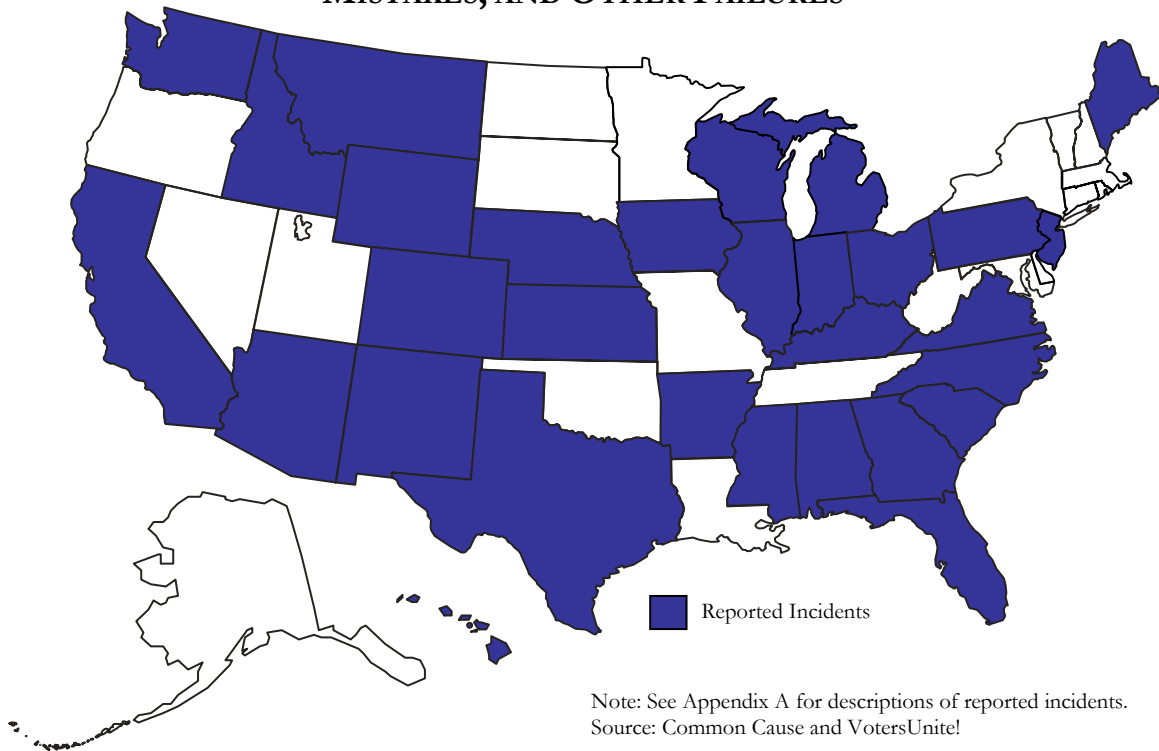


POST-ELECTION AUDITS:  
RESTORING TRUST  
IN ELECTIONS  
EXECUTIVE SUMMARY

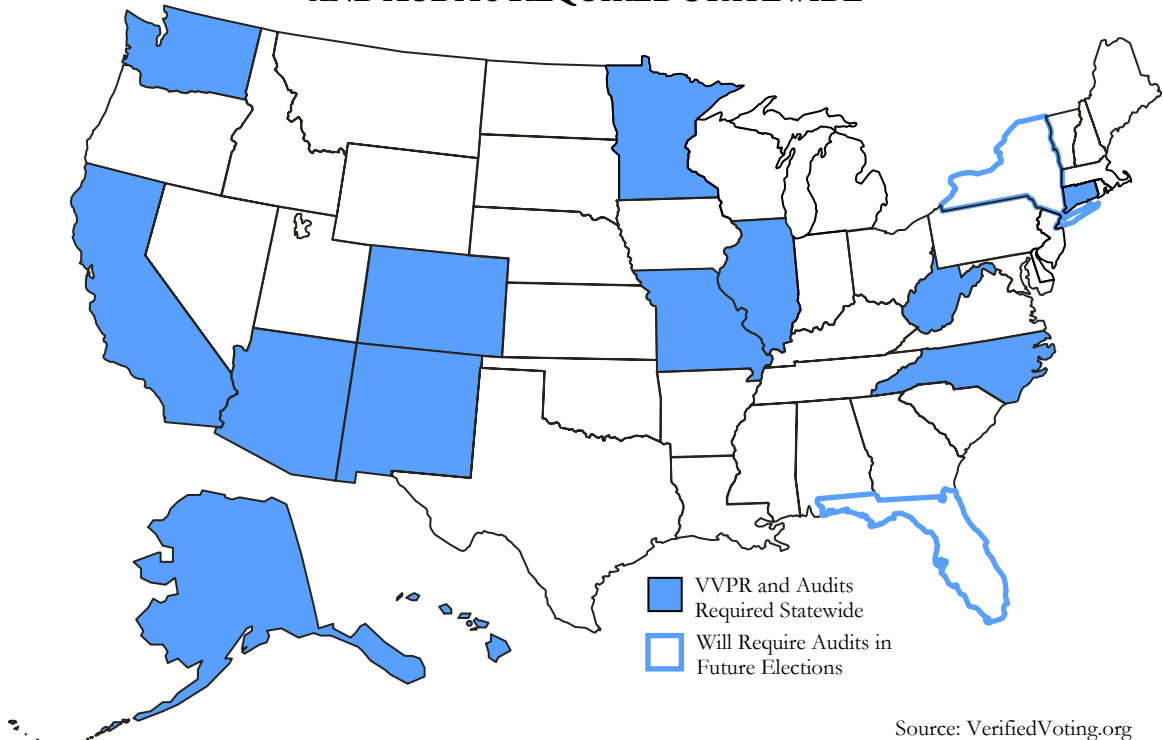
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**FIGURE 1. REPORTED INACCURATE ELECTRONIC VOTE TALLIES AND MACHINE OUTPUT ERRORS CAUSED BY SOFTWARE BUGS, PROGRAMMING MISTAKES, AND OTHER FAILURES**



**FIGURE 2. VOTER-VERIFIED PAPER RECORDS AND AUDITS REQUIRED STATEWIDE**



## INTRODUCTION

In the last several years, most of the public debate on electronic voting has concerned whether voting machines should include a voter-verifiable paper record. Today, in much of the country, that debate is over: thirty states require voter-verifiable paper records.<sup>1</sup> Another eight states use voter-verifiable paper records in every county without requiring them,<sup>2</sup> and of the remaining twelve states that do not use voter-verifiable paper records statewide, several are currently considering legislation that would mandate such records in the future.<sup>3</sup>

The widespread adoption of voter-verifiable paper records does not, however, resolve the security, reliability, and verifiability issues with electronic voting that many groups, including the Brennan Center, have identified. To the contrary, as the Brennan Center noted in its June 2006 comprehensive study of electronic voting system security *The Machinery of Democracy: Protecting Elections in an Electronic World*,<sup>4</sup> voter-verifiable paper records by themselves are “of questionable security value.” Paper records will not prevent programming errors, software bugs or the introduction of malicious software into voting systems. If paper is to have any real security value, it must be used to check, or “audit,” the voting system’s electronic records.

Unfortunately, the purpose and value of voter-verifiable paper records has received scant attention and little study until recently. In the last year, statisticians and election integrity experts have appeared to make up for lost time, authoring and releasing dozens of separate papers about post-election audits of voter-verifiable paper records.<sup>5</sup> Meanwhile, the prospect of a federal requirement for post-election audits has galvanized many election officials and election integrity activists into publicly debating various audit methods and procedures.<sup>6</sup>

Much of the recent literature on post-election audits has been sharply critical of existing audit laws, regulations and practices.<sup>7</sup> However, many of these papers seem to contradict each other by promoting very different audit models, and very few provide practical advice about how to implement their recommendations to improve audit practices.

Sorting through this flood of often seemingly contradictory information and using it to improve post-election audits is no easy task. It is, however, critically important. In the next few months, Congress and several state legislatures are likely to consider and pass into law new post-election audit requirements, and the several states that already conduct post-election audits are considering amendments to existing audit laws and procedures.<sup>8</sup>

With the intention of assisting legislators, election officials and the public make sense of this new information and convert it into realistic audit practices, the Brennan Center and the Samuelson Law, Technology and Public Policy Clinic at Boalt Hall School of Law (University of California Berkeley) convened a blue ribbon panel (the “Audit Panel”) of statisticians, voting experts, computer scientists and several of the nation’s leading election officials. Together with the Audit Panel, the Brennan Center and the Samuelson Clinic spent several months reviewing and evaluating both existing post-election audit laws and procedures, and the papers of academics and election integrity activists that have frequently criticized such laws and procedures as inadequate. Following this review and extensive

consultation with the Audit Panel, the Brennan Center and the Samuelson Clinic make several practical recommendations for improving post-election audits, regardless of the audit method that a jurisdiction ultimately decides to adopt.

## **SUMMARY OF FINDINGS**

Our study of the current academic literature and current state audit laws and procedures points to several important findings:

- Post-election audits of voter-verifiable paper records are a critical tool for detecting ballot-counting errors, discouraging fraud, and improving the security and reliability of electronic voting machines in future elections. Unfortunately, of the thirty-eight states that require or use voter-verifiable paper records throughout the state, twenty-three do not require such audits after every election.<sup>9</sup>
- Of the few states that currently require and conduct post-election audits, none has adopted audit models that will maximize the likelihood of finding clever and targeted software-based attacks, non-systemic programming errors, and software bugs that could change the outcome of an election.
- We are aware of only one state, North Carolina, that has collected and made public the most significant data from post-election audits for the purpose of improving future elections. Based upon our review of state laws and interviews with state election officials, we have concluded that the vast majority of states conducting audits are not using them in a way that will maximize their ability to improve elections in the future.
- Regardless of the audit model a jurisdiction implements, there are several simple, practical, and inexpensive procedures that it can adopt to achieve the most important post-election auditing goals, without imposing unnecessary burdens on election officials.

## POST-ELECTION AUDIT CONSIDERATIONS

In our analysis of the post-election audit debate, we found that much of the disagreement about what constitutes a “sound” audit actually centers on disagreement over the *purpose* of an audit. In fact, there are a number of goals that a post-election audit may serve, and by emphasizing one, jurisdictions may make it more difficult to fulfill another. Among the goals an audit can fulfill are:

- creating an appropriate level of public confidence in the results of an election;
- deterring fraud against the voting system;
- detecting and providing information about large-scale, systemic errors;
- providing feedback that will allow jurisdictions to improve voting technology and election administration in future years;
- providing additional incentives and benchmarks for elections staff to reach higher standards of accuracy;<sup>10</sup> and
- confirming, to a high level of confidence, that a complete manual recount would not change the outcome of the race.<sup>11</sup>

This paper is the first to articulate all of these goals and to comprehensively examine the trade-offs that may be entailed to satisfy all of them. We also look at additional considerations that jurisdictions will probably want to consider when developing audit methods and procedures, including to what extent the audits will be administratively burdensome (i.e., how much they will cost, how many hours they will take to complete, and how much certainty a jurisdiction will have about these issues prior to Election Day) and whether their effectiveness will depend heavily on the subjective judgments of election and other public officials in charge of the audit (something jurisdictions should generally want to avoid).

In most cases, lower administrative costs and greater certainty about the audit ahead of time means less certainty that evidence of an outcome-changing error or of fraud will be found once the election is over. Similarly, audits that are efficient at detecting widely distributed, systemic errors can provide feedback to improve elections, but are often poorer at pinpointing errors that might have affected the outcome of an election. They also generally provide election officials with little guidance as to what should be done when discrepancies between the paper and electronic records are found.

## SUMMARY OF AUDIT RECOMMENDATIONS

We do not endorse any particular audit model as the “best” one. Instead, we have identified certain basic principles that all jurisdictions should adopt, regardless of the audit model they choose. These recommendations are based on consultation with the Audit Panel and a thorough review of current practices in states and counties where audits are conducted, as well as recent academic literature on post-election audits. The recommendations can be broken into three categories: (1) best practices for selecting votes to be audited; (2) best practices for conducting the audit itself; and (3) best practices for ensuring audit effectiveness. They are discussed in much greater detail in “Audit Best Practices” *infra* at page 30 (additional recommendations for specific models are discussed in “A Review of Current and Proposed Audit Models” *infra* at page 9).

### SELECTING VOTES TO BE AUDITED

The method and manner employed by a jurisdiction for choosing votes to audit will have a tremendous impact on whether the audit itself is administratively burdensome, engenders public confidence in election results, detects errors, and provides feedback that will allow jurisdictions to improve elections in the future. Among the most important steps that jurisdictions can take in selecting votes to be audited are the following:

- **Use Transparent and Random Selection Processes for All Auditing Procedures.** Audits are more likely to prevent fraud and produce greater voter confidence in election results if the public can verify that the paper records, machines, or precincts to be audited are chosen in a truly random manner.
- **Consider Selecting Precincts or Machines for Auditing at the State Level.** While there are some disadvantages to centrally-conducted audit selection (discussed *infra* at page 32), there are many benefits for election officials to consider, including efficiency, transparency, and standardized procedures. By choosing precincts or machines to audit at the state level, counties are relieved of this responsibility and associated administrative tasks. Additionally, audit selection at the state level facilitates the selection of precincts to audit in election districts that cross jurisdictional boundaries. Finally, public observers of random selection processes would be able to watch a single selection process, rather than attempt to watch multiple county selection processes around a state.
- **Audit a Minimum Percentage or Number of Precincts or Machines for Each Election, Including At Least One Machine Model and/or Precinct in Each County.** Much of the recent academic literature on post-election audits focuses on catching error or fraud that could change the outcome of an election. But finding an error that has changed the outcome of an election is in many ways a worst case scenario; most would prefer finding and correcting such errors in landslide elections where they could not affect the outcome. An audit of a minimum number of precincts or machines supports election officials’ efforts to monitor overall voting system performance and ensure that the machines operate optimally.

- **Account for Precinct Size Variability in Audit Selection and Sample Size Calculations.** Any procedures that do not take into account the varying number of votes in different precincts are likely to overestimate the audit’s confidence level (or “statistical power”) with respect to uncovering irregularities that could change the outcome of an election. Methods to deal with precinct size variability can be as simple as sorting precincts into bins of certain sizes (e.g., “small,” “medium,” and “large”) and conducting random selection within each bin, or listing precincts in order of size and ensuring that auditors select a certain number of large precincts.
- **Allow Candidates To Select Precincts or Machines To Be Audited.** Making this option available to candidates would serve two purposes. First, it would give greater assurance to candidates and their supporters that the election results are correct. Second, it would allow candidates to prompt audits of seemingly anomalous results that could suggest a programming error or miscount.

## CONDUCTING THE AUDIT

There are specific steps that every jurisdiction can take to make it far more likely that the audit is accurate, useful to election officials, and likely to catch errors that could change the outcome of certain races. Most importantly, jurisdictions should:

- **Freeze and Publish Unofficial Election Results Before Selecting Precincts or Machines to be Audited.** Election officials should freeze and publish unofficial election results once all returns are received from jurisdictions. The random selection of precincts or machines to be audited should only occur afterwards. This practice allows the public to verify the accuracy and fairness of audit results.
- **Conduct “Blind” Manual Counts.** While unofficial totals should be made available to the public so that they can verify the accuracy and fairness of the audit, manual counters should be “blind” to the unofficial election results for the machines they are auditing to ensure that knowledge of the unofficial results does not influence their counting.
- **Don’t Just Match – Count! (Record and Publicly Release Meaningful Data on Votes Cast).** Audits that record and detail the overvotes, undervotes, blank votes, spoiled ballots, and, in the case of DREs, cancellations, could be extremely helpful in revealing software attacks and software bugs and in identifying problems with ballot design and/or ballot instructions. Rather than only matching paper and electronic tallies, election officials should record and publicly release this meaningful data, which should be useful for improving elections in the future.
- **Consider Auditing by Machine Rather Than Precinct.** In many states, it will be more efficient to audit by machine or ballot batches rather than by precinct. Particularly in states that use touch-screen voting machines, jurisdictions will be able to achieve the same level of confidence in their results by auditing a smaller percentage of machines.

- **Audit All Methods of Voting.** In conducting post-election audits, election officials should not exclude any category of votes (e.g., absentee ballots, provisional ballots, damaged ballots). In 2004, seven states reported that more than twenty percent of all votes were cast during early voting periods.<sup>12</sup> Excluding these ballots from an audit would leave a significant opportunity for errors to remain undetected.

## ENSURING OVERALL AUDIT EFFECTIVENESS

If the audit is to be effective, jurisdictions must have certain basic policies and practices in place. Principally, jurisdictions ought to:

- **Ensure the Physical Security of Audit Materials.** Effective auditing of voter-verifiable paper records will serve to deter attacks on voting systems and identify problems only if states have implemented solid procedures to ensure the physical security of election materials used in a post-election audit, including the paper records of the vote, voting machines, and tally servers.
- **Implement Effective Procedures for Addressing Evidence of Fraud or Error.** If audits are to have a real deterrent effect, jurisdictions must adopt clear procedures for addressing discrepancies between the paper records and electronic tallies when they are found. Without protocols for responding to discrepancies, the detection of fraud or error will not prevent it from successfully altering the outcome of an election. Recommended responses include making corrections where warranted, disallowing results if an appropriate remedy cannot be determined, and ensuring accountability for discrepancies. Jurisdictions should document discrepancies and any actions in response to them in publicly available discrepancy logs.

When there have been no losses or additions of paper records, a single unexplained discrepancy between the paper records and electronic tallies is a strong indication of a software problem of some kind. Any such discrepancy, even if it is just one vote and can have no effect on the outcome, is grounds for a review of voting machine software code. Such a review need not delay certification of the election, but it should be investigated. To be effective, election officials must have the ability to audit the code, not just the votes.

- **Audit the Entire Voting System, Not Just the Machines.** Although this study focuses only on post-election audits of voter-verifiable paper records, jurisdictions should conduct audits of the entire voting system to catch errors or fraud in other parts of the voting system. Historically, incorrect vote totals often result from aggregation mistakes at central vote tally locations. Accordingly, good audit protocols will mandate that the entire system – from early and absentee ballots to aggregation at the tally server – be audited for accuracy. This should also include, at the very least, the ability of election officials to audit the code where they deem necessary.

## ENDNOTES

<sup>1</sup> VerifiedVoting.org, *Mandatory Manual Audits of Voter-Verifiable Paper Records*, available at <http://www.verifiedvoting.org> (last visited June 15, 2007).

<sup>2</sup> *Id.*

<sup>3</sup> These states include Georgia, Maryland, Missouri, Pennsylvania, Texas, and Virginia.

<sup>4</sup> Lawrence Norden *et al.*, *THE MACHINERY OF DEMOCRACY: PROTECTING ELECTIONS IN AN ELECTRONIC WORLD* 121 (Brennan Center for Justice ed., 2006), available at [http://www.brennancenter.org/stack\\_detail.asp?key=97&subkey=36343&init\\_key=105](http://www.brennancenter.org/stack_detail.asp?key=97&subkey=36343&init_key=105).

<sup>5</sup> See Andrew W. Appel, *Effective Audit Policy for Voter-Verified Paper Ballots in New Jersey* (Mar. 9, 2007), available at <http://www.cs.princeton.edu/~appel/spapers/appel-nj-audits.pdf>; Arel Cordero, David Wagner & David Dill, *The Role of Dice in Election Audits – Extended Abstract*, IAVOSS Workshop on Trustworthy Elections (WOTE 2006) (June 29, 2006), available at <http://www.cs.berkeley.edu/~daw/papers/dice-wote06.pdf>; Kathy Dopp, *How Can Independent Paper Audits Detect and Correct Vote Miscounts?* (version as of July 25, 2006) (June 30, 2006), available at [http://electionarchive.org/ucvAnalysis/US/paper-audits/Paper\\_Audits.pdf](http://electionarchive.org/ucvAnalysis/US/paper-audits/Paper_Audits.pdf); Kathy Dopp & Frank Stenger, *The Election Integrity Audit* (version as of Sept. 25, 2006), available at <http://electionarchive.org/ucvAnalysis/US/paper-audits/ElectionIntegrityAudit.pdf> (a computer program developed by Frank Stenger and Kathy Dopp for calculating audit details is available at <http://electionarchive.org/auditcalculator/eic.cgi>); Jerry Lobdill, *Considering Vote Count Distribution in Designing Election Audits* (version as of Nov. 26, 2006) (Oct. 9, 2006), available at <http://vote.nist.gov/Considering-Vote-Count-Distribution-in-Designing-Election-Audits-Rev-2-11-26-06.pdf>; Jerry Lobdill, *Election Audit Sampling Plan – It’s Not Just About Sampling Without Replacement* (Oct. 9, 2006), available at <http://vote.nist.gov/Election-Audit-Sampling-Plan-Design-Its-Not-Just-About-Sampling-Without-Replacement-10-09-06.pdf>; Norden *et al.*, *supra* note 2; Ronald Rivest, *On Auditing Elections When Precincts Have Different Sizes* (version as of Apr. 29, 2007), available at <http://people.csail.mit.edu/rivest/Rivest-OnAuditingElectionWhenPrecinctsHaveDifferentSizes.pdf> [hereinafter Rivest, *On Auditing*]; Ronald Rivest, *On Estimating the Size of a Statistical Audit* (version as of Nov. 14, 2006) (Sept. 19, 2006), available at <http://people.csail.mit.edu/rivest/Rivest-OnEstimatingTheSizeOfAStatisticalAudit.pdf> (Howard Stanislevic has developed a computer program for calculating Rivest’s equation at <http://mysite.verizon.net/evoter/AuditCalc.htm>) [hereinafter Rivest, *On Estimating*]; Jonathan D. Simon, JD & Bruce O’Dell, *An End to “Faith-Based” Voting: Universal Precinct-Based Handcount Sampling to Check Computerized Vote Counts in Federal and Statewide Elections*, Election Defense Alliance (Sept. 8, 2006), available at <http://electiondefensealliance.org/files/UPSEndFaithBasedVoting.pdf>; Howard Stanislevic, *Random Auditing of E-Voting Systems: How Much Is Enough?* (version as of Aug. 16, 2006) (Aug. 9, 2006), available at <http://www.votetrustusa.org/pdfs/VITF/EVEPAuditing.pdf>; Ellen Theisen, *Auditing Election Equipment – The Real Scoop!* (Aug. 27, 2005), available at <http://www.votersunite.org/info/auditingissues.pdf> (movie available at: <http://homepage.mac.com/sheltonlankford/.Public/RandomSample.mov>; excel spreadsheet available at: <http://www.votersunite.org/info/AuditEffectivenessCalculator.xls>); *The Titanium Standard for Election Verification and Security* (Oct. 1, 2006), available at <http://www.velvetrevolution.us/titanium.pdf>; Joseph A. Calandrino, J. Alex Halderman & Edward W. Felten, *Machine-Assisted Election Auditing*, 2007 USENIX/ACCURATE Electronic Voting Technology Workshop (forthcoming Aug. 2007), available at [http://www.usenix.org/events/evt07/tech/full\\_papers/calandrino/calandrino.pdf](http://www.usenix.org/events/evt07/tech/full_papers/calandrino/calandrino.pdf); Stephen N. Goggin & Michael D. Byrne, *An Examination of the Auditability of Voter Verified Paper Audit Trail (VVPAT) Ballots*, 2007 USENIX/ACCURATE Electronic Voting Technology Workshop (forthcoming Aug. 2007), available at [http://www.usenix.org/events/evt07/tech/full\\_papers/goggin/goggin.pdf](http://www.usenix.org/events/evt07/tech/full_papers/goggin/goggin.pdf); John McCarthy, Howard Stanislevic, Mark Lindeman, Arlene Ash, Vittorio Addoria & Mary Batcher, *Percentage-Based Versus S.A.F.E. Vote Tabulation Auditing: A Graphic Comparison* (forthcoming 2007), available at <http://www.verifiablevotingfoundation.org/auditcomparison>.

<sup>6</sup> *Election Audits: Hearing Before the Subcomm. on Elections of the H. Comm. on H. Admin.*, 110th Cong. (2007) [hereinafter *Election Audits Hearing*].

<sup>7</sup> See, e.g., Simon & O’Dell, *supra* note 5; Stanislevic, *supra* note 5.

<sup>8</sup> Legislation introduced in 2007 to amend or introduce post-election audit requirements include: H.B. 537, 2007 LEG., REG. SESS. (Fla. 2007). H.B. 53, 2007 LEG., REG. SESS. (Pa. 2007), and H.B. 671, 185TH GEN. COURT, REG. SESS. (Mass. 2007).

<sup>9</sup> VerifiedVoting.org, *supra* note 1.

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<sup>10</sup> *Collaborative Public Audit of the November 2006 General Election*, The Cuyahoga County Collaborative Audit Committee & Cleveland State University Center for Election Integrity (Apr. 18, 2007), *available at* [http://urban.csuohio.edu/cei/public\\_monitor/cuyahoga\\_2006\\_audit\\_rpt.pdf](http://urban.csuohio.edu/cei/public_monitor/cuyahoga_2006_audit_rpt.pdf).

<sup>11</sup> This is sometimes described as “confirm that the right candidate was declared the winner,” though this is probably more than any statistical audit can guarantee.

<sup>12</sup> Election Data Services, Inc., *Final Report of the 2004 Election Day Survey* (submitted to the U.S. Election Assistance Commission), 4-7 (Sept. 27, 2005), *available at* [http://www.eac.gov/election\\_survey\\_2004/pdf/EDS-Full\\_Report\\_wTables.pdf](http://www.eac.gov/election_survey_2004/pdf/EDS-Full_Report_wTables.pdf).

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