

# Effect of DNA Tape Lifting on the Ability of the ESDA® to Recover Latent Indentations in Paper<sup>1</sup>

Melanie Holt<sup>1</sup>, Alison Sears<sup>2</sup>, Chris Lennard<sup>3</sup>

<sup>1</sup>Crime Scene Services Branch, NSW Police Force, Sydney, Australia

<sup>2</sup>Forensic and Analytical Science Service, NSW Department of Health, Sydney, Australia

<sup>3</sup>National Centre for Forensic Studies, University of Canberra, Canberra, Australia

Questioned documents are often received into forensic laboratories requiring examinations for both trace DNA and latent indentations using an electrostatic detection device (EDD) such as the Electrostatic Detection Apparatus (ESDA®). Such documents can include extortion notes, threatening letters, drug ledgers and paper items related to white powder incidents, to name a few. Debate often arises as to which of the various examinations should be undertaken first. Assessments regarding examination sequencing need to be made on a case-by-case basis with the knowledge that each examination has the potential to compromise others.

This article focuses specifically on the effect that the tape lifting process has on the ability of the ESDA to recover latent indentations in paper. The research showed that the tape lifting process had a detrimental effect on the ability of the ESDA to recover and develop latent indentations. At worst, the tape lift can cause tears and areas of the paper's surface to be lifted whilst at the same time effectively 'masking' the indentations, making them difficult for the ESDA to detect. At best, there is fibre disturbance that results in the development of background noise on the ESDA lift; this reduces visibility, definition and legibility of the developed indentations. Given these results, in cases where it is decided that both examinations are required, the ESDA examination should be conducted prior to tape lifting for trace DNA.

**Keywords:** ESDA, latent indentations, DNA sampling, tape lifting

---

## Introduction:

Law enforcement agencies frequently receive questioned documents requiring examinations for both the detection of latent impressions using an electrostatic detection device such as the ESDA and trace DNA.

Previous research has shown that performing ESDA analyses before sampling for DNA is not likely to be detrimental to subsequent DNA analyses, so long as normal handling precautions are taken. This research has shown that it is clear DNA can withstand ESDA analysis and processing for latent fingerprints, at least for questioned

documents consisting of licked stamps and envelopes with subsequent DNA analysis using HLA DQ alpha typing (Presley et al., 1993). Another study explored the potential of DNA cross-contamination via the ESDA (Kuperus et al., 2004). This study looked into the potential for DNA transfer from contaminated exhibit documents to the ESDA with secondary transfer of DNA to documents subsequently examined using the same ESDA device. The authors concluded that such transfer was "... unlikely to occur, even under extreme conditions." DNA recovery was achieved using swabbing and large-scale extraction from entire pieces of paper. However, nei-

<sup>1</sup>This article was presented at the 2013 meeting of the American Society of Questioned Document Examiners, Indianapolis, Indiana. The presentation was derived from a thesis by M. Holt entitled "Sequencing ESDA® Examinations with the Recovery of Trace DNA from Questioned Documents" presented in partial fulfillment of the requirements for the degree of Bachelor of Applied Science (Honours) at the University of Canberra (May, 2013).

ther study considered any potential detrimental effect of performing DNA sampling prior to ESDA examination.

Parsons (2009) found that it was sometimes possible to recover LCN (trace) DNA from targeted sites on a document using a wet/dry 'double' swabbing technique. The recovered traces produced profiles suitable for analysis, comparison and identification. However, on the negative side, the sampling technique employed had a severely detrimental effect on the ability of the ESDA to detect indentations in documents. The wet swab completely obliterated the indentations, resulting in visible smears on the ESDA lifts (i.e., black 'scribble' marks in the developed images). Parsons also considered an alternative sampling method using adhesive lifting but that process was found to cause significant damage and tearing to the document making it inappropriate as a sampling method.

At the New South Wales Police Force, Australia, it is current practice to recover trace DNA from porous surfaces, such as paper, using the 'DNA Tapelift Kit' manufactured by Lovell Surgical Supplies (Figures 1a and b). The kit is designed so that the collected sample is 'robot-ready' for DNA analysis (Figure 1c), and is a different kind of adhesive tape than that used in the Parsons study.

In order to make an informed assessment as to which examination should be undertaken first, it is vital that any detrimental effect an examination might have on another is understood by the various forensic departments.

When dealing with trace DNA on paper, precautions should always be taken to ensure that fragile DNA evidence is not lost or contaminated. However, if DNA sampling is undertaken first, very little is known as to how this may af-

fect subsequent examination using the ESDA. To date, there has been very limited research specifically addressing the effect tape lifting may have on the ability of the ESDA to recover latent indentations in paper.

Whilst it was expected that the tape lifting process would have some detrimental effect it was unclear to what extent it might occur. This research addressed this issue by exploring the process and evaluating any effect in a quantitative manner. In addition, the research considered whether the effect was the same for both of the most commonly encountered paper types – A4 80 gsm office/copy paper and standard lined notepaper.

## Method and Materials:

### Equipment

DNA Tapelift Kit, manufactured by Lovell Surgical Supplies

ESDA Testa kit, manufactured by Foster + Freeman, UK

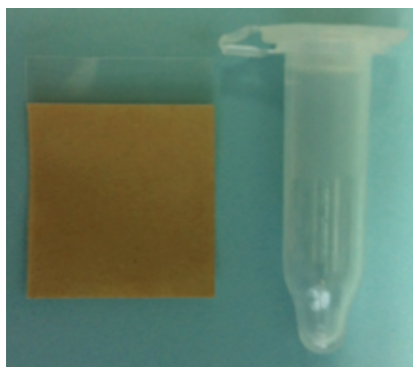
Electrostatic Detection Apparatus – model 2 (ESDA<sup>2</sup>), manufactured by Foster + Freeman, UK

Two paper types chosen as being the most frequently received at the NSW Police Force Document Examination Section Laboratory:

- A4-size 80 gsm office/copy paper
- A4-size lined notepaper

### Sampling preparation

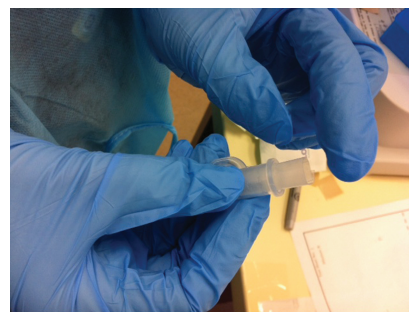
To assess any effect the tape lifting process had on the ability of the ESDA to recover latent indentations in paper, it was necessary to create documents with indentations of a known nature.



**Figure 1a:** Components of tape lift kit manufactured by Lovell Surgical Supplies.



**Figure 1b:** Image demonstrating how to use the tape lift.



**Figure 1c:** The tape lift is placed in the 'robot ready' tube for analysis.



Indentations were placed on the paper samples using two methods. In every instance, the top sheet bearing visible handwriting or markings was discarded and only the underlying sheet(s) bearing indentations were examined.

*Indentation preparation method 1  
(ESDA Testa kit):*

An ESDA Testa Kit was used to produce standardized indentations of varying depths on the paper samples. The ESDA Testa kit consists of a small pulley trolley and individual weights that can be added to produce indentations of varying depths. It is used in some laboratories to calibrate the ESDA apparatus.

Ten samples of standardized impressions were prepared using the ESDA Testa Kit for each paper type, with five indented lines of different depths drawn in a grid pattern (Figure 2).

The advantages of this test sheet preparation method were its reproducibility, i.e., consistent pressure applied to create the indentations was ensured across the various test documents, while indentations of five different depths could be placed on any single test document, enabling a

side-by-side visual comparison on a single ESDA lift.

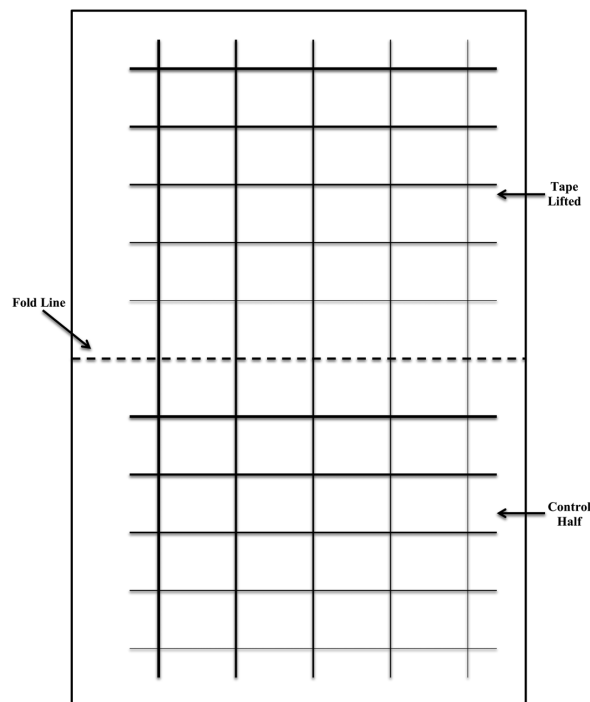
The main disadvantages of this preparation method are that it is not particularly representative of actual casework and that it may be difficult to replicate the procedure due to the limited availability of the ESDA Testa Kit.

*Indentation preparation method 2  
(Handwritten indentations):*

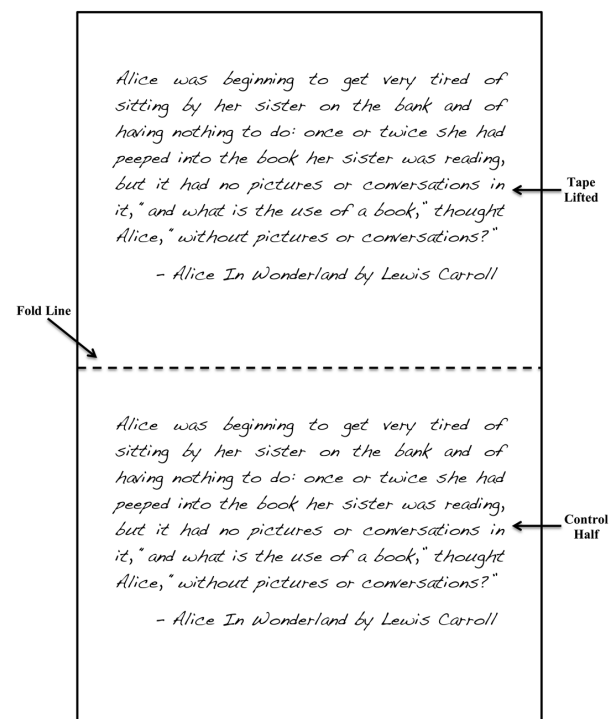
To reflect samples from casework more closely, a handwritten passage was also produced by writing on the top and lower halves of a page resting on top of four underlying sheets.

A passage was handwritten onto a stack of five pages using a blue BIC® ballpoint pen with medium pressure applied. A single writer wrote the same passage on the top and lower halves of each page maintaining as consistent writing pressure as possible (Figure 3).

It was reasoned that such a sample would be more representative of actual casework. The four underlying sheets also provided indentations of varying depths of handwritten text to be assessed. The main limitation of this test method was that



**Figure 2:** Image depicting the placement of indentations on the test documents using the ESDA® Testa Kit.



**Figure 3:** Image depicting the placement of handwritten text on the test documents.

the consistency in the original placement of the indentations could not be ensured, even though a number of measures were taken to reduce variability; i.e., same writer, same pen, same writing position, same number of underlying pages, same environmental conditions and same writing surface. Five sets of the handwritten documents (i.e., with four underlying sheets) were examined for each paper type.

*Tape lifting from document surface—sampling for trace DNA*

The top half of each sample bearing latent indentations (the portion labelled “Tape Lifted” in the above figures) was sampled for trace DNA using a standard protocol for adhesive tape lifting (Sears, 2013). In this procedure, the adhesive side of the tape was repeatedly dabbed onto the document’s surface applying slight pressure. The tape was slowly and carefully removed, and then re-applied repeatedly until the entire surface of the treatment area had been sampled and the tape had lost all (or the majority) of its adhesive nature.

Only the front side of each document half was tape lifted in this research. This approach aligns with current NSW Police Force practice, whereby the reverse side of a questioned document is not always tape lifted. A decision about whether or not to tape lift the reverse side of the page is often made on a case-by-case basis. Sometimes a decision is made not to tape lift the entire surface of the page, but rather focus on particular areas that are more likely to have been touched; e.g., fold lines, or areas where latent fingerprints have been developed. The lower half of each sample (labelled “Control Half” in the above figures) was left untouched.

*Processing for latent indentations using the ESDA*

After the tape lifting of the top halves of the test documents, each page was processed using the ESDA while following instructions provided by the manufacturer (Foster & Freeman, 2008). In this instance, the ESDA examination was undertaken at a room temperature of approximately 24°C (75°F) and 42% humidity. The test documents were processed using the cascade toner application method. Each document was positioned in the same orientation with the top of the document toward the back of the apparatus. Note the documents were not humidified prior to the ESDA examination.

*Scoring of ESDA results*

After processing the samples using the ESDA, the results for the top and lower halves of each page were compared and scored using a numerical scale (shown in Table 1 below). This was done through a survey of seventeen document examiners with varying years of experience who were asked to compare the top and lower halves of each lift. The task was to decide which half of each sample developed a more clearly legible result. The examiners were not told which half had been tape lifted or which was the control, in an attempt to avoid the introduction of experimental bias. However, in reality and given the degree of damage caused to the document by the action of tape lifting, the processed half of the document was immediately obvious. As a result, and for experimental convenience, a deliberate decision was made to always tape lift the top half of the document.

| Score | Result                                                                                         |
|-------|------------------------------------------------------------------------------------------------|
| -2    | Significant improvement of/for the top (tape lifted) half relative to the lower (control) half |
| -1    | Marginal improvement of/for the top (tape lifted) half relative to the lower (control) half    |
| 0     | No difference between the two halves                                                           |
| 1     | Marginal degradation of/for the top (tape lifted) half relative to the lower (control) half    |
| 2     | Significant degradation of/for the top (tape lifted) half relative to the lower (control) half |

**Table 1:** Scoring key for comparing the results of tape lifted and control halves on the ESDA lift.

**Results:**

Without exception, when indentations were developed by the ESDA, the tape lifted half of each page produced poorer results than the control half (see Figures 4 and 5 below). All test samples, other than the bottom-most sheets of handwritten indentations, received scores of +1 or +2 indicating there was marginal to significant degradation in the tape lifted half of the sample. However, for the bottom-most sheets of handwritten material, latent indentations failed to develop on both halves. As a result, zero scores were recorded, as no indentations were visible regardless of whether or not tape lifting was done.

The results from the survey of examiners for each set of test sheets are shown in Appendix 1, Tables 2 through to 5.



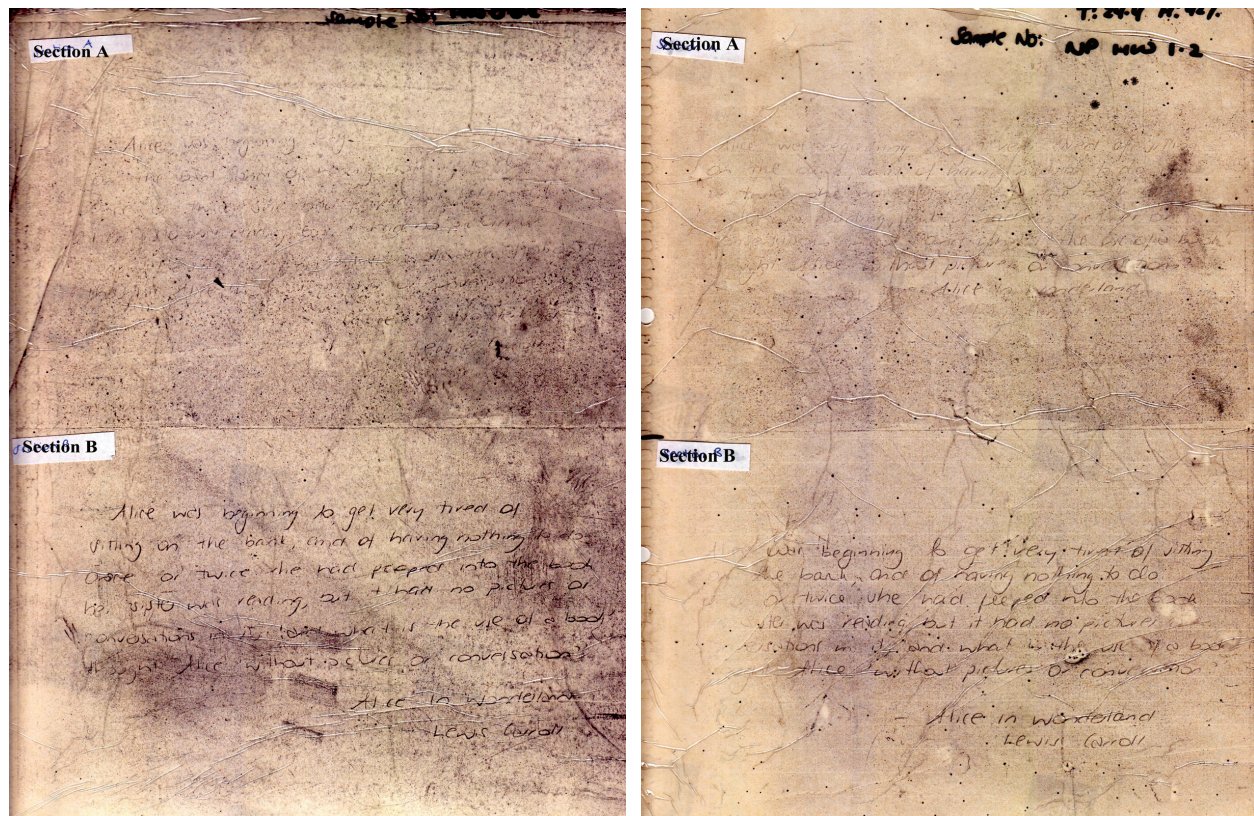


Figure 4: Images of the ESDA lifts of page 2, i.e., the page located directly under the original handwritten page. Here the difference between the two halves can be easily observed.

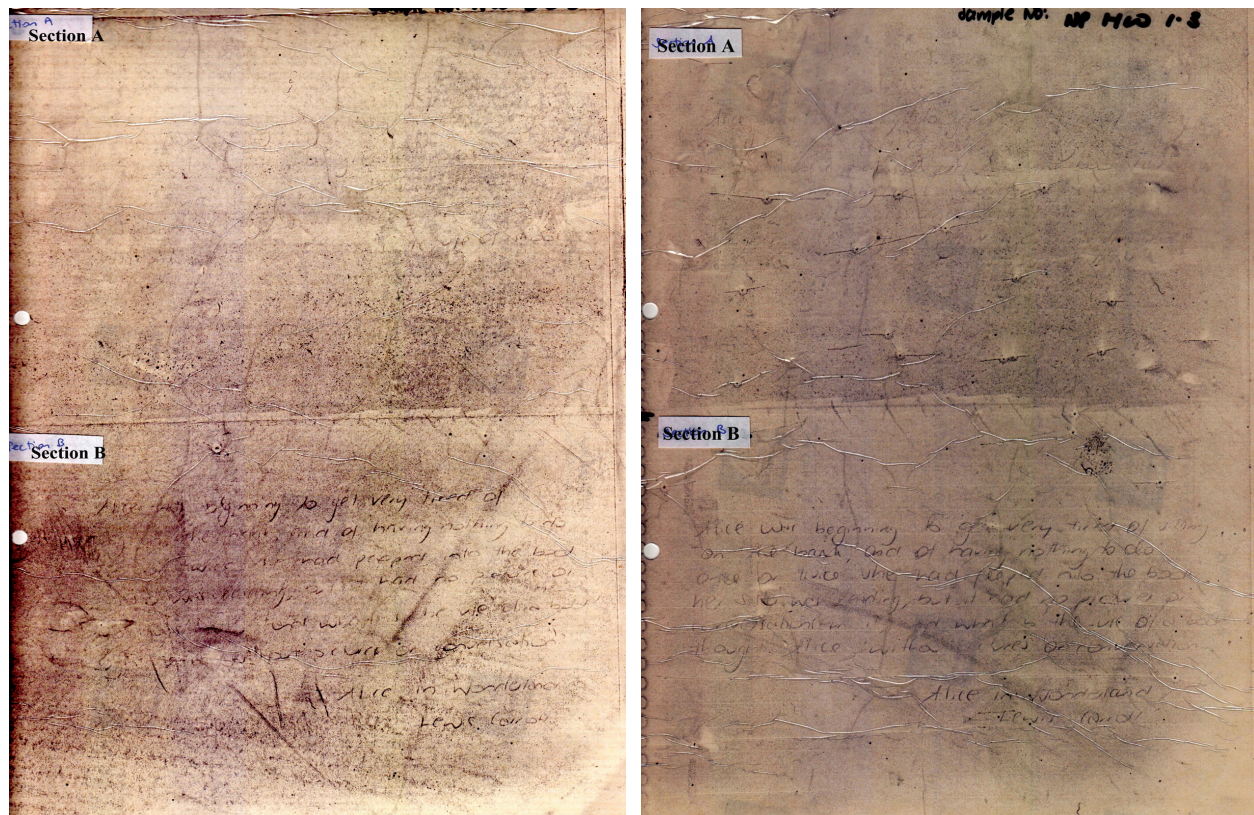


Figure 5: Image of the ESDA foils of page 3 in the stack. Here indentations can be seen on the lower half, but not on the top half.



In the images, portions marked Section A were processed by tape lifting prior to the ESDA examination and Section B indicates the control half. For each figure, in general, the image on the left is office paper and the image on the right is notepaper.

The impressions were lighter, less clear and, in some cases, completely obscured on the tape lifted half of each page. It was observed that tape lifting had the most detrimental effect on shallow indentations, i.e., those indentations caused by lighter pen pressure or because the test document was located two or three pages deep in the original stack. In those situations, the indentations were often entirely 'removed' or obscured. It was also noted that the tape lifting process created significant background noise on the ESDA lift, causing the area to have a mottled or rough appearance and reducing the visibility of the indentations developed.

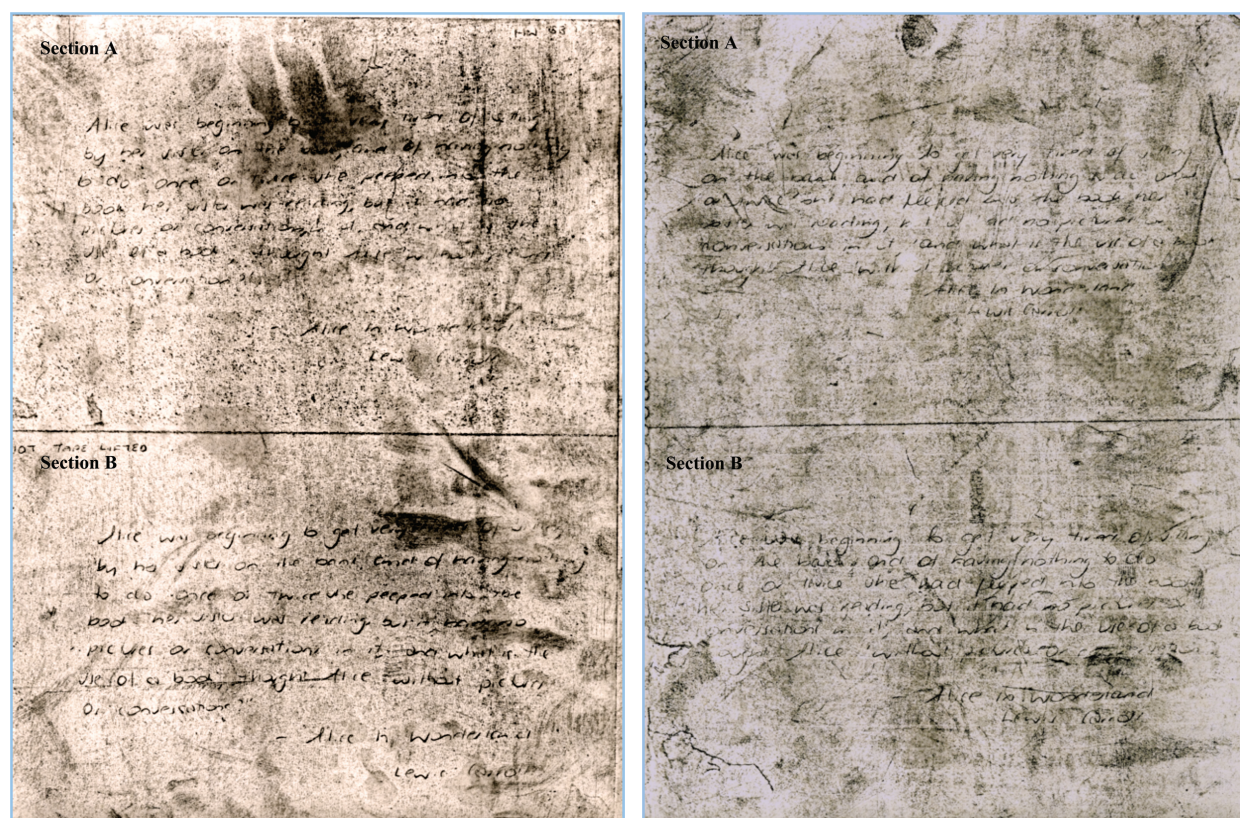
Since tape lifting was performed only on the front of each page as per NSWPF Laboratory policy, it was decided to also conduct an ESDA examination on the reverse side of each page. For pages located directly beneath the original hand-

written page, the degradation noted earlier when the front of each page was examined was not present to the same degree (Figure 6).

However, as the indentations became shallower on pages further down the stack, the difference between the two halves became more pronounced. In addition, it was interesting to note that the background noise caused from tape lifting the front side of the page could also be seen on the ESDA lift taken from the reverse side of the page. This further highlighted the damaging and abrasive effect the tape lifting had on the paper's surface.

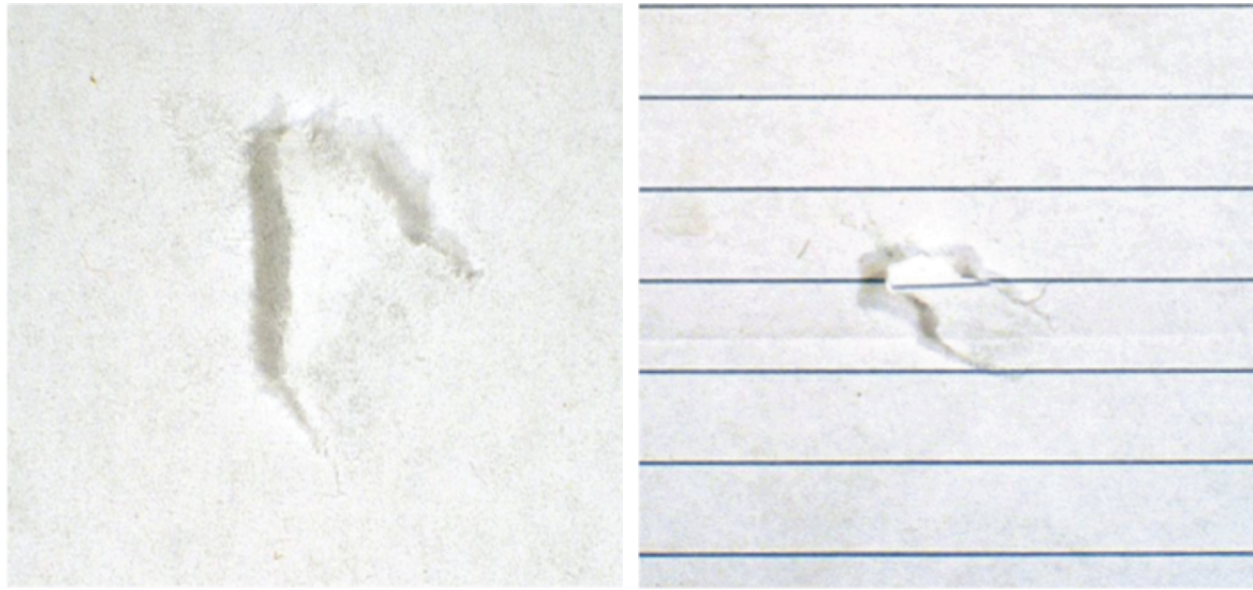
### Discussion:

As indicated above, in every instance where indentations were developed on the ESDA lift, it was observed that the tape lifting process had a detrimental effect on the results obtained. Without exception, indentations developed from the half that had been tape lifted prior to the ESDA examination were lighter and lacked the clarity and definition of those that had been developed from the control half. When the document con-



**Figure 6:** Mirror image of the ESDA® foil of the reverse side of page 2, i.e., the page located directly beneath the original page.



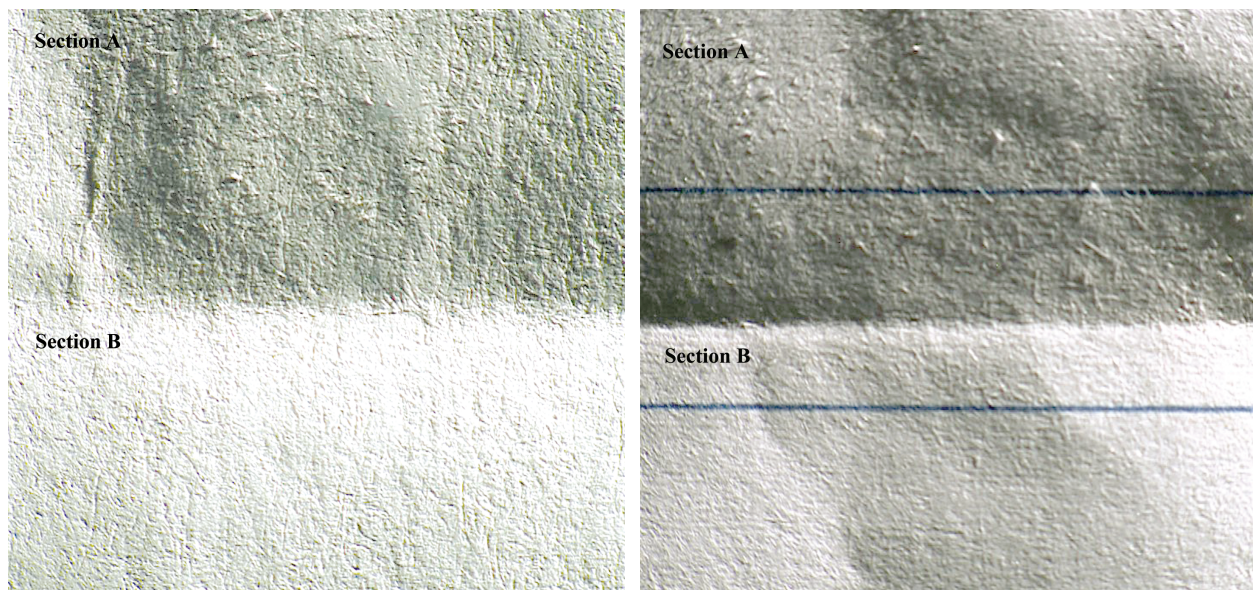


**Figure 7:** Images of damage caused to the paper due to the tape lifting process (shown at 4x magnification). Here the top surface of the paper has been lifted and torn.

tained more shallow indentations, either due to lighter pen pressure being used by the writer or because the page was located two or three pages deep in a paper stack, the indentations were often 'removed' or obscured entirely by the tape lifting process, leaving next to no trace of their existence, even though they were readable on the lower (control) half of the lift. A degree of background noise was also noted in the ESDA lifts

of the tape lifted halves compared to the control halves.

The tape lifting process caused both macroscopic and microscopic damage to both paper types. On the macroscopic level, the process frequently caused tears and abrasions to the surface of the paper regardless of the care and experience of the examiner. There were a number of instances where the page tore, or sections of



**Figure 8:** Image showing the effect of the tape lifting process on the paper fibers (at 8x magnification). In the upper half of the image (Section A) the paper has a mottled appearance whereas the fibers sit flat in the lower half of the image (Section B).



the top layer were lifted and/or removed (Figure 7). There was little difference in the amount of damage observed between the two paper types.

Such damage could be reduced by having the tape lifting process follow the grain of the paper. When the grain was followed, fewer tears and damage occurred to the page. However, in practice, it is quite difficult to determine the direction of the grain of the paper visually and it wasn't until the damage occurred that it was realised that the operator was tape lifting against the grain.

The tape lifting process also caused microscopic damage to the paper's surface. When viewed under high magnification and with oblique lighting, the paper fibers on the tape lifted half of the page were raised above the page's surface, whereas they were sitting flat in the control half (Figure 8).

Previous research has shown abrasions or irregularities on the paper's surface not only negatively impact the ability of the ESDA to recover indentations in paper, but those features may also be developed by the ESDA (Foster & Freeman, 2008, Dunkerley and Riley, 1999). Therefore, it is likely that the fiber disturbance was the cause of the background noise developed on the tape lifted half of the ESDA lifts and a likely contributing factor to the reduced clarity of the indentations.

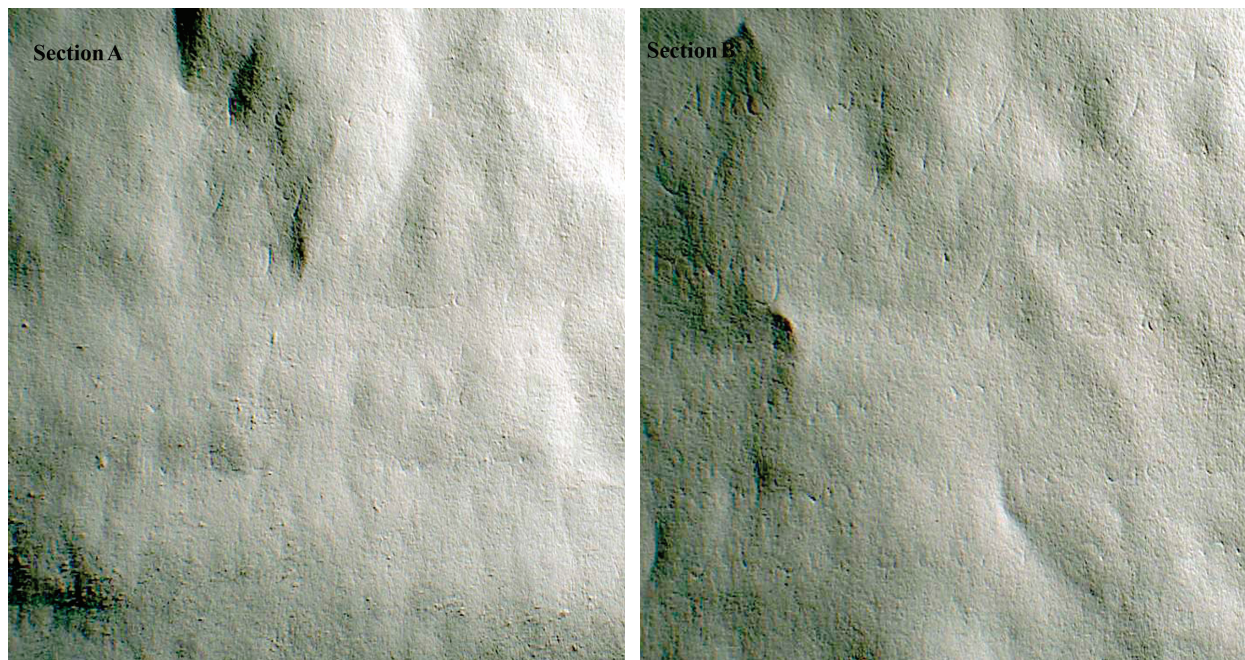
An alternative examination for indentations uses oblique side lighting and, when pages were

examined in this manner, indentations contained within the tape lifted half appeared shallower and lacked the depth, clarity and definition of those contained within the control half. It appeared that the tape lifting process was, in effect, 'pulling' the indentations out of the paper. This result can be seen in Figures 9 and 10 below.

### Conclusions:

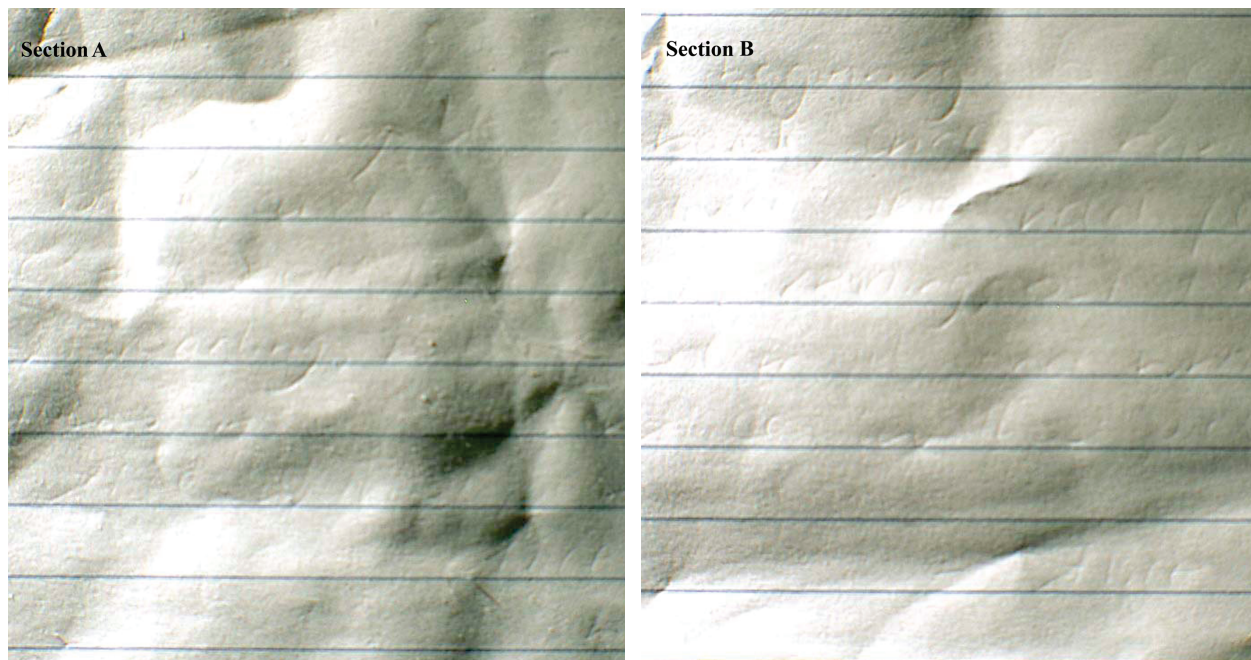
It is clear that tape lifting a document to recover trace DNA prior to an ESDA examination has a severely adverse effect on the ability of the ESDA to recover and develop latent indentations in the paper. At worst, the tape lifting can cause tears and areas of the paper's surface to be lifted whilst at the same time diminishing the visibility of the developed indentations. At best, there is fiber disturbance that causes the development of background noise on the ESDA lift that reduces the visibility, definition and clarity of the recovered indentations. As a result, it is likely that the tape lifting process will adversely affect any indentation contained in a document. Therefore, careful consideration needs to be given to documents that require examinations for latent indentations and trace DNA.

The best sequence of examinations needs to be determined on a case-by-case basis. The first step is to decide what forensic information is poten-



**Figure 9:** These images depict the differences observed in the indentations in office paper under oblique light (at 2x magnification). The image on the left is the tape lifted half and the image on the right is the control half.





**Figure 10:** These images depict the differences observed in the indentations in notepaper under oblique light (at 2x magnification). The image on the left is the tape lifted half and the image on the right is the control half.

tially the most important (useful) for the investigation and proceed from that point. Before determining whether or not an ESDA examination is warranted, documents should first be examined using oblique light to ascertain if there are any indentations visible in the page. It should be noted, however, that this examination might not reveal all latent indentations that may be contained in the page. In some instances, deep indentations can be deciphered and captured using oblique lighting and photography and an ESDA examination may not be required, thus permitting processing for DNA without delay or concern about incidental accidental contamination.

If both tape lifting for DNA and ESDA examinations are required then the ESDA examination must be conducted first. In these instances, the document examiner must take every possible precaution to ensure that contamination to the document does not occur. These precautions should involve the use of all appropriate personal protective equipment such as disposable gowns, face-masks, hairnets and gloves as well as thoroughly cleaning all bench surfaces and implements with an appropriate DNA decontamination process.

#### References:

Dunkerley, M. and Riley, T. (1999). The effect of fingerprint processing on ESDA impressions: Does

fingerprinting prior to ESDA affect ESDA results? *International Journal of Forensic Document Examiners*, 5, 280-282.

Foster & Freeman (2008). ESDA-2 Electrostatic Detection Apparatus User Manual 14-06. Worcestershire, U.K.

Kuperus, W.R., Shalley, H., Nicholson, M.L., and Hryca, T. (2004). Secondary transfer of DNA between questioned documents via the ESDA platen. Presented at the AGM of the Canadian Society of Forensic Science, Orlando, Florida.

Parsons, L.H. (2009). *Low Copy Number DNA Analysis & Document Examination: The Impact of Technologies on Respective Analyses*. M.S.F.S. Thesis 09-416, University of Auckland.

Presley, L.A., Baumstark, A.L., and Dixon A. (1993). The effects of specific latent fingerprint and questioned document examinations on the amplification and typing of the HLA DQ alpha gene region in forensic casework. *Journal of Forensic Sciences*, 38(5), 1028-36.

Sears, A. (2013). Standard Operating Procedure - Tapelift Field Kit Collection Method in *NSW Police Force FSG Crime Scene Manual (General)*, Chapter 6, Section 11, 6.

## Appendix 1: Results of the survey of 17 document examiners

### Office Paper – ESDA® Testa Kit Results:

| Sample Reference | -2 | -1 | 0 | +1 | +2 |
|------------------|----|----|---|----|----|
| E1               |    |    |   | 17 |    |
| E2               |    |    |   | 17 |    |
| E3               |    |    |   | 17 |    |
| E4               |    |    |   | 17 |    |
| E5               |    |    |   | 10 | 7  |
| E6               |    |    |   | 9  | 8  |
| E7               |    |    |   | 8  | 9  |
| E8               |    |    |   | 16 | 1  |
| E9               |    |    |   | 14 | 3  |
| E10              |    |    |   |    | 17 |

**Table 2:** Survey results for Office Paper comparing clarity of indentations obtained with and without tape lifting prior to ESDA examination for indentations made using the ESDA Testa Kit.



**Office Paper – Handwriting Results:**

| Sample Reference | -2 | -1 | 0  | +1 | +2 |
|------------------|----|----|----|----|----|
| 1.2              |    |    |    |    | 17 |
| 1.3              |    |    |    |    | 17 |
| 1.4              |    |    |    | 16 | 1  |
| 1.5              |    |    | 17 |    |    |
| 2.2              |    |    |    |    | 17 |
| 2.3              |    |    |    |    | 17 |
| 2.4              |    |    |    | 1  | 16 |
| 2.5              |    |    | 17 |    |    |
| 3.2              |    |    |    |    | 17 |
| 3.3              |    |    |    | 9  | 8  |
| 3.4              |    |    |    | 17 |    |
| 3.5              |    |    | 17 |    |    |
| 4.2              |    |    |    |    | 17 |
| 4.3              |    |    |    |    | 17 |
| 4.4              |    |    |    | 17 |    |
| 4.5              |    |    | 17 |    |    |
| 5.2              |    |    |    |    | 17 |
| 5.3              |    |    |    | 2  | 15 |
| 5.4              |    |    |    | 16 | 1  |
| 5.5              |    |    | 17 |    |    |

**Table 3:** Survey results for Office Paper comparing clarity of indentations obtained with and without tape lifting prior to ESDA examination for indentation made by handwriting a passage.

**Note Paper – ESDA® Testa Kit Results:**

| Sample Reference | -2 | -1 | 0 | +1 | +2 |
|------------------|----|----|---|----|----|
| E1               |    |    |   |    | 17 |
| E2               |    |    |   | 9  | 8  |
| E3               |    |    |   | 8  | 9  |
| E4               |    |    |   | 15 | 2  |
| E5               |    |    |   | 9  | 8  |
| E6               |    |    |   | 10 | 7  |
| E7               |    |    |   |    | 17 |
| E8               |    |    |   | 17 |    |
| E9               |    |    |   | 9  | 8  |
| E10              |    |    |   | 17 |    |

**Table 4:** Survey results for Notepaper comparing clarity of indentations obtained with and without tape lifting prior to ESDA examination for indentations made using the ESDA Testa Kit.



**Notepaper – ESDA® Handwriting Results:**

| Sample Reference | -2 | -1 | 0  | +1 | +2 |
|------------------|----|----|----|----|----|
| 1.2              |    |    |    |    | 17 |
| 1.3              |    |    |    |    | 17 |
| 1.4              |    |    |    | 9  | 8  |
| 1.5              |    |    | 17 |    |    |
| 2.2              |    |    |    |    | 17 |
| 2.3              |    |    |    | 14 | 3  |
| 2.4              |    |    |    | 17 |    |
| 2.5              |    |    | 17 |    |    |
| 3.2              |    |    |    |    | 17 |
| 3.3              |    |    |    |    | 17 |
| 3.4              |    |    |    |    | 17 |
| 3.5              |    |    | 17 |    |    |
| 4.2              |    |    |    | 10 | 7  |
| 4.3              |    |    |    |    | 17 |
| 4.4              |    |    |    | 2  | 15 |
| 4.5              |    |    | 17 |    |    |
| 5.2              |    |    |    |    | 17 |
| 5.3              |    |    |    |    | 17 |
| 5.4              |    |    |    | 17 |    |
| 5.5              |    |    | 17 |    |    |

**Table 5:** Survey results for Notepaper comparing clarity of indentations obtained with and without tape lifting prior to ESDA examination for indentation made by handwriting a passage.

