



Orange County
Registrar of Voters
2018 Risk Limiting Audit
Pilot Project Report



**ORANGE COUNTY
REGISTRAR OF VOTERS**

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EXECUTIVE SUMMARY

In a typical election year, counties in California hand count tens of thousands of ballots as part of the one-percent (1%) manual tally; yet, doing so provides little or no statistical evidence that the machine tally found the true winner for each contest on the ballot – and does nothing to correct any erroneous electoral outcomes. California’s 1% manual tally laws date back to the 1960s and requires all county elections officials to randomly select 1% of all precincts after each election and hand count all the votes from those precincts. As In Orange County, the nation’s fifth largest voting jurisdiction, the 1% manual tally requires significant staff resources and time to complete.

In 2007, the California Secretary of State created a Post-Election Audit Standards Working Group to review the state’s 1% manual tally law and new post-election audit models. The Working Group’s report recommended a risk-based approach to post-election audits, an adjustable sample model, and a comprehensive methodology to verifying election results, including rules for escalating an audit when the hand count of the initial audit sample cannot confirm that the voting system results are correct.

The risk-limiting audit is a robust method of manually auditing election results to provide statistical confidence in the outcomes. This method provides a higher statistical confidence level of the reported election results than traditional manual count methods and is, therefore, becoming more prolific and desirable for elections officials to implement. The risk-limiting audit provides the ability to determine, with a predefined risk level, if it can correct an erroneous outcome. The 1% manual tally, although it provides confidence the voting system is working properly, does not provide the ability to correct an erroneous outcome.

The Governor signed, AB 2023 in 2010, which authorized the Secretary of State to conduct a post-election audit pilot program to test risk-limiting audits in select counties. A final report was submitted to the Election Assistance Commission (EAC) in 2014 with research findings, recommendations, and project outcomes.

With growing support over the years since, AB 2125 was passed in September 2018 to allow county election officials to conduct a risk-limiting audit in place of the 1% manual tally required by Elections Code Section 15360 during the official canvass of any election, commencing with the March 3, 2020 Statewide Primary Election.

In 2018, the Orange County Registrar of Voters concurrently conducted the 1% manual tally and a risk-limiting audit pilot program to compare the use of statistically based audit techniques and traditional post-election audits. To serve as an example to jurisdictions that may consider conducting a risk-limiting audit, Orange County successfully conducted two risk-limiting audit pilots using its legacy voting system. The first pilot was conducted in two phases during the June 2018 Statewide Primary Election and the second pilot was conducted during the November 2018 Statewide General Election.

Although jurisdictions throughout the country have been seeking to implement risk-limiting audits, they have faced significant challenges. The challenges have included:

- Many jurisdictions throughout the country have legacy voting systems that were not designed to handle risk-limiting audits.
- There are no pre-established procedures for conducting risk-limiting audits for the various voting systems used throughout the country, especially for legacy voting systems.

As a result, the Orange County Registrar of Voters looks forward to sharing its data on pre-audit procedures, audit processes and procedures, and observations made during the pilot program to provide best practices to other county elections officials considering implementing risk-limiting audits.



Neal Kelley
Registrar of Voters
Orange County, CA

DETERMINING THE METHOD

Ballot Polling versus Comparison

Before attempting a risk-limiting audit, Registrar of Voters Neal Kelley was required to choose a method to conduct the audit. There are at least two types of audits – a comparison audit and a ballot polling audit. A comparison audit requires one to manually check a single ballot or group of ballots to exactly know how that ballot or group of ballots was tallied by the voting system. In comparison, a ballot polling audit randomly selects ballots to be counted, which when tallied gives sufficiently strong evidence that the candidate with the most votes according to the originally reported vote tally would be the same candidate prevailing in a full hand recount of all the ballots. The ballot polling audit only requires the final vote tally to be known.

Orange County's legacy voting system is not designed to allow auditing of individual voting records, which would have made it more challenging to implement a ballot-level audit comparison. As a result, the Registrar decided on the ballot polling audit method to conduct the audit.

HOW DOES IT WORK?

Planning for A Risk-Limiting Audit

For a risk-limiting audit to work with a legacy voting system, the requirements of a risk-limiting audit had to be considered, and the theoretical concepts had to be practically applied.

The Ballot Manifest

A ballot manifest “describes in detail how the ballots are organized and stored, ”and is a basic requirement to conduct the risk-limiting audit. It is simply a list of all the ballots cast in the entire election, organized in a table that allows the risk-limiting audit tool to randomly select ballots to be audited and allows those individual ballots to be located¹. For the integrity of audit, the ballot manifest needed to be created independently of the voting system containing ballots cast electronically and on paper. At polling places in Orange County, voters cast their ballots on electronic voting machines, which have a paper audit trail. Voters who vote-by-mail simply return a paper ballot. The ballot manifest must account for every ballot cast on an electronic voting machine at the polling place and every vote-by-mail ballot returned as a paper ballot.

Developing a ballot manifest was one of the most difficult challenges to overcome to perform a risk-limiting audit on a legacy voting system. The voting system used in Orange County does not have a tool to produce a ballot manifest; therefore, an alternative solution was needed.

	A	B	C	D	E	F	G	H	I	J	K
1	Database	Scanner	Batch	Images	Rejected	Ballots			batch	images	
2	1	1	1	390	0	65			1-1-1	390	
3	1	1	2	468	6	77			1-1-2	468	
4	1	1	3	294	0	49			1-1-3	294	
5	1	1	4	426	6	71			1-1-4	426	
6	1	1	5	486	2	81			1-1-5	486	
7	1	1	6	354	0	59			1-1-6	354	
8	1	1	7	360	0	60			1-1-7	360	
9	1	1	8	360	4	60			1-1-8	360	
10	1	1	9	432	4	72			1-1-9	432	
11	1	1	10	528	0	88			1-1-10	528	
12	1	1	11	793	0	47			1-1-11	793	
13	1	1	12	486	0	81			1-1-12	486	

¹ Stark, Philip (2012-03-16). “Gentle Introduction to Risk-limiting Audits” <https://www.stat.berkeley.edu/~stark/Preprints/gentle12.pdf>

Voter Verifiable Paper Audit Trail (VVPAT)



Figure 1. Voter Verifiable Paper Audit Trail is a paper record of the cast-vote record which was confirmed by the voter.

Independence from the Voting System

An important concept of risk-limiting audit is that it is intended to be performed independently from the voting system. This presents a challenge when auditing paper ballots on a legacy voting system as the legacy voting system only reports results at a precinct level. Paper ballots, however, are scanned into the voting system in “batches” without regard to precinct order. This creates an issue because the legacy voting system does not provide what is needed to properly conduct a risk-limiting audit. To find a specific ballot for a risk-limiting audit, one must be able to locate the specific batch in which it was scanned.

As a solution to this problem, the Registrar decided to separately and manually record each batch of paper ballots that was scanned and the number of paper sheets in that batch in a spreadsheet. For added accuracy, a precision scale was used to weigh and validate the number of sheets that were scanned in each batch. This process allowed for the creation of an independently verified list of batches of scanned ballots with the number of ballots in each batch. This spreadsheet was then used to create the ballot manifest.

Auditing Electronically Cast Ballots

In California, every vote cast electronically has a Voter Verifiable Paper Audit Trail (VVPAT), which is a paper record of the cast-vote record which was confirmed by the voter. All ballots cast in Orange County are centrally tallied at the Registrar of Voters’ central office; ballots are not tallied at any polling place or anywhere else. These paper audit trails were used to conduct the risk-limiting audit. The votes represented on the paper audit trails are cast electronically from polling places on Election Day; therefore, all precinct ballots are already grouped together on the same rolls of paper. The legacy voting system provides a report of the number of ballots cast at each precinct and polling place; therefore, the ballots are then organized in the same manner. This list of polling places and the number of ballots cast was then used to create the ballot manifest

Changes to the Process Required by the Risk-Limiting Audit

One practical difference between a risk-limiting audit and a traditional 1% manual tally is that a risk-limiting audit identifies specific ballots to be audited, while a traditional manual tally identifies specific precincts to be tallied. Rather than putting aside all the ballots in specific precincts for a 1% manual tally, a risk-limiting audit requires the ballots

to be organized in a way to pull randomly identified ballots that span across the entirety of all ballots cast. Therefore, preparations had to be made in order to pull specific ballots spread across all ballots cast, rather than simply isolating the ballots from a select number of precincts.

The risk-limiting audit identifies the batch of ballots and the ballot within the batch for auditing. To quickly find any paper ballot, teams laid out every batch in the order in which it was scanned. While this process required thousands of square feet of space, it allowed us to quickly locate any batch of ballots and, as a result, any ballot sheet within the batch.

Below is an example of the first few lines of the resulting manifest that was produced for paper ballots (only the last two columns are used):

Database	Scanner	Batch	Images			Batch	Images
1	1	1	390			1-1-1	390
1	1	2	468			1-1-2	468
1	1	3	294			1-1-3	294
1	1	4	426			1-1-4	426
1	1	5	486			1-1-5	486

Below is an example of the first lines of the resulting manifest that was produced for ballots cast electronically:

Precinct	Ballots
2001	164
2003	224
2008	185
2009	138
2011	397

ENSURING A TRANSPARENT PROCESS

Transparency is a key component of any type of audit. The implementation of a risk-limiting audit allows for additional opportunities for transparency. Listed below are steps that were taken to make the process as transparent as possible:

- A press release was sent, informing members of the public of the dates and times of the risk-limiting audit.
- The ballot manifest used in the risk-limiting audit was posted online, including a hash² of the manifest itself.
- The random seed was generated by numerous people, including members of the public, rolling ten-sided dice.
- The rolling of the dice was video recorded.
- The random seed was posted online.
- The entire risk-limiting audit process was live-streamed online.
- The software used to randomly select the ballots is publicly available online at <https://www.stat.berkeley.edu/~stark/Vote/ballotPollTools.htm>.

Press Release

Orange County, CA Elections to Conduct Risk Limiting Audit of November General Election Results

Posted to: choose Printer Friendly Version

While not required under California law pilot audit designed to provide strong statistical evidence that the election outcome is right.

SANTA ANA, CA -- November 19, 2018 - Orange County will conduct its second risk-limiting pilot audit beginning Monday, November 26, 2018. The ballot polling audit is not required under California law and is being conducted as an additional pilot to refine our approaches to risk-limiting audits.

The risk-limiting audit is a procedure that provides strong statistical evidence that the election outcome is correct, or has a high probability of correcting an outcome that wouldn't match a full hand count of the ballots. The audit itself requires human beings to examine and verify more ballots in close contests and fewer ballots in contests with wider margins.

Quote by Registrar of Voters Neal Kelley

"Conducting a risk-limiting audit is an excellent way to audit elections and provide an important check on the integrity of the election process." He continued, "This is a valuable opportunity to collect useful data on the process of conducting a risk-limiting audit, while at the same time ensuring that the outcomes are true and correct."

The risk limit for this ballot polling audit has been set at 20%. This means that at a minimum there is an 80% chance that the audit would correct an incorrect outcome.

Prior to the commencement of the risk-limiting audit the Registrar of Voters will establish the random seed for use with the audit software's random number generator.

The seed is a number consisting of at least 20 digits, and each digit will be selected in order by sequential rolls of a 10-sided die. The Registrar of Voters will randomly select members of the public who attend the audit process to take turns rolling the die and designate one or more staff members to take turns rolling the die in the event that no members of the public are present.

Establishing the seed in this manner results in a properly random, and verifiable, selection of individual ballots for examination and audit, and ensures the integrity and statistical validity of the risk-limiting audit.

The Registrar of Voters will publish the election results to be audited, along with a cryptographic hash of their contents, prior to the seed ceremony, and will publish the seed on its website immediately after it is established.

WHEN:

- Monday, November 26, 2018 - 10:00am (random seed selected by the rolling of 10-sided die)

WHERE:

- Registrar of Voters, 1300 South Grand Avenue, Building C, Santa Ana, CA

HOW:

- Once the random seed is established the physical pulling of the actual ballots will take place and the manual hand count will begin.

Figure 2. A press release is sent to inform the public of the details of the risk-limiting audit.

² A published hash allows a user to verify that the file they downloaded has not been modified.

THE DAY OF THE AUDIT

The Orange County Register of Voters conducted two risk-limiting audit pilots in 2018; one for the June 2018 Statewide Primary Election and another for the November 2018 Statewide General Election. Although both pilots operated under the same concept, there were some procedural changes that were implemented in the November 2018 Statewide General Election pilot. Any changes in the process are identified within the following sections.

Determining the Risk Limit

The Registrar set a 20% risk limit, which means that there is at least an 80% percent chance that the audit will correct the outcome if the outcome is wrong³.

Generating the Random Seed

The risk-limiting audit cannot begin until the random seed is generated. The random seed is essential to a truly random draw of ballots to be audited, while simultaneously providing a way for the public to independently duplicate and verify the listing of ballots to be audited. The public can duplicate the process if they use the same ballot manifest and the same random seed, which are both posted to the Registrar's website after the random draw. The randomness of the seed comes from the number generated by 20 rolls of the dice. Any difference in the random seed results in a completely different list of ballots to be audited. The algorithm used to generate the list of ballots to audit incorporates the random seed, so the generated list is entirely unable to be predicted. The ability for the public to reproduce the results come from the fact that the same seed and ballot manifest produces the same list of ballots to pull for the audit. The random seed was a 20-digit number, generated using multiple ten-sided dice, individually rolled by various people including members of the public. Each person took a turn rolling a ten-sided dice, while the random seed was video recorded and placed online.

The Day Of The Audit



Figure 3. Registrar Neal Kelley provides an overview of the risk-limiting audit process.

3 Stark, Philip (2012-03-16). "Gentle Introduction to Risk-limiting Audits" <https://www.stat.berkeley.edu/~stark/Preprints/gentle12.pdf>



Randomly Selecting Ballots to Audit

A random seed tool was used to perform the random selection of ballots to audit. In the June 2018 Statewide Primary Election pilot, the Colorado Risk Limiting Audit Tool was used to perform the selection of ballots to audit and, in the November 2018 Statewide General Election pilot, the publicly available Tools for Ballot-Polling Risk-Limiting Election Audits was used.

Both tools required the following information to select the ballots to audit:

- The ballot manifest
- The random seed
- The risk limit (20%)

The random seed, along with ballot sheet manifest, was entered in the Tools for Ballot-Polling Risk-Limiting Election Audits, which generated a sequence of ballots to audit. The process of randomly selecting the ballots using the tools were projected onto a screen and live-streamed online.

In the June 2018 Statewide Primary Election pilot, a risk-limiting audit advocate was remotely observing the process and downloaded the ballot manifest and random seed that was posted on the website, and independently generated the ballots to audit. A thorough review confirmed that the advocate's list of randomly selected ballots matched the Orange County Registrar of Voters' list of randomly selected ballots.

Retrieving the Ballots to Audit

Preparation of Paper Ballots

In order to locate randomly selected ballots from the ballot manifest, paper ballots must be organized in a way that makes this possible. In Orange County, paper ballots are scanned in batches. Although ballots of the same precincts are often in the same batch, there are also cases where multiple precincts are in one batch. Additionally, there are multiple batches with the same precincts scanned on different days, because ballots are arriving every day from all over the County. After each batch is scanned, the batch is assigned a batch number, and the scanner used to scan the batch is also recorded. Then, each batch is laid out in order by scanner and batch number. Therefore, after the randomly selected batches and ballots are identified from the ballot

manifest, the batch is able to be quickly located.

Preparation of Ballots Cast on Electronic Voting Machines

The paper audit trail generated from the electronic voting machines are the records used during the risk-limiting audit to audit ballots cast on the machines. Because these ballots are cast at polling places (as opposed to being returned by mail in no particular order), the ballots from the same precincts are already grouped together. Additionally, the paper audit trails are returned to the central office on Election Night grouped with nearby precincts. This makes it easy to locate a particular precinct's paper audit trail when selected to be randomly audited.

Locating Randomly Selected Ballots

The random selection tool produced a list of ballots to audit, including the information required to locate the ballots (specifically the scanner, batch and sequence number). This list was given to a team of staff who retrieved the ballots for the audit. As an example, if the team member was given a paper ballot to locate with the batch number of 132 from scanner number one, and a sequence number of 65, they would locate the ballot sheet by finding the batch labeled 132 from scanner one, and count to the 65th sheet in the batch. The team member would then pull that ballot sheet, and paper clip a cover sheet to the ballot to keep track of where the ballot originated.

If the ballot was originally cast at a polling place on an electronic voting machine, the batch number indicated the precinct and polling place. The team member would simply retrieve all paper audit trails from that polling place and then locate the specified ballot.

Preparing Audit Boards

Individuals identified to be part of the four-person audit boards were provided with training that included an overview of the concept of risk-limiting audits and the process that had been created for the pilot program. The audit boards were trained on how the ballot count was to be recorded; first, it was manually recorded by using paper tally sheets and then logged into the risk-limiting audit web tool. Review of the manual tally sheet focused on identifying and tallying the correct ballot as determined by the random selection tool.

Random Selection of Paper Ballots

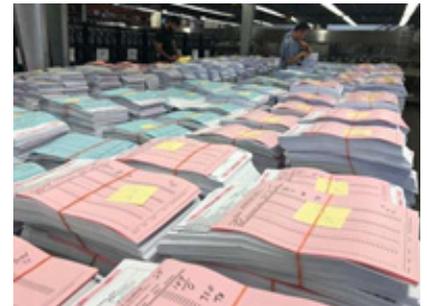


Figure 4. Paper ballots organized with batch sheets are randomly selected to audit by a team of staff.

Manual Audit of the Ballots



Figure 5. Paper and electronic ballots are audited by a team of four members.

Manually Auditing the Ballots

Paper and electronic ballots were retrieved by a separate team and provided to the audit boards in the order that they were randomly selected. Each ballot counted was examined by a four-person audit board. One person called out the name of the candidate of which the ballot was cast for that contest, while two board members recorded a tick mark on their own paper tally sheet. The remaining board member verified that the candidate was called out and recorded correctly by the other three board members.

When recording electronic ballots, the four-person audit board looked through the paper audit trail's printer rolls by precinct and identified the correct randomly selected ballot; then, they recorded the results for the identified contests on the paper tally sheets.

After groups of twenty randomly selected ballots were audited, the results were added to the risk-limiting audit web tool. Each group of twenty ballots contained a mix of paper and electronic ballots.

The same audit requirements were maintained when inputting results into the risk-limiting audit web tool; two board members called out for what was to be inputted while two others observed for accuracy.

Completion of Auditing Ballots

After each group of twenty ballots were entered into the risk-limiting audit web tool, data was produced to display statistical confidence and an estimate of how many ballots would need to be audited to meet the determined confidence level. The Registrar reviewed the status of the audit after each round of twenty ballots were entered and determined when it would be an appropriate time to conclude the audit. For example, in the June 2018 Statewide Primary Election pilot, the Registrar determined the required confidence level (20%) was met after 160 ballots were manually counted.

OUTCOMES

Of available methods to run the risk-limiting pilot audit, the Orange County Registrar of Voters opted to conduct a ballot polling audit. Ballot polling audits select ballots at random and manually review ballots until there is strong evidence that the outcome is right, or until all the ballots have been counted by hand. The audit assesses whether the outcome is correct, rather than assessing whether the tabulation was accurate.

First Pilot - June 2018 Statewide Primary Election

The Orange County Registrar of Voters conducted its first risk-limiting audit for the June 2018 Statewide Primary Election. The following three countywide contests were selected for the audit: County Assessor, Auditor-Controller, and Clerk Recorder. The audit was completed in two phases: 1) before all ballots were received and 2) after all ballots were received.

Phase 1

In Phase 1, the Orange County Registrar of Voters projected that the risk-limiting audit pilot would require 180 ballots to complete the process. The vote tally included Election Day electronic ballots, vote-by-mail ballots, and provisional ballots that were received up until that point.

Since the pilot was conducted without a final count of actual ballots, it was not possible to confirm the risk limit necessary for statistical evidence to support election outcomes.

Phase 2

In Phase 2, all ballots were considered since the second phase of the pilot was conducted after all ballots had been included in the final vote tally. Additionally, the risk-limiting audit in Phase 2 utilized the publicly available Tools for Ballot-Polling Risk-Limiting Election Audits to provide the ballot manifest, random seed, and the risk limit. The risk-limiting audit continued until the risk limit was met, regardless of the projected total number of ballots reviewed. The risk limits for the three selected contests was less than the 20% after auditing 180 ballots.

The first pilot not only provided evidence that the election outcomes

“The risk limits for the three selected contests was less than the 20% after auditing 180 ballots.”

Election Results
Orange County
 2018 General Election
 November 6, 2018
 Official Results for Election

List of Contests: <ul style="list-style-type: none"> • Registration and Turnout • Governor • Lieutenant Governor • Secretary of State • Controller • Treasurer • Attorney General • Insurance Commissioner • Member, State Board of Equalization 4th District • UNITED STATES SENATOR • UNITED STATES REPRESENTATIVE 38th District • UNITED STATES REPRESENTATIVE 39th District 	Registration and Turnout Completed Precincts: 1546 of 1546 <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Reg/Turnout</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Total Registered Voters</td> <td>1,558,988</td> <td></td> </tr> <tr> <td>Precinct Registration</td> <td>1,558,988</td> <td></td> </tr> <tr> <td>Precinct Ballots Cast</td> <td>393,423</td> <td>25.2%</td> </tr> <tr> <td>Early Ballots Cast</td> <td>23,550</td> <td>1.5%</td> </tr> <tr> <td>Vote-by-Mail Ballots Cast</td> <td>689,756</td> <td>44.2%</td> </tr> <tr> <td>Total Ballots Cast</td> <td>1,106,729</td> <td>71.0%</td> </tr> </tbody> </table> <p>Top</p> Governor Completed Precincts: 1546 of 1546 <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Vote Count</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>GAVIN NEWSOM (DEM)</td> <td>543,047</td> <td>50.1%</td> </tr> <tr> <td>JOHN H. COX (REP)</td> <td>539,951</td> <td>49.9%</td> </tr> </tbody> </table> <p>* Indicates Incumbent Candidate, if any Top</p> Lieutenant Governor Completed Precincts: 1546 of 1546 <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Vote Count</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>ELENI KOUNALAKIS (DEM)</td> <td>463,979</td> <td>53.5%</td> </tr> <tr> <td>ED HERNANDEZ (DEM)</td> <td>402,773</td> <td>46.5%</td> </tr> </tbody> </table>		Reg/Turnout	Percentage	Total Registered Voters	1,558,988		Precinct Registration	1,558,988		Precinct Ballots Cast	393,423	25.2%	Early Ballots Cast	23,550	1.5%	Vote-by-Mail Ballots Cast	689,756	44.2%	Total Ballots Cast	1,106,729	71.0%		Vote Count	Percentage	GAVIN NEWSOM (DEM)	543,047	50.1%	JOHN H. COX (REP)	539,951	49.9%		Vote Count	Percentage	ELENI KOUNALAKIS (DEM)	463,979	53.5%	ED HERNANDEZ (DEM)	402,773	46.5%
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Figure 6. Official election results are referenced in risk-limiting audits to verify election outcomes.

of the election were correct, but it also provided useful data for best practices on the process of conducting a risk-limiting audit.

Challenges of Conducting Multiple Phases

The pilot of the risk-limiting audit for this election allowed the Orange County Registrar of Voters the opportunity to attempt conducting the audit before all ballots were tallied. The advantage to this method is that it allows an agency to start sooner and may shorten the window of time to certify an election. The disadvantage, which was discovered while performing this process, is that it requires additional coordination of resources. As an example, the office’s resources that are dedicated to processing and tallying ballots are not available to assist with the audit process. Additionally, as stated earlier, the preparation and organization of tallied ballots must be done meticulously, and all ballots must be accounted for. Therefore, if tallying ballots while simultaneously attempting to prepare them for risk-limiting audit, this can be challenging. After the experience of the first pilot, Orange County decided to begin the risk-limiting audit after all ballots had been tallied for the second pilot.

Second Pilot - November 2018 Statewide General Election

The second risk-limiting audit was conducted for the November 2018 Statewide General Election. The Registrar of Voters selected three contests for the audit: District Attorney - Public Administrator, United States Representative 45th District, and United States Representative 48th District.

Two of the three contests selected had smaller margins of victory according to the final vote tally than compared to the contests audited in the June 2018 Statewide Primary Election pilot. In general, ballot-polling audits that include contests with smaller margins of victory require a greater number of ballots to be audited. While the risk-limiting tool provided an expected sample size of 16,000 ballots to audit before meeting the risk limit, the Registrar of Voters decided to stop the audit once the risk limit was met for all contests or once 1,000 ballots had been counted. This was due to the fact that the risk-limiting audit pilot was simultaneously conducted with the mandated 1% manual tally, which required a large portion of the office’s resources. The 1% manual tally required manual counting of 57,178 ballots, which required the staffing support of over 60 employees for three weeks. The 1% manual tally provided evidence that the voting system was

working correctly but did not provide a risk level and confidence that it would correct an incorrect outcome.

In the risk-limiting audit pilot, the risk level for the District Attorney-Public Administrator contest was below the 20% risk limit after auditing only 540 ballots. Although the risk level did not fall below the 20% risk limit for the other two contests after reviewing 1,000 ballots, this was to be expected due to the very low margins of victory between the candidates; in fact, these contests were chosen because they were close contests to exemplify the use of a risk-limiting audit for contests with various margins of victory.

CONCLUSION

The goals of the risk-limiting audit pilots in 2018 were to collect data on the processes of conducting risk-limiting audits and provide statistical evidence to affirm that the election outcomes were correct. The two pilots succeeded in both regards.

The 2018 pilot audits showed that:

- Even with challenges posed by the legacy voting systems, the risk-limiting audit could be conducted with slight adjustments
- The ballot polling method was an appropriate method for Orange County's legacy voting system
- Creating a ballot sheet manifest without a compatible voting system can be a challenge
- Simultaneously conducting a risk-limiting audit and a 1% manual tally draws upon resources that are already scarce during the post-election period

The risk-limiting audits conducted by the Orange County Registrar of Voters produced best practices and lessons learned for other county election officials and policymakers to consider in developing post-election procedures and policies. Simply having a legacy voting system would not prevent the ability of an elections agency from conducting a risk-limiting audit. The results of the Orange County Registrar of Voters' 2018 risk-limiting audit pilots show that it may be a promising alternative to the current 1% manual tally method to validate election outcomes.

APPENDIX

Appendix A: Risk Limiting Audits Glossary of Terms

Audit boards: a group of individuals tasked with reviewing and tallying the selected ballots to audit in a risk-limiting audit.

Ballot manifest: a list that indicates how the ballots in an election are organized and stored. For instance, a ballot manifest might list the ballot containers used for an election, the number of batches in each container, and the number of ballots in each batch.

Ballot polling audit: a method to conduct a risk-limiting audit where a random sample of ballots are selected and the results for the selected contest(s) are tallied; the audit stops if it produces strong enough evidence to support the reported outcome.

California Secretary of State: the State of California's chief elections officer who oversees all aspects related to elections within California.

Official canvass: the processing, counting, and inspection of early-returned vote-by-mail ballots and the ballots cast in each voting precinct

Colorado Risk Limiting Audit Tool: an online software utility used by the Colorado Secretary of State (SOS) and local election officials to conduct risk-limiting audits.

Comparison audit: a method to conduct a risk-limiting audit where individual ballots are randomly selected and compared to the voting system's cast vote record (CVR) for each ballot

Election Assistance Commission (EAC): an independent, bipartisan commission charged with developing guidance to meet Help America Vote Act (HAVA) requirements, adopting voluntary voting system guidelines, and serving as a national clearinghouse of information on election administration. EAC also accredits testing laboratories and certifies voting systems, as well as audits the use of HAVA funds.

Hash: a method of verification for a user to determine that the downloaded file or software has not been modified.

Legacy voting system: old or outdated voting systems that no longer meet current standards.

One-percent (1%) manual tally: a post-election audit to verify election outcomes conducted publicly as a manual tally of the ballots cast in 1% of the precincts chosen at random by the elections official.

Paper audit trail: a paper record of ballots cast through an electronic voting machine.

Polling place: a building where voting takes place during an election, typically one that normally has another function, such as a school.

Precinct: Each city, county, or geographic area is divided up by address into precincts for the purpose of assigning a polling place and gathering votes. A precinct can sometimes be called an election district or voting district.

Random seed: A set of numbers generated by numerous people, including members of the public, rolling a ten-sided dice to generate the random sequence of ballots to be audited in a risk-limiting audit.

Risk limit: the largest statistical probability that, if an outcome is wrong, the RLA does not correct that outcome. For example, assume the reported outcome of an election contest is wrong, and the risk limit for the audit is 5%. In this instance, there is at most a 5% chance that the audit will not correct the wrong outcome, and at least a 95% chance that the audit will correct the wrong outcome. The risk limit is a number between 0 and 1 that limits the risk of certifying an incorrect outcome and is chosen by the RLA administrative authority before the audit is conducted.

Risk-limiting audit (RLA): a post-election audit that provides strong statistical evidence that the election outcome is correct and has a high probability of correcting a wrong outcome.

Tools for Ballot-Polling Risk-Limiting Election Audits: a freely public and available web-based tool to conduct ballot-polling risk-limiting audits.

Voter Verifiable Paper Audit Trail (VVPAT): a method of providing feedback to voters on how they voted using a ballot-less voting system.

Appendix B: Risk Limiting Audits Procedures

Procedure: Manually Auditing the Ballots

Each audit board will consist of four members:

- 1 Caller
- 1 Observer
- 2 Tally Members

Tally Sheets:

Two tally sheets are given to each audit board. All audit board members sign and initial each tally sheet.

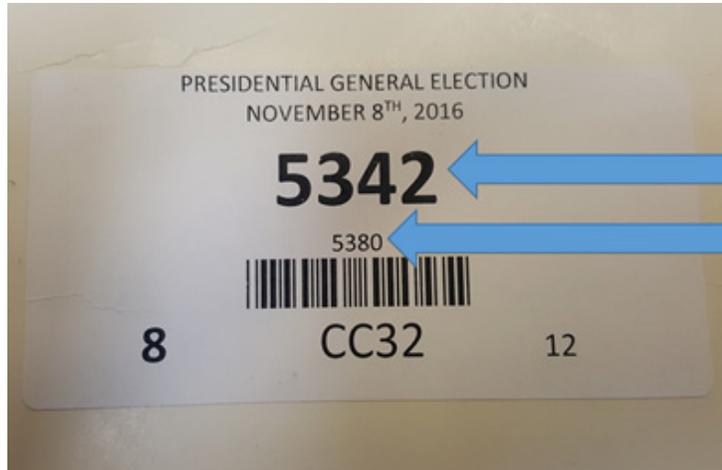
BATCH 1		Statewide Direct Primary Election - 6/5/18																BOARD MEMBERS (PRINT NAME)		INIT
BALLOT COUNT _____		Risk Limiting Audit																1		
DATE: _____																		2		
																		3		
																		4		
BATCH NAME:	11-85	11-64	11-142	12-10	12-346	12-394	12-442	13-073	13-288	13-388	13-446	14-074	14-323	15-025	16-4	16-468	18-267	18-19	M075	40296
NUMBER:	256	290	206	223	264	291	66	99	107	203	52	66	77	321	105	72	53	150	163	242
POSITION																				
ASSESSOR - vote for 1																				
	RICHARD B. RAMIREZ																			
	NATHANIEL FERNANDEZ EPSTEIN																			
	CLAUDE PARRISH																			
AUDITOR-CONTROLLER - vote for 1																				
	TONI SMART																			
	ERIC H. WOOLERY																			
CLERK-RECORDER																				
	HUGH NGUYEN																			
	STEVE ROCCO																			
DISTRICT ATTORNEY-PUBLIC ADMINISTRATOR - vote for 1																				
	TODD SPITZER																			
	TONY RACKAUCKAS																			
	BRETT MURODCK																			
	LEONORE ALBERT-SHERIDAN																			

Electronic Ballots (VVPAT Rolls)

Supplies Needed:

- Paper rolling machines
- Tally sheets
- Red and green pencils
- Precinct VVPAT rolls
- Precinct VVPAT report
- Color stickers

1. Ballot pulling team removes VVPAT rolls from the VVPAT printer.
2. VVPAT rolls are given to the audit board that have the corresponding precinct in their Tally Sheet



3. Identify the order of the rolls by matching the Printer Serial Number of each VVPAT roll to the Precinct VVPAT report.
4. Place sticky note labeling each roll. For example: "Roll 1 of 8"
5. Take note of the corresponding ballot number in the Tally Sheet.
6. Place VVPAT roll in the paper rolling machine.
7. Find identified ballot:
 - a. Start with Roll 1, advance roll to polls open report
 - b. One board member will verbally count every accepted ballot. For example: "Accepted, one"
 - c. One board member will place a sticker on ballot to keep track of the number.
 - d. Continue with Roll 2 until the ballot number is found. Label each roll with the running ballot count.
 - e. Counting stops when the correct number ballot is identified.
 - i. If the identified ballot is a Provisional Ballot, check to see if the provisional ballot is excluded or included. Only count the votes included provisional ballots.
 - ii. one person in the board will announce the vote. Two people will mark the votes on the tally sheets. One person will observe the calling and tallying.
 - iii. Change pencil colors after each ballot.

Paper Ballots

Supplies Needed:

- Tally sheets
 - Red and green pencils
 - Paper ballots with individual cover sheet
1. Once the ballot pulling team finishes pulling a batch of paper ballots, they are given to the staff member in charge of leading the RLA. The RLA lead matches the paper ballot batch number/position to the correct tally sheet/Audit board.
 2. Audit board verifies the paper ballot cover matches Tally Sheet.
 3. Once verified, one person in the board will announce the vote. Two people will mark the votes on the tally sheets, changing pencil colors after each paper ballot. One person will observe the calling and tallying.
 4. If the paper ballot sheet does not include identified contests, count as undervote.

Procedure: Finishing Auditing the Ballots

The audit board continues to count paper and electronic ballots until entire Tally Sheet (comprised of 20 ballots) is complete.

1. Once Tally Sheet is complete, the entire audit board moves to the computer to report total votes for the identified contests.
2. On the laptop, go to <https://www.stat.berkeley.edu/~stark/Vote/auditTools.htm>.

Under Contest Information include the following:

- a. Ballots cast in all contests
- b. For contests included in the RLA add:
 - i. Contest name
 - ii. Candidates for each contest
 - iii. Add the votes from the manual count
- c. Under audit parameters, include the risk limit set by the

Registrar of Voters

4. After totals from each tally sheet are entered, take a screen shot of the Audit Progress for reference.
5. Continue counting ballots and completing tally sheets until the Audit Progress for a contest reaches the risk limit. The contest will be highlighted green.

