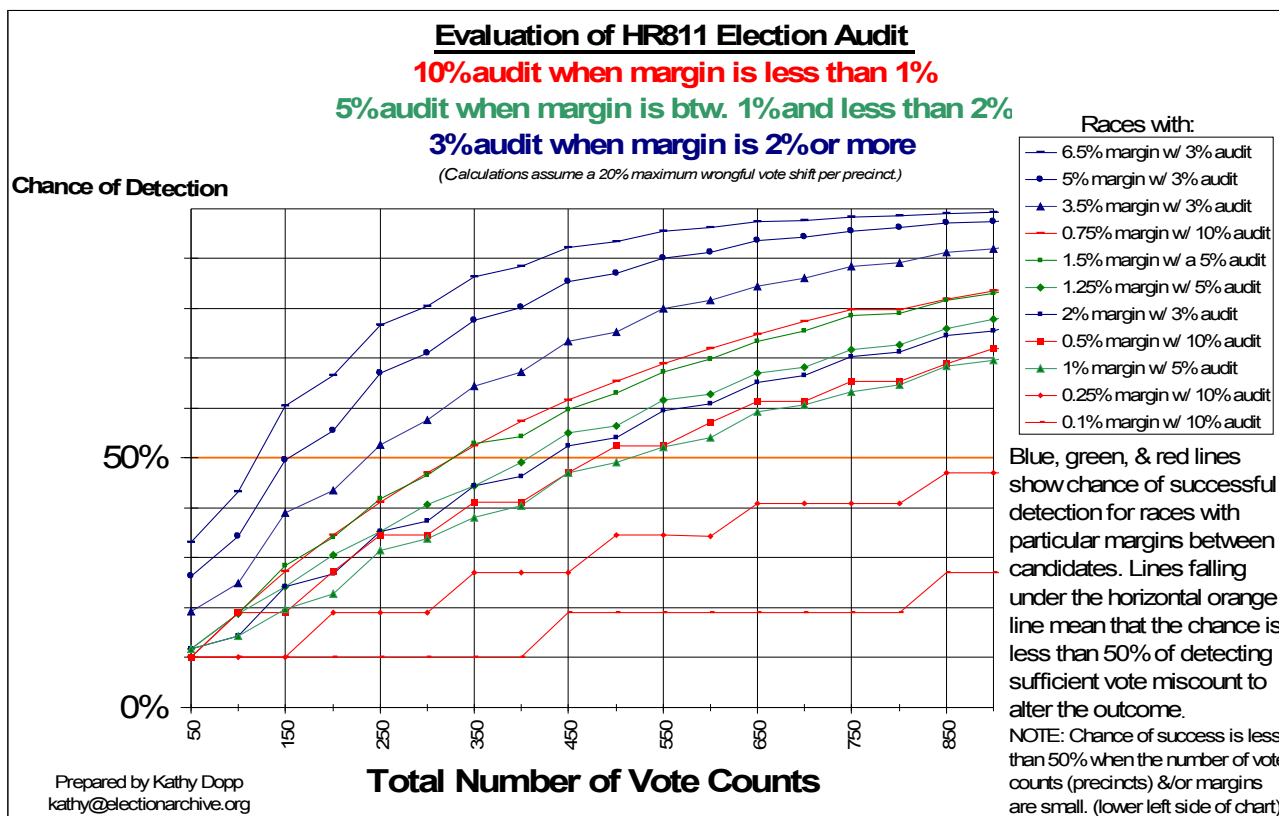
Proposal 1: US HR811 and S559 Audits are Insufficient to Detect Vote Miscount in Many US House Races

Margins Between Candidates	Precinct Audit %
0 % to .99..%	10 %
1 % to 1.99..%	5 %
2 % +	3 %

A tiered election audit, as proposed by Representative Holt and Senator Nelson (in HR811 and S559 - section 322) as shown in the small table at left, is an excellent idea because when a race is close, a small amount of vote miscount can wrongly alter the election outcome, so that larger audits are needed to find miscount which could be hidden in fewer precincts.

The problem is that the HR811/S559 audit ignores the variety in the number of precincts in US House districts. E.g. a 10% audit in an 800-precinct House district gives an audit of 80 precincts, whereas a 10% audit in a 150-precinct House district gives an audit of 15 precincts which would not be sufficient in any close race where fewer than 1 in 15 miscounted precincts could alter the outcome.

The chart below gives probabilities for detecting vote miscount sufficient to alter election outcomes using HR811/S559 audits. Each curved line



gives the chance for successful detection in a race with a specific margin between the leading candidates, for various numbers of total precinct (and batch) vote countsⁱ.

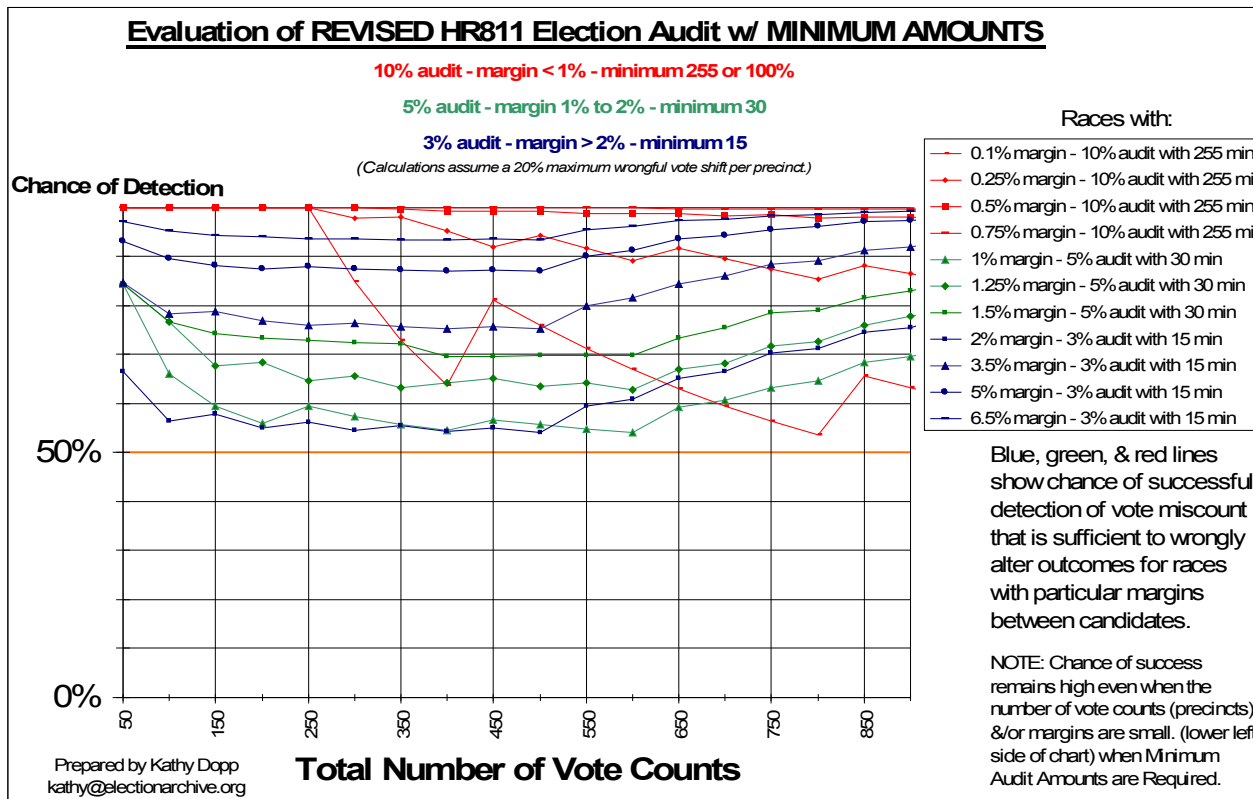
Whenever a given margin-curveⁱⁱ falls below the horizontal 50% orange line, the chance of an HR811/S559 audit successfully detecting miscount sufficient to alter the outcome is less than 50% for races with that number of total precinct (and batch) vote counts.

A group of university professors wrote a letter to Representative Holt supporting HR811's audit,ⁱⁱⁱ but their analysis was restricted to a few margins for the case of a 400-precinct House district. The professors' numbers, except in one case^{iv}, agree with the numbers found on the chart to the left. I.e. for 400-precinct House races with margins of 0.5%, 0.75%, 2%, and 5%, the success probabilities for HR811/S559 audits are respectively 41%, 58%, 46% and 80%.

Proposal 2: HR811 and S559 Audits could be revised to protect all US House Races

The small table below shows a suggested revision to election integrity bills HR811 and S559 audit protocols to require minimum *amounts* of precinct (or batch) vote counts^v for each margin tier. (When the minimum required amount is more than the total number of precinct and batch vote counts in a US House race, then a 100% manual audit is required.) Notice that imposing these minimums results in success probabilities above 50% for detecting vote miscount sufficient to alter outcomes. Notice that because HR811/S559 audit rates are insufficient at low margins, the minimums must be very high: 255 (or 100% of precincts, whichever is less) for the 10% audit tier, 30 precincts for the 5% audit tier, and 15 for the 3% audit tier; effectively requiring higher than a 10% audit rate for low margins. But this revised HR811/S559 audit may not protect^{vi} some races with margins under 0.1%, such as the currently disputed Florida House District 13 race between Jennings and Buchanan.

Margins Between Candidates	Precinct Audit %	Minimum Audit Amounts
0 % to .99..%	10 %	255
1 % to 1.99..%	5 %	30
2 % +	3 %	15



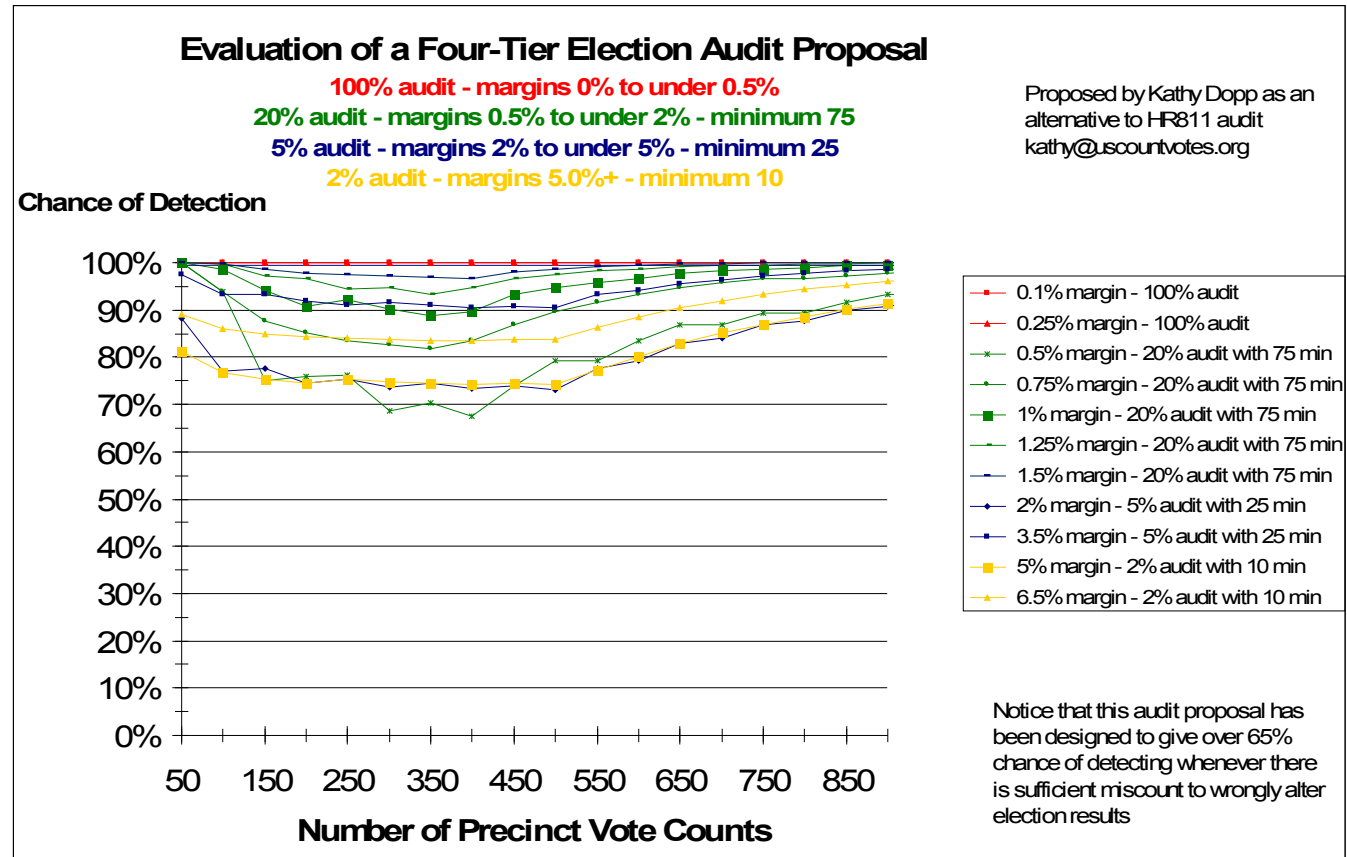
Why Are Minimum Audit Amounts Necessary?

One can easily imagine that if one in every 25 precinct vote counts are corrupt (have miscounts) then at least 25 precinct-counts must be sampled to have a decent chance to find a bad one! Indeed we must sample at least 40 or 50 precinct-counts to have a reasonably high chance to detect at least one corrupt count. This is true no matter what the total number of precinct-counts is in a particular race. A minimum number of precinct-counts to audit must be specified in any tiered election audit in order to bound the success probability from below. E.g. To detect one out of 25 corrupt precinct vote counts (plenty to alter a 1% margin race): 10% of 1,000 total vote counts gives a sufficient 100 sample size, but 10% of 150 total vote counts gives an insufficient 15 precinct-count audit sample size.

Proposal 3: A More Effective Tiered Election Audit Proposal

Margins Between Candidates	Precinct Audit %	Minimum Audit Amounts
0 % to 0.49..%	100 %	NA
0.5 % to 1.99..%	20 %	75
2 % to 4.99..%	5 %	25
5 % +	2 %	10

This tiered election audit protocol (small table at left) gives higher success probabilities than the HR811/S559 audit and is less costly than proposal #1 or #2 above whenever the margin between the two leading candidates is 5% or more because it then requires a 2% rather than a 3% audit; and it may also be more efficient (less costly) for other specific cases of margins and total number of precinct vote counts, for example, it would often be less costly than proposal #2 when margins are between 0.5% and 1%. Note that if there are fewer than 75 precincts in a race with margin between leading candidates of from 0.5% to less than 2%, then 100% of precincts would be audited.



Conclusion

House Resolution 811 and Senate Bill 559 election audits, as currently proposed without any minimum audit amounts, would not be effective in many US House races because there would, in many cases, be less than a 50% chance of detecting when there is sufficient vote miscount to alter election outcomes. In fact, the HR811/S559 audit protocols could be evaded by intentionally constructing a smaller number of larger-sized precincts.

By requiring a minimum number of precinct (and batch) counts to be audited, the success probabilities for HR811/SHol559 audits could be increased above 50% for all US House races. However, accomplishing this increase in successful audits for all US House races would, in many cases, require substantially more auditing than HR811/S559 audit rates currently demand. And even if revised with minimum audit amounts, HR811/S559 audit tiers would not sufficiently protect some House races with less than 0.1% margins.

Hence I suggest employing a more effective audit with higher success probabilities which is less costly than the proposed HR811/SHol559 audit in cases of races with margins over 5%. It uses tiers that conform more to the actual shape of an optimal election audit sample size curve.^{vii}

Alternately, federal legislation could, instead of mandating a specific tiered election audit protocol, allow jurisdictions to directly calculate the minimum audit sample size needed to give a fixed high probability of detection (say 95%) by using either a formula or a numerical program.^{viii}

Note:

In order to do an in-depth analysis of the efficacy of any election audit proposals; and, more importantly, in order to calculate an accurate cost estimate for conducting any nation-wide manual audits of federal elections, we need to know the race margins, the total number of ballots cast, and the number of total precincts for all recent US House and Senate races for each state in recent election years. Tax-deductible donations to defray the \$1,500 that is needed to obtain the necessary data for 2002, 2004, and 2006 from EDS.com would be very appreciated and accepted at ElectionArchive.org. (Unfortunately states are not required to publicly post precinct-level election results and other detailed election data and election records, so that election data and election records needed to evaluate the electoral process can be difficult to obtain, especially for prior years.)

Acknowledgements: Thank you to Warren Smith, Sharon Christiansen and Marian Beddill who kindly suggested improvements to text explanations and to Peter Jones and Sharon for helping to write the press release (<http://electionarchive.org/ucvAnalysis/US/press/Release-ElectionAuditEval-200703.pdf>).

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Appendix A: Table 1:

Probability for Successful Detection of Sufficient Corruption to Alter Outcomes for **HR811 and S559 Election Audit Proposal**

%Corrupt Precinct Counts to Alter Outcome	0.25%	0.63%	1.25%	1.88%	2.50%	2.75%	3.13%	3.75%	4.38%	5.00%	5.63%
Audit Percentage	10.0%	10.0%	10.0%	10.0%	5.0%	5.0%	5.0%	5.0%	5.0%	3.0%	3.0%
Margins Between Candidates ->	0.10%	0.25%	0.50%	0.75%	1.00%	1.10%	1.25%	1.50%	1.75%	2.00%	2.25%
50	10.0%	10.0%	10.0%	10.0%	11.8%	11.8%	11.8%	11.8%	17.3%	11.8%	11.8%
100	10.0%	10.0%	19.1%	19.1%	14.4%	14.4%	18.8%	18.8%	23.0%	14.4%	17.1%
150	10.0%	10.0%	19.1%	27.3%	19.9%	24.3%	24.3%	28.4%	32.4%	24.3%	26.9%
200	10.0%	19.0%	27.2%	34.6%	22.8%	26.8%	30.6%	34.2%	37.6%	26.8%	31.3%
250	10.0%	19.0%	34.6%	41.2%	31.5%	31.5%	35.2%	42.0%	45.1%	35.2%	39.5%
300	10.0%	19.0%	34.5%	47.2%	34.0%	37.4%	40.6%	46.6%	52.0%	37.4%	41.3%
350	10.0%	27.2%	41.1%	52.5%	38.2%	41.4%	44.5%	52.9%	57.9%	44.5%	48.2%
400	10.0%	27.2%	41.1%	57.3%	40.5%	43.5%	49.2%	54.3%	61.1%	46.4%	51.4%
450	19.0%	27.2%	47.1%	61.6%	47.1%	49.9%	55.1%	59.7%	65.8%	52.6%	57.1%
500	19.0%	34.5%	52.4%	65.5%	49.1%	51.7%	56.6%	63.0%	68.4%	54.2%	59.7%
550	19.0%	34.5%	52.4%	69.0%	52.3%	57.2%	61.5%	67.3%	73.7%	59.4%	63.3%
600	19.0%	34.5%	57.2%	72.1%	54.1%	58.7%	62.8%	70.0%	75.7%	60.8%	65.6%
650	19.0%	41.1%	61.5%	74.9%	59.2%	61.4%	67.1%	73.5%	78.7%	65.3%	69.6%
700	19.0%	41.0%	61.5%	77.5%	60.7%	64.7%	68.2%	75.6%	80.3%	66.5%	71.5%
750	19.0%	41.0%	65.4%	79.7%	63.2%	66.9%	71.9%	78.5%	82.7%	70.3%	74.8%
800	19.0%	41.0%	65.4%	79.7%	64.6%	68.1%	72.8%	79.2%	84.0%	71.3%	75.6%
850	27.1%	47.0%	68.8%	81.8%	68.6%	71.7%	75.9%	81.6%	86.7%	74.6%	78.4%
900	27.1%	47.0%	72.0%	83.6%	69.7%	72.8%	77.9%	83.1%	87.7%	75.5%	79.8%
950	27.1%	46.9%	72.0%	85.3%	71.6%	75.8%	79.4%	85.1%	89.2%	78.3%	82.2%
1000	27.1%	52.3%	74.8%	86.7%	72.7%	76.7%	81.1%	86.3%	90.1%	79.0%	83.3%

Note: Calculations assume a maximum vote shift of 20% within a single precinct vote count which would not be noticed as suspicious. Measures can be derived to calculate when precinct vote counts seem suspicious and those calculated precincts or discretionary precincts chosen by candidates should be manually audited in addition to the randomly selected precinct vote counts.

Table 2: Probability for Successful Detection of Sufficient Corruption to Alter Outcomes for HR811 and S559 Revised Election Audit Proposal

%Corruption to Alter	0.25%	0.63%	1.25%	1.88%	2.50%	3.75%	4.38%	5.00%	6.88%	7.50%	8.13%	8.75%
LookUP Audit Percentage	10.0%	10.0%	10.0%	10.0%	5.0%	5.0%	5.0%	3.0%	3.0%	3.0%	3.0%	3.0%
LookUP Min Audit Amt	255	255	255	255	30	30	30	15	15	15	15	15
Margins Between Candidates -	0.10%	0.25%	0.50%	0.75%	1.00%	1.50%	1.75%	2.00%	2.75%	3.00%	3.25%	3.50%
50	100.0%	100.0%	100.0%	100.0%	84.5%	84.5%	94.2%	66.6%	77.3%	77.3%	84.7%	84.7%
100	100.0%	100.0%	100.0%	100.0%	66.1%	76.6%	83.9%	56.4%	69.2%	74.1%	78.4%	78.4%
150	100.0%	100.0%	100.0%	100.0%	59.5%	74.5%	79.8%	57.9%	69.9%	73.2%	76.1%	78.7%
200	100.0%	100.0%	100.0%	100.0%	56.0%	73.4%	77.6%	55.0%	67.7%	70.3%	74.9%	77.0%
250	100.0%	100.0%	100.0%	100.0%	59.6%	72.8%	76.2%	56.2%	68.5%	70.5%	74.2%	75.9%
300	85.0%	97.8%	100.0%	100.0%	57.4%	72.5%	77.9%	54.5%	67.2%	70.7%	73.8%	76.6%
350	72.9%	98.0%	99.9%	100.0%	55.8%	72.2%	76.9%	55.5%	67.9%	70.8%	73.4%	75.9%
400	63.8%	95.3%	99.4%	100.0%	54.6%	69.6%	76.2%	54.3%	67.0%	69.6%	73.2%	75.3%
450	81.3%	91.9%	99.4%	100.0%	56.8%	69.7%	75.6%	55.1%	66.3%	69.8%	73.0%	75.8%
500	76.0%	94.3%	99.4%	99.9%	55.7%	69.8%	75.1%	54.2%	66.9%	70.0%	72.8%	75.4%
550	71.3%	91.8%	98.8%	99.9%	54.8%	69.9%	76.2%	59.4%	70.9%	74.6%	77.1%	80.0%
600	67.0%	89.1%	98.8%	99.9%	54.1%	70.0%	75.7%	60.8%	73.4%	75.9%	78.9%	81.5%
650	63.1%	91.8%	98.9%	99.9%	59.2%	73.5%	78.7%	65.3%	76.7%	79.6%	82.2%	84.5%
700	59.6%	89.7%	98.4%	99.8%	60.7%	75.6%	80.3%	66.5%	78.7%	81.3%	83.6%	86.2%
750	56.5%	87.6%	98.5%	99.8%	63.2%	78.5%	82.7%	70.3%	81.3%	84.2%	86.2%	88.4%
800	53.6%	85.4%	97.9%	99.7%	64.6%	79.2%	84.0%	71.3%	82.4%	85.0%	87.3%	89.3%
850	65.8%	88.3%	98.1%	99.7%	68.6%	81.6%	86.7%	74.6%	85.0%	87.3%	89.7%	91.3%
900	63.2%	86.5%	98.2%	99.7%	69.7%	83.1%	87.7%	75.5%	85.9%	88.4%	90.5%	91.9%
950	60.9%	84.8%	97.7%	99.7%	71.6%	85.1%	89.2%	78.3%	88.0%	90.2%	92.0%	93.5%
1000	58.7%	87.4%	97.9%	99.6%	72.7%	86.3%	90.1%	79.0%	88.7%	90.7%	92.6%	94.0%

Note: Calculations assume a maximum vote shift of 20% within a single precinct vote count which would not be noticed as suspicious. Measures can be derived to calculate when precinct vote counts seem suspicious and those calculated precincts or discretionary precincts chosen by candidates should be manually audited in addition to the randomly selected precinct vote counts.

Table 3:

Probability for Successful Detection of Sufficient Corruption to Alter Outcomes for **Dopp's Alternative Election Audit Proposal**

% Corrupt Precinct Counts to Alter Outcomes	0.25%	0.63%	1.25%	1.25%	1.88%	2.50%	3.13%	3.75%	5.00%	8.75%	12.50%	16.25%
LookUP Audit Percentage	100%	100%	100%	20%	20%	20%	20%	20%	5%	5%	2%	2%
LookUP Min Audit Amt	0	0	0	75	75	75	75	75	25	25	10	10
Margins Between Candidates ->	0.10%	0.25%	0.50%	0.50%	0.75%	1.00%	1.25%	1.50%	2.00%	3.50%	5.00%	6.50%
50	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	88.3%	97.5%	81.3%	89.1%
100	100.0%	100.0%	100.0%	93.9%	93.9%	98.6%	99.7%	99.7%	77.1%	93.4%	76.9%	85.9%
150	100.0%	100.0%	100.0%	75.2%	87.8%	94.0%	97.1%	98.6%	77.6%	93.2%	75.3%	84.8%
200	100.0%	100.0%	100.0%	75.8%	85.0%	90.8%	96.5%	97.9%	74.6%	92.0%	74.6%	84.3%
250	100.0%	100.0%	100.0%	76.2%	83.5%	92.1%	94.5%	97.4%	75.5%	91.2%	75.3%	83.9%
300	100.0%	100.0%	100.0%	68.6%	82.5%	90.3%	94.7%	97.1%	73.8%	91.5%	74.8%	83.7%
350	100.0%	100.0%	100.0%	70.3%	81.8%	88.9%	93.3%	96.8%	74.6%	91.0%	74.4%	83.5%
400	100.0%	100.0%	100.0%	67.4%	83.5%	89.6%	94.8%	96.7%	73.4%	90.6%	74.1%	83.4%
450	100.0%	100.0%	100.0%	74.0%	86.8%	93.4%	96.7%	97.9%	74.0%	90.9%	74.6%	83.7%
500	100.0%	100.0%	100.0%	79.2%	89.5%	94.7%	97.4%	98.7%	73.2%	90.6%	74.3%	83.6%
550	100.0%	100.0%	100.0%	79.2%	91.6%	95.8%	98.3%	99.2%	77.7%	93.2%	77.4%	86.3%
600	100.0%	100.0%	100.0%	83.4%	93.3%	96.6%	98.7%	99.5%	79.4%	94.2%	80.2%	88.5%
650	100.0%	100.0%	100.0%	86.8%	94.7%	97.9%	99.2%	99.7%	82.9%	95.5%	83.0%	90.3%
700	100.0%	100.0%	100.0%	86.8%	95.7%	98.3%	99.3%	99.8%	84.1%	96.4%	85.0%	91.9%
750	100.0%	100.0%	100.0%	89.4%	96.6%	98.6%	99.6%	99.9%	86.8%	97.3%	86.9%	93.2%
800	100.0%	100.0%	100.0%	89.4%	96.6%	98.9%	99.7%	99.9%	87.8%	97.7%	88.4%	94.3%
850	100.0%	100.0%	100.0%	91.5%	97.3%	99.3%	99.8%	99.9%	89.9%	98.3%	90.1%	95.3%
900	100.0%	100.0%	100.0%	93.3%	97.8%	99.5%	99.9%	100.0%	90.6%	98.6%	91.3%	96.1%
950	100.0%	100.0%	100.0%	93.2%	98.3%	99.6%	99.9%	100.0%	92.2%	99.0%	92.3%	96.7%
1000	100.0%	100.0%	100.0%	94.6%	98.6%	99.7%	99.9%	100.0%	92.8%	99.1%	93.3%	97.3%

Note: Calculations assume a maximum vote shift of 20% within a single precinct vote count which would not be noticed as suspicious. Measures can be derived to calculate when precinct vote counts seem suspicious and those calculated precincts or discretionary precincts chosen by candidates should be manually audited in addition to the randomly selected precinct vote counts.

ⁱ Votes are usually not tallied all at once, but in smaller groupings that are then added together. A “vote count” is a group of ballots that are counted at one place and time. These vote counts are often loaded into a database, from which the overall results are computed. U.S. voting systems use a variety of types of vote counts including:

- Precinct or polling location vote counts (counted by precinct op-scan machines, by hand counting, or by DRE voting machines), where each count is associated with all the paper ballots or voter-verifiable paper records cast at a precinct or polling location, or
- DRE voting machine vote counts, where each vote count is associated with the voter-verifiable paper records of ballots cast on one DRE voting machine, or
- Batches of ballots (counted by hand or by central count optical scan voting systems), where each vote count is associated with a batch of ballots maintained as a group.

See <http://electionarchive.org/ucvInfo/US/Letter2Congress.pdf> For audits to work effectively, the batches of ballots counted by any central count op-scan system need to contain roughly the same number of ballots as an average-sized audited precinct vote count. i.e. All audited vote counts need to be roughly the same size or fraud can be hidden with lower chance of detection in fewer large-sized vote counts. In the case that there is unavoidable large variation in vote count size, the exact number of vote counts that could hide sufficient vote miscount to alter an election outcome can be calculated and used to exactly calculate the optimal audit sample size.

ⁱⁱ The stair-step appearance of some margin-curves occurs due to necessary rounding up or down to the next integer in calculations. Only integer values for the number of corrupt vote counts and the audit sample sizes are possible in the real-world application of election auditing.

ⁱⁱⁱ “Thoughts on Mandatory Audits” Found here http://www.brennancenter.org/dynamic/subpages/download_file_47860.pdf or here <http://electionarchive.org/ucvAnalysis/US/paper-audits/SupportHR811-RivestDillWagnerNordenBursteinHokeMebaneHall.pdf>

^{iv} In the case of 1% margins, the professors miscalculated by wrongly applying a 10% audit rather than the 5% audit which is what HR811 and S559 requires and they slightly miscalculated or misprinted the probability for a 5% audit with a 1% margin which is 41%, not 47%.

^v *ibid* i.

^{vi} “Protected” means there is at least 50% chance of discovering miscount under the assumption that sufficient miscount exists to alter an outcome.

^{vii} See “Tiered Election Audits” <http://electionarchive.org/ucvAnalysis/US/paper-audits/FourTierAudit/TieredElectionAudits.pdf> and

“The Election Integrity Audit” <http://electionarchive.org/ucvAnalysis/US/paper-audits/ElectionIntegrityAudit.pdf>

^{viii} See “The Election Integrity Audit” <http://electionarchive.org/ucvAnalysis/US/paper-audits/ElectionIntegrityAudit.pdf> and “How Big Should an Election Audit Be?” <http://electionarchive.org/ucvAnalysis/US/paper-audits/ElectionAuditEstimator.pdf>

This report “Fool Me Once: Checking Vote Count Integrity” is found on-line at <http://electionarchive.org/ucvAnalysis/US/paper-audits/TierElectionAuditEval.pdf>