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Post-Election Risk-Limiting Audit Pilot Program 2011-2012
Semi-Annual Progress Report to the Election Assistance Commission
Reporting Period Close: May 31, 2012

Summary

The Secretary of State (SOS) Post-Election Risk-Limiting Audit Pilot Program is designed to test the effectiveness and efficiency of risk-limiting audits. Between December 1, 2011 and May 31, 2012, additional audits were conducted in 4 counties following elections held in November 2011. All 4 audits successfully confirmed official election results by reviewing a small number of ballots (i.e., a few dozen to a few hundred ballots) cast in each contest audited. By contrast, California law requires elections officials to hand tally 100% of the ballots from 1% of all precincts after each election, an exercise that typically requires hand counting thousands of ballots.

Despite the high number of ballots hand tallied for the 1% manual tally, the pilot project team's analysis showed this statutorily-mandated manual tally to be ineffective and inefficient at confirming election results. The post-election risk-limiting audits were able to confirm with 90% confidence that election results were correct after hand counting very few randomly selected ballots. By contrast the 1% manual tally in the same elections gave very little statistical proof that the election outcomes were correctly calculated by the voting system.

Overall, 20 counties have volunteered to participate in the program. So far, 8 audits have been conducted. Of the 8 audits, 2 were conducted in spring 2011 prior to the grant award, 2 were conducted during the prior progress reporting period and 4 were conducted in December 2011, during the current reporting period.

The $230,000 two-year grant from the federal Election Assistance Commission (EAC) helps fund:

1) Audits of election results following live elections in 20 California counties;

2) Detailed analyses of the efficacy of risk-limiting audits and recommendations on modifications needed to make current voting systems auditable; and

3) Creation of auditing tools for elections officials. The pilot program team has developed draft audit rules for selecting the initial sample size and for determining when enough ballots have been audited, methods for ballot-level audits, and user-friendly web-based tools and procedures for conducting and reporting on risk-limiting audits. (A preliminary version is available at statistics.berkeley.edu/~stark/Vote/auditTools.htm)

Risk-limiting audits are audits based on modern statistical principles. The number of ballots initially reviewed in a risk-limiting audit varies based on the margin of victory. The audit escalates – potentially to a full hand count of every ballot cast – if significant

differences between the hand tally and the voting system tally are found. Risk-limiting audits are efficient when conducted at the "ballot level," meaning individual ballots from the entire voting jurisdiction are subject to the random draw and the audit. This contrasts with California's statutorily-mandated 1% manual tally, where only the precincts are subject to the random draw from across the entire election jurisdiction, not the ballots themselves. Put another way, risk-limiting audits generally involve hand counting fewer ballots overall, but those ballots come from across the entire voting jurisdiction, whereas the 1% manual tally generally involves significantly more ballots but only from specific areas of the voting jurisdiction.

Now that a variety of methods for risk-limiting audits have been tested, the SOS believes efficient and effective election auditing requires auditing at the ballot level. Therefore the team will develop standards, procedures and tools for such audits as part of this project. This will:

1) Help California and other states develop new, more robust and informative election auditing laws,

2) Inform the design of next generation voting systems,

3) Provide election auditing best practices and procedures that can be used by many jurisdictions in the U.S. using a broad variety of voting systems; and

4) Build public confidence that if there are errors in election results, those errors will be caught and corrected.

Progress

During this phase of the project the pilot program team:

1) Conducted audits in 4 counties; and

2) Further developed and tested draft web-based tools, instructions and methods for conducting risk-limiting audits.

3) Prepared for the next 6 audits to be conducted following the June 2012 election in Madera, Marin, Napa, Orange, Santa Cruz and Yolo counties.

Counties

The 20 counties below volunteered to participate in the pilot program. Two of these counties participated in pilot audits prior to the grant award but may participate again during the grant period. The results of their participation are included in this report, even though the expenses related to the two audits were absorbed by the counties and the Secretary of State.

County	Election Date	Audit Date
Alameda	Nov. 8, 2011	Dec. 5, 2011
Alpine	Nov. 6, 2012	tba
Colusa	Nov. 6, 2012	tba
El Dorado	Nov. 6, 2012	tba
Humboldt	Nov. 8, 2011	Dec. 16, 2011
Madera	June 5, 2012	tba
Marin	June 5, 2012	June 25, 2012
Merced	Nov. 8, 2011	Dec. 12, 2011
Monterey	May 3, 2011	May 6, 2011
Napa	June 5, 2012	July 20, 2012
Orange	Mar. 8, 2011	Mar. 14, 2011
Orange	June 5, 2012	June 28-29, 2012
Sacramento	Nov. 6, 2012	tba
San Francisco	tba	tba
San Luis Obispo	Aug. 30, 2011	Sept. 12, 2011
Santa Cruz	June 5, 2012	late June
Stanislaus	Nov. 8, 2011	Dec. 2, 2011
Sutter	Nov. 6, 2012	tba
Ventura	Nov. 8, 2011	Nov. 29, 2011
Yolo	June 5, 2012	Week of July 9, 2012
Yuba	Nov. 6, 2012	tba

University of California

The SOS is under contract with the University of California for the purpose of engaging Professor Philip Stark as lead researcher for the project.

Advisory Panel

At the outset of the pilot program, the SOS established an advisory panel, which is comprised of the following experts, advocates, and community activists in the field of election auditing and reform:

Dean Logan
Registrar-Recorder/County Clerk, Los Angeles County

Pam Smith
President, Verified Voting

Joseph Lorenzo Hall
Postdoctoral Research Fellow, New York University Department of Media, Culture and Communication

Hovav Shacham
Assistant Professor, University of California, San Diego, Department of Computer Science and Engineering

Mark Halvorson
Director and Founder, Citizens for Election Integrity Minnesota

Susannah Goodman
Director, Common Cause National Campaign for Election Reform

Margaret MacAlpine
Research Associate, SafelyLocked, LLC

Conducting Ballot-Level Risk-Limiting Audits Using a Parallel Scan and Tally

For most election audits, the results of a hand tally are compared to the results recorded by the voting system. For California's 1% manual tally, elections officials hand tally entire precincts of ballots and compare those hand tally totals to the machine-tallied totals generated by the voting system.

In order for risk-limiting audits to be efficient, they must be conducted at the individual ballot level, not at the precinct level. A ballot-level audit compares the result tallied by the voting system for a given ballot to a hand tally of the same ballot. To conduct a risk-limiting audit at the ballot level, two things are necessary: 1) the voting system must have a cast vote record (CVR) for each ballot. A CVR is a line of data that shows how the

votes on a given ballot were actually tallied by the voting system; and 2) elections officials must be able to match a CVR to the corresponding physical ballot, which requires keeping ballots and CVRs in the same identical order.

Earlier in the program, the pilot project team conducted a series of conference calls with voting system vendors to determine the capabilities of existing voting systems. Through these calls and discussions with participating counties, the team determined that none of the voting systems in use in California is capable of exporting CVRs that can be associated with corresponding physical ballots.

For this reason, the team has conducted some of the audits for this pilot program by means of a parallel scan and tally of the votes. A parallel scan and tally is a second tally of the ballots, using commercial-off-the-shelf (COTS) scanners and open source tally software, which was developed during spring and summer 2011 for the pilot program.

County elections officials scanned the ballots using a COTS scanner and either marked the ballots or kept the ballots in order to permit each physical ballot to be paired with its scanned ballot image. This method allowed auditing the interpretation of individual ballots rather than auditing vote subtotals for entire precincts. Making individual ballots auditable – i.e., creating auditable "batches" of one ballot each – brings very significant efficiency, as described above. The hand counting work load for a ballot level audit can be smaller than the workload of a precinct level audit by a factor of 1,000 or more. Since the parallel tally for each audit showed the same results (winners and losers) as the official voting system, the audit was able to confirm the official results *transitively* (i.e., If A = B, and B is correct, then A is correct).

Web-Based Tools and Instructions

The pilot program team, led by Stark, has honed the audit models and developed a set of web-based tools (statistics.berkeley.edu/~stark/Vote/auditTools.htm) and instructions (attached) designed for elections officials to use to conduct risk-limiting audits. The tools explain how the audits work and show the math that the tools implement, so elections officials and the public can understand risk-limiting audits. These tools are continually being refined and improved as a part of the pilot program.

Audits Conducted Between December 1, 2011, and May 31, 2012

The pilot program team conducted successful risk-limiting audits in 4 counties during the current reporting period. For each audit, the team worked with participating counties and voting system vendors to plan the audits. With the exception of Humboldt County, Stark traveled to each county and provided on-site assistance to jurisdictions carrying out the audits, including performing all computations and helping with the manual tally as required.

In some counties, the team successfully conducted simultaneous audits of several contests at one time. The simultaneous audits proved very efficient where the contests audited overlapped completely (or almost completely) in jurisdiction. The team found that unless there are large margins in the contests to be audited, conducting audits of each contest separately was more efficient if the jurisdictions among the contests did not overlap. The team plans to develop a web tool that will allow elections officials to enter contest data to determine whether it is more efficient to audit two or more contests simultaneously or separately.

The time it took to conduct the audits was minimal – a few minutes to a few hours – compared to the time it takes to conduct the 1% manual tally. However, counties participating in the pilot audits had to spend a considerable amount of time scanning the ballots in preparation for the audits. Each county used a regular scanner, rather than a set of high speed scanners. For the 2012 audits, the team plans to help counties rent high speed scanners to minimize the time spent scanning ballots in preparation for the audits.

1. Stanislaus County: December 2, 2011

Stanislaus County conducted a risk-limiting audit of City of Oakdale Measure O, in which 3,152 ballots were cast. To prepare for the audit, Stanislaus County staff rented a scanner for a day and scanned all of the paper ballots cast in the election to produce digital images. (One ballot could not be located for scanning; it was treated as a "no" vote by the audit, to ensure that the audit was conservative.) Stanislaus County staff kept the ballots in the physical order in which they were scanned so the CVRs could be associated with the paper ballots they represented. The ballots were organized into batches for scanning to make it easier to find individual ballots. The digital images were processed using software developed for the pilot program. The software created a CVR for each ballot and tallied the votes on the CVRs. According to the software, there were 1,728 "yes" votes and 1,391 "no" votes, a margin of 336 with the missing ballot treated as a "no." This corresponds to a diluted margin of 336/3152 = 10.6%.

The web tools at http://statistics.berkeley.edu/~stark/Vote/auditTools.htm were used to determine an initial sample size for an audit at 10% risk limit, which turned out to be 49 ballots. A seed for the random number generator was selected by drawing film canisters containing numbered slips of paper at random from an opaque bag. The web tools were then used to select the ballots to audit. The human eye interpretation of all 49 ballots matched the CVRs for those ballots, so the audit stopped. It took approximately 1 hour and 5 minutes to conduct the audit.

The statutory 1% audit required a hand tally of all the ballots cast in one of the five precincts that contained the contest. The precincts ranged in size from 452 ballots cast to 792 ballots cast. The average number of ballots – the expected number of ballots the 1% audit would require tallying in this contest – was 630 ballots. Even though the 1% audit examined far more than the 49 ballots the risk-limiting audit examined, the statutory 1% manual tally could have had a chance as large as 80% of not finding a single error even if

the machine-count winner had been wrong. In contrast, the risk-limiting audit had a 90% chance of requiring a full hand count if the machine-count winner had been wrong. Again, this shows the power and efficiency of risk-limiting audits compared to the current statutory audit.

2. Alameda County: December 5, 2011

To prepare for the audit, Alameda County staff used a small county scanner and scanned all of the paper ballots cast in the election to produce digital images. Before scanning the ballots, county staff stamped each ballot with an identification number to make it easier to associate CVRs with the physical ballots. The digital images were processed using ballot tally software developed for the pilot program. The software created a CVR for each ballot and tallied the votes on those CVRs. Alameda County staff kept the ballots in the physical order in which they were scanned so the CVRs could be associated with the paper ballots they represented. The ballots were organized into batches for scanning to make it easier to find individual ballots.

Four City of Alameda contests were audited simultaneously: City Council (vote for 3 of 5) and three measures. All votes were cast on paper ballots; 1,374 ballots were cast in all. The software developed for the pilot found one extra vote for Bukowski for City Council (409 versus 408) and one extra "no" vote for measure F (841 versus 840). The tools at http://statistics.berkeley.edu/~stark/Vote/auditTools.htm were used to determine an initial sample size for an audit at 10% risk limit: 17 individual ballots to be selected at random from the 1,374. Numbered ping-pong balls were drawn at random from a bingo-like tumbler by county staff to generate a seed for the random number generator in the web tool. The 17 ballots were retrieved and compared to the CVRs. All 17 ballots matched their CVRs, so the audit stopped without escalation. Two members of the public observed the audit, which took approximately 25 minutes.

3. Merced County: December 12, 2011

Two City of Merced contests were audited simultaneously, Mayor and City Councilmember (vote for 3 of 8). A total of 7,321 ballots were cast in these contests. The reported winner in the mayoral contest was Stan Thurston, with 2,231 votes; the runner-up was Bill Blake with 2,037 votes. The three reported winners of the City Council contest were Noah Lor (3,736 votes), Mark "Tony" Dossetti (3,669 votes) and Mike Murphy (3,375 votes); runner-up was Richard L. Cervantes (2,416 votes). The diluted margin for the two contests was (2231 - 2037)/7321 = 2.6%, the smallest diluted margin among contests audited under the pilot so far.

To prepare for the audit, Merced County staff used an office scanner they owned to scan all of the paper ballots cast in the election to produce digital images. The digital images were processed using software developed for the pilot program. The software created a

CVR for each ballot and tallied the votes on those CVRs. Merced County staff kept the ballots in the physical order in which they were scanned so the CVRs could be associated with the paper ballots they represented. The ballots were organized into batches for scanning to make it easier to find individual ballots.

The web tools at http://statistics.berkeley.edu/~stark/Vote/auditTools.htm were used to determine an initial sample size for an audit at 10% risk limit (which turned out to be 198 ballots), to draw the random sample, and to locate the selected ballots within bundles of stored ballots. The human eye interpretation of all 198 ballots matched the CVRs for those ballots, so the audit stopped without escalation. It took about 3 hours and 15 minutes to conduct the audit.

4. Humboldt County: December 16, 2011

Humboldt County was the first in the program to conduct risk-limiting audits of election results without on-site help from the pilot program team. The county used the draft instructions and web tools developed for the pilot program and conducted a risk-limiting audit of three contests on the ballot.

Humboldt County works with the Humboldt Transparency Project after each election to confirm election results by scanning ballots and creating a parallel tally using Transparency Project software (TEVS). Humboldt County conducted risk-limiting audits of three contests using the Transparency Project CVRs and results for the contests:

Resort Improvement District #1 (elect 3):
(6 candidates)

Total Ballots Cast	193
Ballots Examined for 1% Manual Tally	72
Ballots Examined for Risk-Limiting Audit	52

Eureka City Schools Trustee Area 4 (elect 1):
(2 candidates)

Total Ballots Cast	5,455
Ballots Examined for 1% Manual Tally	15
Ballots Examined for Audit	34

Ferndale Unified School District (elect 2):
(3 candidates)

Total Ballots Cast	640
Ballots Examined for 1% Manual Tally	89
Ballots Examined for Audit	57

Even though Humboldt County examined 176 ballots for the 1% manual tally of the three contests above, the statutory 1% manual tally left at least a 50% chance of not finding a single error, even if the machine-count found a wrong winner.

In contrast, the risk-limiting audit involved reviewing fewer ballots – 143 ballots – and guaranteed a 90% chance of catching and correcting errors that could have caused the voting system to find a wrong winner. Since no errors were found in the initial sample for each contest, no escalation was needed to confirm results.

As with the prior audits in other counties, the Humboldt County audit showed the power and efficiency of risk-limiting audits compared to the flat 1% manual tally currently required by law.

Cost-Efficiency Analysis: Risk-Limiting Audits Compared to the 1% Manual Tally

The time it took to conduct the audits was minimal – a few minutes to a few hours – compared to the time it takes to conduct a manual tally of all ballots from 1% of precincts, as currently required by California law. However, counties participating in the pilot audits typically spent significantly more money on the risk-limiting audit than they did for their 1% manual tally.

There are two reasons for this:

1) Counties spent a considerable amount of time scanning the ballots in preparation for the audits. Each county used a standard office scanner or scanner/copier, rather than a high-speed scanner. For the 2012 audits, the team plans to help counties rent high-speed scanners to minimize the time spent scanning ballots in preparation for the audits; and

2) The audits conducted in 2011 were of small local elections. During 2012, larger audits are planned following the June and November elections to show the efficiencies that can be created with risk-limiting audits of larger elections.