Tuesday, 6 December 2022

(10.01 am)

LORD BRACADALE: Good morning. The Assessor Raju Bhatt is going to follow proceedings remotely this week.

Good morning, Ms Dawson. Before you are asked questions I need to either put you on oath or get you to give an affirmation. Which do you wish to do?

A. Oath, my Lord.

PROFESSOR LORNA DAWSON (sworn)

LORD BRACADALE: Ms Thomson.

Questions from MS THOMSON

MS THOMSON: Good morning, Professor Dawson.

A. Good morning.

Q. What is your full name, please?

A. My name is Professor Lorna Ann Dawson.

Q. May I ask how old you are?

A. I'm 65.

Q. And you are a principal research scientist at the James Hutton Institute in Aberdeen, where you are the head of the soil forensic section, is that right?

A. That is correct.

Q. I'm going to ask you some questions about your qualifications and experience shortly. Professor, you were asked by the Inquiry to examine a number of items for the presence of soil, to analyse any soil found to

be present and to prepare a report.

A. That is correct.

Q. I want to begin this morning by making sure that you've got all you need to give your evidence today to hand and you will see in front of you a folder. You should find within the folder the letter of instruction that you received from the Inquiry, which is dated 27 July of this year. Do you have that?

A. Yes, that's correct.

Q. The report that you prepared in response to that letter of instruction, which is dated 1 November.

A. Yes, that's correct.

Q. There should also be a report prepared by your colleague, Dr Nicholas Schurch dated 3 November.

A. That's correct.

Q. Is that there too?

A. Yes.

Q. And a statement that Dr Schurch gave to the Inquiry on 7 November.

A. That's correct.

Q. They're all there?

A. Yes, thank you.

Q. I should explain, Professor, that your report and the other documents that we have referred to, are available to the Chair and to the Assessors for their

consideration and will be published on the Inquiry's website today, so it's not necessary for us to go through your report line by line, but it is there in the folder and if you would find it helpful to refer to your report at any point when you are giving evidence then you should feel free to do so.

A. Thank you.

Q. Professor, you have also prepared a PowerPoint presentation which I believe summarises the work that you carried out on behalf of the Inquiry and your findings and conclusions?

A. That is correct.

Q. Am I right to understand that the PowerPoint is intended to simplify some difficult scientific concepts and to explain key points?

A. Yes.

Q. My plan today is to simply go through the PowerPoint presentation and to ask you questions in relation to each slide and it will be disclosed and published on our website later today.

Before we go through the slides, I would like to ask you some questions about your qualifications and experience. Your full CV is an appendix to your report and so is available to the Chair and the Assessors.

You have a BSc Honours in geography?

A. That's correct.
Q. And also a PhD in soil science?
A. Yes.
Q. As we have mentioned already, you are the head of soil science at the James Hutton Institute. Can you explain what that role involves?
A. The role of head of forensic soil science is to oversee all the work that we do in the institute in connection with soil, botany, geology, all the ecological sciences in relation to the criminal justice system, from civil work right through to criminal work, across Scotland, the United Kingdom and in several countries in the world.
Q. What is the James Hutton Institute then?
A. The James Hutton Institute is an institute that was the merger of two former institutes: one, the Macaulay Institute for Soil Science and the Scottish Crop Research Institute for the understanding of crop sciences and that merged just over 10 years ago to form the James Hutton Institute, so we specialise in environment, soil, crops, plants and aspects such as climate change and farming and food.
Q. How long have you held your current position at the James Hutton Institute?
A. I have been employed by the James Hutton Institute, or

formally the Macaulay Institute since 1984.

Q. You're also a visiting professor in forensic science at the Robert Gordon University?

A. Yes, that is correct.

Q. And a professor in forensic science at a university in Porto in Portugal?

A. Yes, that's correct.

Q. You're a chartered scientist?

A. Yes.

Q. And a fellow of the Institute of Soil Science?

A. Yes.

Q. And you have published extensively in the field of soil science?

A. Yes.

Q. You received a CBE in the Queen's birthday honours in 2018?

A. Yes.

Q. What was that for?

A. It was for my services to the disciplines of soil science and forensic science.

Q. And last year I believe you gave something called a TED Talk?

A. I did.

Q. What is a TED Talk?

A. TED Talks are ways of communicating with the general

public about a particular topic. It's a form of communication of whatever your theme or your topic is, so that it's for wide understanding of the science.

Q. So to help the public to have an understanding of quite specialist work?

A. Yes, that's correct.

Q. And what topic did you choose to communicate through your TED Talk?

A. I chose to talk about the importance of considering both sides within a particular investigation, both alternative propositions and considering -- I set it in the context of a couple of cases where I gave evidence to those particular criminal trials.

Q. On the subject of criminal trials, I understand that you have given evidence in a number of high profile prosecutions?

A. Yes.

Q. Including, amongst them, Her Majesty's Advocate v Sinclair in 2014.

A. Yes.

Q. Was that the "World's End" murder case?

A. Yes, that is correct.

Q. Can you help us to understand the role of soil science in that particular case?

A. That was, I believe, the first time for the double

jeopardy application and originally there wasn't methods that could be used to look at the soil, but with the advancement of techniques from myself and my colleagues we developed methods that we could look at trace amounts of soil which couldn't previously be carried out.

So what we looked at was very, very small pieces of soil which had been kept from the original investigation that had been recovered from -- sadly from Helen Scott's feet and what we could show by looking at those pieces of soil that she had stood in two different places: one place at the verge and also the place where she was sadly found, so that we could bring that information to the whole investigation and also in court to work out what actually had happened to Helen that night.

Q. Do I understand that you have also given evidence in prosecutions south of the border?

A. That is correct.

Q. Quite recently, in a case called R v Halliwell from 2016. Can you explain what the role of soil science was in that case?

A. In that particular situation, Christopher Halliwell had taken the police officers to a site where sadly Becky Godden's remains were found, but this information could not be used in the actual trial, it wasn't done through the proper means, and the police discovered

tools that Mr Halliwell had used, spades and pick axes, tools that he kept in his garden shed. So we looked at soil that was recovered from these tools and compared the traces of soil with the soil where Becky was found in the field -- in the corner of the field and we could show that the soil that had come from there, because it was quite distinctive, that it couldn't have come from anywhere else, the soil on the spade and the field where she was found. So that helped the investigation show that there was a link between the tools that were in his shed and the site where Becky was found.

Q. Thank you. Am I right to understand that as well as giving evidence in both Scotland and in England you have given evidence further afield and as far away as Australia?

A. Yes, that's correct.

Q. Have you undertaken work in criminal cases on behalf of the defence?

A. The case in -- I believe it was 2012, the case in Australia was actually for -- the evidence that I looked at was for the defence and it was to look at the context of whether a soil that was found in a particular area could have come from the soil -- the soil on the boot could have come from the driveway and I looked at that in the context of other alternative propositions in that

particular case and yes, I -- our whole team, we openly do work for either prosecution or defence, or civil work as well.

Q. Are you able to help me understand what proportion of your work is for law enforcement, what proportion for defence and what proportion for civil cases?

A. It's probably 60% for the investigating authorities and probably 30% for defence and the rest is civil work or research.

Q. Thank you. I wonder if we can have your PowerPoint on the screen. If we can move on to the second slide. Thank you. Is it possible to adjust the size of the slide slightly? Lovely. Thank you. Professor, I wanted to begin by asking you, if you could help us to understand, what is soil?

A. Soil is varied. Soil is the result of coming together of many different factors because we don't just have one soil, we have many different soils, even in a country the size of Scotland and in particular we've got a varied geology. Soil -- its very basis is that -- is the parent material, the geology, the bedrock. What minerals are in that bedrock break down to form the elements that are in the soil and it varies depending on what rock that is, what elements that you will find in the soil.

You have also got the climate, so depending on whether you've got a wet, cold climate you will get organic matter building up, compared to if you've got a very dry and warm climate, you will get the organic matter breaking down, so you will get very low organic matter in that type of environment.

You will also get the impact of organisms and that -- when I say organisms -- are both the botanical organisms and also the animals and also the influence of humans. All of those things impact on the soil by affecting the organic matter that returns to the soil and then you've got the landscape, the topography, whether it's south-facing, north-facing, in a ditch, in a slope or on the top of a hill. All those factors together, also with the process of time -- soils take hundreds and hundreds and thousands of years to form, particularly in a cold environment, but they can take -- they can take weeks to be lost, so that's why they're a very precious resource.

Q. So you have headed this slide "Soil forming factors" and you have discussed the role played by each of the factors listed in the formation of soil.

If we can move to the next slide please. This slide is headed "Soil Composition" and you explain that soil is composed of: inorganic matter, organic matter,

biological organisms, air and water. So I wanted to ask you about each. Can you tell us a little more about the inorganic matter that forms part of soil?

A. The inorganic matter in soil is the part that is formed from that bedrock, or inorganic material that has been added by human beings, by adding, say, fertiliser to soil, that will affect that soil and, as I said, the geology, depending on whether you've got -- if you've got a granite, you've got quartz, mica and feldspar, that will be quite different to if you've got a sandstone where you've got a very large proportion of quartz within it. So it ranges, the inorganic matter will be affected by what your bedrock is and also what inorganic material has been added to that soil and the inorganic and organic portions vary from a beach sand, let's say, which is almost 100% inorganic, to an upland peat which is almost 100% organic matter and we've got all the range of different types in-between.

Q. So should we understand that different soils can form, at least in part, different minerals depending on the bedrock and there can be varying proportions of inorganic and organic matter in any different soil type?

A. That's correct.

Q. Tell us a little more about organic matter.

A. The organic matter that is formed in the soil is largely

the result of the breakdown of all the plant material that has ever grown at that particular location, from the start of that soil forming and what's left behind are the parts that don't totally break down, so the resistant compounds, and they are left behind and leave a signature in that soil that reflects that history of input of decomposing leaves.

If you walk around and see leaf material in the autumn having fallen and left on the ground, they will be incorporated by earthworms and other organisms into that soil, with parts of that material left for hundreds and hundreds of years in that soil. So it's a combination of everything that has accumulated and decomposed in that soil and also you've got the material that's been introduced by human beings, the organic material, the hydrocarbons that come from vehicles, let's say, for example, that all resides and binds with the organic matter in soil.

Q. So you say that human-induced compounds can be either inorganic and you gave an example of a fertiliser being applied to soil, or organic and you have given the example of hydrocarbons, so we can see humanity's influence over the composition of different types of soil.

Next on your slide are biological organisms, plants

and animals.

A. Yes and when we look at soil, when we examine it in the laboratory, we would be looking to recover any fragments of plant material, any fragments of organisms, mites, bugs, when we recover them and they can be identified and they also tell us about information about the habitat of where that soil came from. So it's a whole wealth of information that you can deduce when you look at a soil and you are asked "Where did that soil come from?" It's all the information that we can derive that helps answer those types of questions.

Q. Can you give an example?

A. I suppose one example which was for the general public was The One Show presenter went to an area in Scotland and walked and sent us his boots and said "We have been somewhere in Scotland, can you work out where we were?" and all we had was the soil on the boots that he had worn, Marty Jopson it was, and we analysed it with inorganic methods, organic methods, we looked at the fragments of vegetation and it came down to three areas: one in Stirling, one in -- near Edinburgh and one at a park just at the north of Edinburgh and when we identified that particular park it was kept for the television programme that indeed we had got within 700 metres of where he had stood, just by using the

combination of analytical techniques, along with the mapping information that we host, so that you can put the information -- the data, the analytical data in the context of the spatial data that we hold within the James Hutton Institute database.

Q. So what information did you have to work with in that particular case, in that example? What was the inorganic matter, what was the organic matter? What was distinctive about it that led you to these three possible locations across Scotland?

A. We looked at the mineralogy, so that is the suite of different minerals that are present in a soil and that identified that it was igneous parent material, so that we could exclude all of the geology of Scotland that did not have that type of geology.

We also looked at the elemental composition of that soil and we could compare that with the elemental data that we had mapped every 10-kilometre grid point in Scotland, so we could exclude many areas of Scotland that did not have the characteristics of that questioned soil from the boot.

So that, combined with the -- we then used gas chromatography to analyse the organic matter in the soil and we could say that it was a mixed woodland beside farmland where there had been cattle grazing and then we

used palynology which tells us about the individual plant species that are there. So, by excluding about 95% of Scotland, narrowing it down to the 5%, we could then identify which areas then shared those characteristics with the questioned soil.

Q. So in this case you were looking for an area of woodland that was also close to a farm?

A. That is correct, with that geology.

Q. With that geology and that would be on the -- the woodland, the farm, would that be on the basis of the organic matter within the sample --

A. That's correct.

Q. -- coming from trees, farm manure, that sort of thing?

A. That's correct.

Q. You have mentioned a mapping, can you explain what the concept of mapping involves? Is this the soil database that I have heard about?

A. So at the -- then, the Macaulay Institute, in the 1970s, we were commissioned by the Scottish Government to go out to every 10-kilometre grid point and sample the soil, so soils vary horizontally, but they also vary vertically with depth, so a whole team of soil surveyors went out across the whole of Scotland and visited these grid point locations, dug a profile pit, a soil pit, sampled each of the horizons, took samples back, those

samples were analysed using recognised accredited methods to analyse the characteristics of mineralogy, elemental composition, PH, organic matter content, and that was then all kept within a database and maps were made from that.

In those days it was paper maps and those maps were used to derive such attributes as land capability for agriculture and land capability for forestry, those types of derived product.

But then in the 2000s Scottish Government asked us to go back to those same locations, or at least every 20-kilometre point and to resample, to see if the soils had changed over time in terms of characterisation of climate change effects, of pollutant effects. So we could compare the data that was gathered in the 1970s with the data that was gathered in the early 2000s and compare to see if there were changes and loss of organic matter in which there weren't. Thankfully, in Scotland we're not having a huge problem with loss of carbon, so it allows us to put that sort of data in a time context as well.

Q. I see. And do these databases remain accessible to you?

A. In Scotland we share all the data, it's all freely available, so that anyone can go onto what is called the Scottish environment web and at that site the data is

available for download for anyone who wishes because it was Scottish Government tax payer funded work.

Q. Thank you. Returning to the slide, the final composition listed there is "air and water". What part do air and water play in soil composition?

A. They're a very important part and one of the four -- or five parts of what makes soil distinctive. The air are the pore spaces, so that soil must have the aeration to allow the organisms to live within soil. So what we don't want is a compacted soil where we don't have enough air for the roots to grow and the organisms to grow also, but we also need enough water -- not too much water, but enough water in the pore space to, again, allow the plants to grow and that environment to thrive.

Q. And what then makes one soil different from another? Is it a combination of the different inorganic matter, the different organic composition, the different organisms that live within it and different quantities of air and water?

A. It's the different combinations that you get of these multiple attributes of soil that make them so variable across, particularly, a country like Scotland where we've got a varied geology and we've got a very varied different habitat types, where you've got different organic matter being added to the soil.

Q. In the context of the mapping, you mentioned a scheme whereby 10-kilometre mapping points were determined and samples taken across the whole of Scotland. Within a range of 10 kilometres can there be variation in a soil type, or would you expect consistency over a period of about 10 kilometres?

A. Different characteristics of soil vary at different scale and, for example, geology, the mineralogy varies at about a kilometre scale, while organic matter can vary at about a metre scale, so depending on what you're measuring it will vary, but the closer you get two locations to each other, the more similar they will be than if you move further away and in that sampling grid what we tried to do was hit all combinations of geologies and habitat type and if that grid didn't cover it, we went back to sample other locations such as the Machair on the west coast of Scotland where they're particularly calcareous soils so they're different and they've got a different, very diverse grassland ecotype, so we went and added in other types in addition to the grid sampling positions.

Q. Was that to give you as clear a picture as was reasonably possible to have of the soil types across the whole of Scotland?

A. These soil types were then classified into different

types of soils and by covering that on a grid based system with additional points we were representing every possible combination of geology and land cover type.

Q. Do samples continue to be added to the database? If, for example, you're involved in a case would you add the sample from your casework to the database, or is that an entirely separate matter?

A. So there are several databases. There is what's called the national soil archive and the national soil inventory database and that covers that structured sampling of the grid-based system, but in addition to that there were other types of sampling, so around all major cities there was a more intensive sampling, so they are also added into the database.

If we work on commercial work, that is kept commercially confidential for the client and any casework is within another database as well, so it's a distinctly different database to the one that is publicly available, but yes, we do have that database building all the time.

Q. Can we move on to the next slide please: "Natural and urban soils". So you have explained to us the formation and composition of natural soils. How do urban soils differ from naturally formed soils?

A. So you can see in the picture on the left you've got

distinct depth layers. Those are called "soil horizons" and they're quite clearly defined, with the darker organic material at the surface, then in the middle you've got where you get the reaction between the organic acids and the minerals, other minerals being in the very foot at the bedrock material.

Above that you've got a natural environment where you've got the input of the vegetation as it falls and decomposes and the organisms incorporate it over time and that leads there to be a darker organic matter at the surface.

However, in the profile on the right, you can see that in a city, while you will generally get the same underlying bedrock, so the same geology that persists in a particular place, that is formed from the geology of where that location was, you get a lot of introduced components from human activity. You get drains being dug, you get soil being transported, you get herbaceous borders being dug in, you get pollutants, you get industrial processes, you get vehicles travelling over that area. That all adds in other components to that soil and you can get the soil mixed up, you don't get the same layering that you get in a natural soil profile, so it adds to more variability that you might expect to find in an urban soil that you would get in

a natural soil.

Q. You mentioned soil horizons and the layers that I think we can see, particularly in the left-hand photograph. Now, we have touch technology in this hearing room, so I wonder if you could perhaps return to the left photograph and if you just put your finger on the screen, a little circle will appear. If you could help us to understand what each of the layers are that we see in the left-hand photo. Do you want to take one of those away. I think there's a means of doing that. There we are.

A. So, number 1, so that is the geology, so that is the underlying depth. That's about a metre and a half depth and this is what a soil starts from, the geology, the parent material. And above, in comes the vegetation, from any material that is grown there that dies and decomposes and is left behind as organic matter. That material -- the organic material leeches down from the top and interacts with the minerals and together there's a lot of chemical reactions going on which particularly make that soil distinctive for that particular location.

Q. We've got quite a lot of circles there. I think the screen is quite -- it's actually quite touch-sensitive. So, let me just be clear about this. We have spoken about the bottom horizon band, where we've got circle

number 1 and you have explained that comes from the geology.

A. Yes.

Q. That's the parent material that you spoke about at the beginning.

A. That's correct.

Q. Immediately above that where we have a circle with number 5 on it, that sort of ochre or yellowish layer --

A. That's called the B horizon, so the lower, geological layer is the C horizon, the bedrock. The middle interactive zone is the B horizon and that's where you get the orange-brown colour is iron and aluminium sesquioxides and that's because of the interaction between the organic matter in the dark brown layer, near the surface, where we've got 4, 3, 2 and 6 where we've got a very complex horizon where you've got a lot of microbial activity, you've got a lot of earthworm activity, you've got a lot of root growth activity, so that area there is a very dynamic zone. That's the A horizon of a soil.

Q. So the A horizon is largely organic material, the bottom one, was that C, sorry?

A. C horizon.

Q. The C horizon is largely the parent material --

A. That's correct.

Q. -- and the B horizon, in the middle, is influenced by both --
A. That's correct.
Q. -- from beneath it and above it.
A. Yes.
Q. Do I understand that correctly?
A. That's correct.
Q. And again, if you would care to use the technology, might you be able to point out some of the horizons or bands in the urban soil that we see to the right?
A. In the urban soil, we can see that there is a distinct organic layer, circle number 7, and that's where there has been a grassland vegetation growing and that has contributed organic matter in that, also in A horizon, but as we go down you can see the introduction of -- here we've got brick particles and man-made calcite material added in here as well, and then down here we have probably got old drains. But you see, there is not a distinctive horizonation here, it's much more mixed up because there has been digging to introduce utilities to a particular area and that makes this a less distinctive profile, but also a much more heterogeneous profile and much more mixed up than the natural profile on the left.
Q. What do you mean by heterogeneous?
A. It's more variable. It has got many more features

within it. There can be glass, there can be paint, there can be brick, there can be tiny particles of metal, they can all have been introduced by human activity in a city area.

Q. Thank you. Can we move on to the next slide, please. "Locard's Exchange Principle", "Every contact leaves a trace". Can you help us to understand the relevance of this principle to soil science?

A. Dr Locard introduced this quite early on in the development of the forensic sciences and it applies where you've got any trace material that may have been transferred into a scene, or out of a scene, so that includes hairs, fibres, glass, plant material and also soil.

When you've got any two objects potentially coming into contact there will be an exchange of material. By me sitting on this seat today, there will be exchange of my DNA and exchange of my hair, my skin flakes and I will leave it behind on the seat that I'm sitting on today.

I will take out carpet fibres from the floor on my boots. So when there is a contact between a person or an object and another location, then there will be transfer. It's just down to the technology -- in the day when Dr Locard developed it there weren't the

sophisticated techniques in forensic science that there are now, such as touch DNA, or, for example, microanalysis, than there are now, so now there are methods that we can actually characterise and actually show that there has been exchange of material from one to another.

Q. We see from the slide that Dr Locard was born in 1877 and died in 1966. Do you know when, in the course of his lifetime, he first espoused this principle?

A. I think it was in 1910 that it was established as a working principle within the forensic sciences.

Q. And I dare say that forensic science has moved on somewhat in the last 100, 110 years?

A. It has moved on a lot, particularly in the advancement of the techniques that can be used. However, that principle still holds.

Q. So far as soil science is concerned, applying this principle to soil, if a person walked across soil would you expect a transfer of soil onto their shoes or boots?

A. It depends on the type of soil, it depends on whether the soil is wet or dry, it depends on how much soil is exposed for potential transfer. What I mean there is, for example, if a surface is particularly well covered and there is no area of soil that is exposed, then it's very unlikely that transfer will take place.

On the other hand, if there is a shrubbery, a border, and there's exposed soil, then if someone goes through that it is extremely likely that soil will be transferred to the footwear, or in cases where someone has knelt, it could be transferred to fabric as well, to jean fabric, for example, on a knee.

Q. What conditions then are most conducive to the transfer of soil onto footwear?

A. Soil will be transferred, or can be transferred, if particularly soils are composed of clay materials, so clays tend to stick because they are layered in their formation, they are very fine particles within it and particularly if they're wet. So not too wet, but if they've got a significant amount of moisture in it, the mud will stick.

Also if there is a tread on the item of footwear itself, the soil will stick within that tread. Also, if the person -- with the pressure, if they're standing and forcing with pressure then it's more likely to transfer and also the time before an incident occurred, if the footwear is clean, and also the time after, so if someone wears footwear for a long time after contact has been made at a particular place and they have come into contact with other locations, then that can affect the primary transfer onto the item of footwear in the first

place.

So again, there are many factors that can influence that transfer and the persistence of that soil on the item in question.

Q. And in a situation where soil has been transferred onto footwear and the item of footwear comes in contact with a piece of clothing, again, might you expect a transfer to take place?

A. Again, that would depend on the type of fabric. If you've got a piece of plastic such as leather trousers it probably wouldn't transfer very readily. However, if there is a weave to it, then soil is much more likely to transfer to that particular fabric.

If there's pressure then more would transfer than if there's less pressure, so it's all the likely -- the time of contact, so if there is a short time it's less likely that soil will be transferred compared to a longer exposure period to that soil.

Q. Can we move on to the next slide please. This is headed "Methods of analysis in forensic soil science". If you are asked to analyse a sample of soil, what methods of analysis are available to you?

A. In our laboratories we are fortunate in that we have a whole range of potential different techniques that we can use. We can use colour, spectral colour, we can use

infrared, we can use XRF. We can use -- for example, in the foot here, we've got "X Ray Diffraction" which gives us the mineralogy which reflects that of the parent material.

We can look at gas chromatography, which we've got here -- I don't think the pen is -- there we are, sorry.

We've got a profile which tells us how much of each individual organic compound we've got in a soil and the x-ray diffraction tells us how much of a mineral that you've got within a particular soil and then we've got elemental composition that we can quantify, we've got the biology, the microbial profile we can also quantify, we can also look at the organisms within the soil and we can also use -- we use microscopy, whether that's macro lenses right through to light microscopy, to scanning electron microscopy, when we've got very small samples.

Q. So it's not a one-size-fits-all test every time a sample comes into your lab. You will have a range of options open to you, where you can look at the inorganic composition of the soil or the organic composition, or the biological elements within the soil.

A. And as part of the sample handling protocol, one of the first things to do is examine the sample without touching it, so visually examine it to ascertain what would be the most appropriate methods to choose in that

particular investigation and it very much varies depending on the size of the sample, the condition of the sample, the length of time the sample has been stored, a whole range of factors will help us decide which of the methods that we would suggest to the investigator to use.

Q. So again, it's not a one-size-fits-all, you will start by looking at the sample with the naked eye, with the benefit of a microscope of one sort or another --

A. Yes.

Q. -- and then you will determine which are the most appropriate analytic methods depending on the sample type that you're dealing with.

A. That's correct.

Q. And you mentioned a number of different factors being relevant to your decision as to what analytical methods to use, one of which is the size of the sample.

A. That's correct.

Q. Why might the size of the sample have a bearing on what type of analysis you can carry out?

A. Ideally, if you have a sample that is a thimble full size then you can then run a couple of independent methods, so that you can characterise the inorganic and the organic and it's akin to corroboration because if you can show that two samples are indistinguishable,

using inorganic and organic, it increases the evidential strength of any potential link that that is being tested and the more you have, the more methods that you can apply to give you greater confidence that you are coming to the right conclusion that a sample has likely shared a common origin with another particular sample. So the ideal situation is to have a large sample, about a thimble full size and then you would apply probably a combination of quantitative methods to compare those two samples.

Q. But if you only have a very small sample might you be more limited in the range of options that are open to you?

A. Yes, that is correct. If you have a very small amount of sample that really requires microscopy to identify it then you are limited in which techniques you can use.

Q. So size is one consideration. Is the place that the sample came from, if that is known to you, is that also a relevant consideration when you're determining which of the range of types of analysis to carry out?

A. Yes, that is correct, because if a sample is embedded in fabric then you have to consider what is the best approach to recover that sample, because if you can imagine if you've got a very small sample on a woollen jumper and you try to brush it off, most of that soil

would adhere to the brush that you have used to take it, so you have to consider as well, what are the most appropriate methods to recover the sample, as well as what will you subsequently do with that sample once you have recovered it, to analyse it.

Q. Can we move on to the next slide, please. Now, there's a lot of information on this slide, Professor, but we see at the bottom that this is:

"[An] approach to examination and analysis of forensic soil adapted from ENFSI ... Best Practice Manual for the Forensic Comparison of Soil Traces."

So, I want to begin by asking you, what is ENFSI?

A. It's the European Network of Forensic Science Institutes, so it's laboratories where they carry out forensic work, have set up this group in Europe to share best practice and to develop protocols so that the standards are high across all these collaborating institutes. So most of the countries in Europe are members of ENFSI and within ENFSI they have individual working groups on specific topics. So, for example, there's a fibres working group, there's a DNA working group, there's a crime scene working group and the one where I'm on the committee of is for animal, plant and soil traces working group and myself and five other forensic soil scientists, from 2017 to 2019, carried out

a review of what were the best procedures to deal with soil if they come into a forensic laboratory and we wrote this best practice manual, which is openly available on the ENFSI website and it lays out -- and apologies for the complexity of the diagram, but, however, it is divided into four main stages and those are the guidelines that we recommend that any forensic soil scientist carries out when they're working on a forensic case.

Q. Thank you. We will look at the four stages in just a moment. Before we do that, you explained that you were effectively involved in the creation of this manual through your working group.

A. Yes.

Q. You were one of six, I think you said.

A. That is correct.

Q. From across Europe or from within the UK?

A. I was the only member from the United Kingdom. Somebody from the Netherlands forensic institute, somebody from the German police, from Latvia and Spain. So collectively representing a range of countries across Europe, we met over a period of two years and carried out research and the objective and we published and submitted this, through quite a rigorous submission procedure, this guideline for handling of soil samples.

Q. And the purpose of this guideline, you explained, is to at the time minimum standards in laboratories across Europe.
A. That's correct.
Q. What is the status of this manual, these guidelines? Are countries obliged to follow the guidelines, or are they simply guidelines for best practice?
A. Because different countries across Europe operate in different legal systems, they can't be prescribed operating procedures, but they're good practice guidelines and if a laboratory was not adhering to good practice guidelines then it's extremely likely they wouldn't be allowed to carry on operating.
Q. Okay. As you have said, Professor, there are four stages and I wonder whether we might take a little time to look at each stage in turn and I will begin by asking you just to explain stage 1. How do you go about the process of examination? And I may then have a few further questions about that stage before we move on.
A. The first stage is an iterative process with whoever is requesting the work to be carried out, so making sure that the case question is well-established and to identify the item and to identify where the soil is adhering to the item that one is being asked to look at, look at that within the questioned item and also

consider where there would be reference material that you could compare that questioned soil with. So, at the particular alleged location, where the transfer had taken place, it would be to compare that with that particular location by sampling that location in an appropriate manner to represent it.

Air dry the samples, sieve out any stones or fragments of vegetation and then, at that stage, as we said just previously, looking at it under the magnifying lens and under the light microscope, decide what is the most appropriate method of analysis to carry out for that particular sample. Describe it, recover any pieces of botany, get them identified, any artefacts, glass, bits of pottery, bits of plastic, all these sorts of things, plus hairs and fibres, they're all recovered into separate production vials and they are submitted to the relevant scientist to do any work at that stage.

And then, at stage 2 --

Q. Sorry, before we -- can I ask you a few more questions about stage 1 if you don't mind, before we move on? I want to be absolutely clear about some of the language used and I see on the chart there's a reference to something called a "case question". Can you help me to understand what a case question is?

A. So when a forensic soil scientist is working with an

investigating authority, the case question could be "Could that soil have come from this particular location?" Or the question could be "Can you tell us where that particular soil came from?" For example, in the case of a missing person, so that would be the question: "Can you tell us as quickly as possible where that soil on that item might have come from?"

Q. I see, so the case question is, essentially, the question that you're trying to answer as a forensic scientist?

A. That's correct.

Q. You also mentioned -- and again we see this on the slide -- "question sample" and "reference samples". Can you help us to understand what they are?

A. So, the questioned or unknown sample would be the sample on a spade, a pair of boots, or on clothing where you do not know the origin, the origin of that sample is in question.

On the other hand, you get a known, or a reference or a control sample and that's where you know where they come from, you know they came from under that oak tree, or you know they came from the garden at the front of the house. You know the location and they can be given a reference and they can be compared with the question sample and the characteristics of that unknown sample

compared with all the known samples and all those known samples, with the meta data, are kept within the databases so that you can then ascertain for that question sample if you're asked to say where does it come from, you can say "Well, it shares the characteristics of all the pine woodlands on granite parent material that are near to a river". So it helps you ascertain about the questioned sample what would be the likely attributes and where it likely came from.

Q. So in some cases your task might be to identify possible locations, source locations for a soil sample, a questioned sample, and in other cases your work might be more comparative, you're comparing a questioned sample to known reference samples?

A. Yes. The one question is helping in search to identify location and the other part of the work we do is the trace evidence comparison, so comparing a questioned sample from a questioned item with either another item, or with a particular location.

Q. And at the beginning of your evidence where you discussed your involvement in the Sinclair and the Halliwell cases, might they be examples of the latter type of work, of comparative trace analysis work?

A. That is correct.

Q. Let's turn to stage 2 now and, again, can you please

explain to us what happens at stage 2, "Analysis of case samples"?

A. So at that stage, when we're clear in our mind what the question we're trying to help the investigating authorities with and when we're clear what type of soil, is it a sand, is it a peat, is it somewhere in-between? Is it an urban soil, is it a rural soil? How much of it is there? How long it has been kept, if it's in a single clod, or is it fragmented? All these things then help us try and decide what is the best method to use to characterise that soil and to compare it, to help answer the case question.

And for that, if we've got the ideal amount, such as a thimble full of soil, we would split the sample. We would keep a portion back so that there was an amount that a defence scientist could look at it independently and keep that to one side and then split the other part, ideally in two, so that we can look at the inorganic characteristics of that soil and, independently, the organic characteristics of that soil.

Q. You explained earlier in your evidence that when you have a very small sample to work with you might be very limited in the number of analytic methods that you can employ and is that precisely why: because you need a separate sample for each analytic method?

A. Yes, that is correct.
Q. And, as you explained earlier, there are both inorganic analyses that you can carry out, as well as organic analyses, in addition to a visual examination of any soil sample.
A. Yes, that's correct.
Q. Let's move on to stage 3, "Comparison of results". Can you talk us through this stage of the process?
A. So, the middle box here where there's a comparison of the different methods, so here we've got two independent methods and we see if they are showing us the same relationship between the questioned sample and the known sample and we also, to the left of that box -- forgive me, I don't --
Q. I think the technology might work better with your finger. I think.
A. Oh, yes, thank you. That is then the stage of comparing the results that we get between the two samples that are in the case context with what we have also got in databases and applying statistics to that data, so that we are independently assessing the relationships between the questioned and the known samples and also putting it in the context of past experience of previous casework of transfer and persistence and then assessing whether the results are suitable for being presented to

the court, or in some cases it's just insufficient material and we have to report back and say "We couldn't get any results on the organics of this sample, we therefore -- we cannot say there's a relationship between these two or not."

Q. I think that takes us to stage 4, "Evaluation of evidential value of the comparisons and [forming] an opinion". Can you explain this stage to us?

A. So, stage 4 is in the context of all those exterior influences, the fact of transfer and persistence, the moisture conditions, the texture of the soil, how long a person had been wearing a pair of footwear before the incident, how long they were seized, so were they immediately seized, or was there a long period after the incident that someone wore a particular pair of shoes, or clothing, or wore an item of clothing for a longer period of time? That would all affect the interpretation of your comparison of those traces.

Q. Sorry, can I interrupt you there, if I may, I'm so sorry, just to ask: why might these things matter? Why are they important, how long you have carried on wearing an item, for example?

A. Ideally what you want is a single source sample, so to put that in context, if you have a footwell mat of a vehicle, there will be a mixture there and in the old

days they used to hoover up that sample and that would be a single sample, but that is never going to be comparable with a reference sample from a particular location because it's a mixture and if you get a multiple mixture it will have a different analytical result to a single source sample. So what we do is we take individual peds, so individual aggregates, so they are discrete parts of soil that are held together by the organisms in soil, single source, so they are more likely to represent that individual location rather than being a mixture where that's much lower evidential strength of a comparison. So that's the reason that we carefully sample, to try and get as much as possible that single source sample from a questioned item, and consider also whether if someone has walked a particular location and they have walked to three other locations after that, you have to be very careful to recover the stratigraphy of that soil on the footwear to represent those three different locations, so the ideal thing is to seize an item, a questioned item, almost immediately that transfer has occurred, so that you get that distinct single source sample.

Q. Going back to the example that you gave of a footwell in a car and in the old days you would take a hoover and hoover up all the soil, you said that would be a mixed

sample. Why would that be a mixed sample?

A. Because the person who had been driving that car had likely been to several locations after the time that the footwell mat was cleaned and material would have fallen off the footwear from these multiple locations and all of that will have fallen in that footwell mat, got mixed up and then that single hoovered sample would represent probably more than 20 different locations where the person had carried soil. Primary contact with the location, secondary contact with the feet on the footwell mat.

Q. And potentially could there also be soil that pre-dates the incident with which you might be concerned? Could there possibly be -- I suppose, depending how often one cleans one's car -- years worth of accumulation of soil in the footwell of a car?

A. Yes, that is correct. It's the time pre-event, the event date itself and post-event that can affect the integrity of that particular sample.

Q. Looking at the list of factors where you have put the circle with the number 3 on it, I think we have spoken about the time between the questioned item -- sorry, the time before the questioned item is seized. There are other factors listed there which it might be interesting to ask you about: "Transfer and persistence", we have

touched on that already, but could you say a little more about transfer and persistence and its relevance at this stage of your analytic process?

A. So when you're interpreting your results, it has got to be done in the context of that transfer event, so when the material likely transferred from one to another using the Locard Exchange Principle, so an item -- the soil transfers, let's say, to an item of footwear. If someone walks on a hard surface for a considerable length of time after that transfer then the material will not persist, a lot will fall off.

Also if that material is of a coarse grain nature it will fall off more readily than if it's a fine textured material which will stick and dry on the item and is less likely to fall off and also if there's tread then the material can get embedded in the tread and persist, despite someone walking over a hard surface, so there's all the combination of factors that can affect how much and the integrity of the sample that's on the particular item in question.

Q. Returning to that list, there's a reference to weather and soil conditions. Again you have touched on this already. Is there anything that you would wish to add in relation to the relevance of weather and soil conditions at this stage of the analytic process?

A. So the important things, or the main things here is the areas of exposed soil, the fact that if soil is fine textured then it's more likely to transfer and also if it's wet, so it's sticky, so I'm sure we have all experienced going out for a walk after it has been raining and we come back and our feet are muddy, but if you go out and it's dry, you're less likely to get dry, dusty soil transferred to your feet.

Q. "Time" we have spoken about and the final factor in the list there is "case circumstances". What would those be?

A. So that's the information that you have been given in terms of the case context, so how many people were involved? The date, the time of the incident, so had it been raining prior to the particular incident? What was the environment at the location like? All those case contexts, so: how many people involved? How long the people were in contact? The time of day, all those external factors and also, as we have said, the context of when the items were seized and whether there was likely a single source sample, or anything that could relate to the evaluation of the comparison between the trace material.

Q. Before we move on from stage 4, to the right-hand side of the slide there's a box that reads:

"Interpretation of results in context of hypothesis of investigation and consider alternative hypotheses."

What does that mean? What does that involve you doing?

A. Because soil science is not categoric, it's probabilistic, so that we cannot say with certainty, because soils -- they are not -- it's not like an individual. Soils are not individual; they vary and they all relate to each other in multiple ways. So it's probabilistic, if a soil is likely to have come from one place and one also has to consider, is there an alternative proposition that it could have come from another location? So it's not only the case proposition that should be a test hypothesis, but there should be an alternative hypothesis as to where that particular soil could have come from.

Q. And finally, in the bottom right-hand box, should we understand from "conclusion", "opinion", "report" and "court", that all of these stages, 1, 2, 3 and 4, ultimately result in you reaching a professional opinion which you express in a report and then, potentially, you are called upon to give evidence to and to speak to your report?

A. That's correct.

Q. Thank you. Can we move on to the next slide please,

"Factors that influence the use of soil in forensic science". Some of these we have touched on already, but I wonder if I could just invite to you talk through each of the factors and if there's anything further that you might wish to say as to how they influence the use of soil in forensic science.

A. So this diagram was adapted from a publication about forensic pedology, pedology being soil science, and looking at it in the context of soil trace evidence. As we said, the characteristics of soil, so whether the soil is sandy, or clayey, organic or not organic, that will all affect whether the soil will transfer to an item or not.

External factors such as: are there exposed surfaces of soil where the soil can readily transfer, has it been raining recently, is the soil muddy, will it then likely transfer? Has there been sufficient force and time of contact to allow that soil to transfer? Is the contact material of a sufficient nature that that soil will be able to be transferred? And have the items been seized rapidly enough after the incident that the trace does not degrade and that you have still got confidence that it has got integrity?

And understanding that period of transfer and how long it's likely persisted, that you've got enough

material that you can compare with any other material, such as reference samples. And then, ultimately, that will impact on the size of that sample and that will then impact on the investigation, as to what analytical techniques are then most appropriate to use on that sample.

Q. Professor Dawson, I want to move on now to ask you some questions about the work that you were instructed to carry out by the Inquiry.

I wonder, Ms Kell, if we could jump to slide 12 please. There is one slide that I would like to take out of sequence. So, here you set out the Inquiry request:

"To recover and carry out trace evidence analysis and comparison of traces from a police vest worn by PC Nicole Short, with traces from two pairs of boots; one pair worn by Mr Sheku Bayoh and another pair worn by PC Craig Walker in the early morning of 3 May 2015."

Now, we have referred already to your letter of instruction. We don't need to put that on the screen, but it's dated 27 July of this year and in that letter of instruction, Professor, were you made aware that the Inquiry had been set up to examine the events surrounding the death of Sheku Bayoh, who died on 3 May 2015 after being restrained by police officers in

Hayfield Road in Kirkcaldy?

A. Yes, that's correct.

Q. Were you made aware that the Chair will require to determine whether Mr Bayoh stamped on the back of a female officer, PC Short, as she lay on the ground?

A. Yes, that is correct.

Q. And were you, therefore, asked to examine her vest and Mr Bayoh's boots for the presence of soil?

A. That's correct.

Q. And to compare any soil found on the vest with any soil found on Mr Bayoh's boots?

A. That's correct.

Q. Further, were you made aware that a suggestion had been made that Constable Walker might have stood on PC Short and so you were also asked to examine Constable Walker's boots and compare any soil found on the vest with any soil found on his boots?

A. That's correct.

Q. Before we look at the items that you were asked to examine and discuss the work that you carried out, can I ask you, did you come back to the Inquiry and request information as to the route taken both by Mr Bayoh and Constable Walker in order to get to Hayfield Road on the morning of 3 May?

A. Yes, that is correct. That is to understand the context

of the potential transfer of material to either Mr Sheku Bayoh or PC Craig Walker on that particular occasion, that's getting as much of the case context that allows me to carry out the work.

Q. And were you advised that Mr Bayoh had walked from Arran Crescent to Hayfield Road?

A. That's correct.

Q. And that Constable Walker had been on mobile patrol when he was asked to attend Hayfield Road and that he drove there?

A. That's correct.

Q. Did a colleague of yours, a Professor Miller, prepare a map of the assumed route that Mr Bayoh took on 3 May from Arran Crescent to Hayfield Road.

A. Yes, Professor Miller prepared that map, that's correct.

Q. I wonder whether we can look at that. Can we jump back please, Ms Kell, to slide 9. Is this the map that Professor Miller prepared on your behalf?

A. That's correct.

Q. Let's take a few moments to look at it. We see -- and again it may be that you can assist us with the touch-screen technology, but we see Arran Crescent towards the top left-hand corner of the screen and we see Hayfield Road towards the bottom right-hand corner of the screen.

There's a legend at the bottom of the map and we can see that the yellow line, the bold yellow line, denotes the assumed route taken by Mr Bayoh and his direction of travel is marked with black arrows.

A. That's correct.

Q. We see that the map is to scale and you have recorded that the total distance of the assumed route is 0.69 kilometres.

A. That's correct.

Q. The legend tells us that man-made surfaces are those marked in grey, so what would man-made surfaces include?

A. Those would be pavements and tarmacked areas, so the road surface, or the pavements, or factory areas that are -- a solid surface of a footprint and those are areas that are in grey, and the houses are multiple uses, so such as the footprint of a house and its garden area.

Q. And they are in a sort of creamy yellow colour?

A. That's correct.

Q. The legend also tells us that natural surfaces are shown in green. Can you help us to understand what is meant by "natural surfaces"?

A. These are the landscaped areas in the Kirkcaldy area, so the areas in green are either grass, or soil, or borders, or trees, so they're landscaped by the city to

enhance the green space in a city. You can see the green areas, it's quite a bright green area, and there is grass and exposed areas along that route for much of the route, along Templehall Avenue which is here, but in particular at and around the Hayfield Road junction there's a considerable amount of surface area which is of natural category.

Q. It is stated at the foot of the map:

"Edges of the assumed route which was likely walked by Mr Sheku Bayoh in 2015 contained [approximately] 60% natural cover for potential exposure to natural surfaces."

60% natural cover, does that mean that 60% of the assumed route was bordered by natural surfaces?

A. That's correct. My colleague, Professor Miller, calculated the per cent of that assumed route -- we can't know the actual route, but on that assumed route 60% of the adjacent material -- land was trees, grass or bare soil.

Q. That calculation was carried out by your colleague --

A. That's correct, yes.

Q. -- on your behalf.

This map is copyright 2021 and am I right to understand that you went on to compare the map with Google Earth images from 2015 and from more recently?

A. That is correct. My colleague, Professor Miller, who is a geographer, prepared these maps for me.
Q. Let's look at slide 10 please, the next slide. So this is an image again showing Templehall Avenue, Hendry Road and Hayfield Road from 7 September 2015 from Google Maps --
A. That's correct.
Q. -- and, again, we can see green areas. Would it be reasonable to assume that they are trees, grass and other natural surfaces?
A. Yes. The sort of bright green areas there, that's a grass ward(?) so that's been planted amenity grassland, for example, and the darker green here, you can see the trees at the site of the incident and they are the darker green rounded, that's looking down at it from above with the canopy of the tree and you can see those in that area, at and around the site of the incident.
Q. Having examined this image from September 2015, how does this fit with your colleague's assessment that approximately 60% of the assumed route was adjacent to a natural surface?
A. That calculation still holds.
Q. Can we move to the next slide, please. This is the same image, but from September 2021.

A. That's correct.
Q. What was the purpose of considering more recent imagery?
A. The reason for considering more recent imagery was to ascertain if there had been any changes since the material time, because if -- when looking at the particular area, it's important to see trees -- where the trees were, would they still have been there at the time and any changes to that landscaping from that period to present day.
Q. Did you note any changes to the landscaping between 2015 and 2021?
A. There was an additional path that had been -- hard-standing path, that had been put in from Hendry Road to Hayfield Road, across triangular track from -- hard-standing had been put in by the Council. But, if I may --
Q. Please.
A. I think the important thing being that when I went to the site to have a look at it for potential contact locations, these mature sycamore and cherry trees, they were still there in 2015, so -- and as was the herbaceous border which is at this corner here, at the very corner of Hayfield Road and Hendry Road. This herbaceous border where there was exposed soil, it was also there in 2015.

Q. You mentioned having gone to the locus, so let me ask you some questions about that now. I understand that you visited Hayfield Road last month, on 17 November.
A. That's correct.
Q. What was the purpose of your visit?
A. The purpose of the visit was to actually see for myself what that environment was like. Were there areas that soil could have transferred to footwear or clothing at that particular location? It may have been changed, it may have had a total cover of landscaping, it may have been tarmacked over. All these things are important to consider. Were there areas around the trees that had bare soil? You can't see that from photographs. You have to go and see for yourself and what I was also wanting to do was geo-reference the large trees, the mature trees that are there to see if they were there and, indeed, the main trees were all there in 2015 that were currently there in 2022.
Q. Okay. The trees that you're talking about, where are the trees? Again, if you could perhaps use the circles.
A. Well, there are trees up Hendry Road, so about where the "3" circle is. Those trees were there in 2015 and all the border of trees that comes down here, so marker 1, there are three mature trees along that edge of the road and here, at number 1 there now, there's a herbaceous

border where there are shrubs grown and the shrub area was still there in 2015 and it had large areas of exposed soil.

Q. What allows you to say that the mature trees and the shrubs were there in 2015 when your visit was in 2022?

A. By comparing the imagery. So go back -- the 2015 imagery that was taken, aerial imagery in 2015, you can geo reference and see the same trees that were there.

Q. I see. And visually, did the trees appear to be of such maturity that you would have expected them to have been there for some time?

A. And the estimation of the age of the trees, these were trees that were over 100 years old, so that I could ascertain that while I was there in 2022 they must have been there in 2015.

Q. And that fitted with the geo-matching work that you did --

A. That's correct.

Q. -- and the Google Earth images. And what type of trees were they?

A. They were sycamore and cherry and some birch trees.

Q. You have described their locations and clearly at the time of your visit, you visited Hayfield Road, did you walk the entire length of the assumed route, or did you simply visit Hayfield Road?

A. I walked along Hayfield Road and I walked up Hendry Road and along Templehall and then I went back and got my vehicle and drove the rest of the way. I didn't want to walk outside, respecting the home, at Arran --

Q. Of course, in Arran Crescent.

You have described seeing mature trees and shrubs and there being areas of bare soil, in particular where you have marked circles 1, 2 and 3 on the Google Earth bird's-eye view. The soil that you saw, can you characterise it at all? I appreciate that you did not take samples and you didn't analyse the soil, but visually can you tell us anything about the soil that you saw around the area of Hayfield Road?

A. And admittedly it had been raining quite heavily before I visited and actually during my visit. However, I could see that the areas -- there were significant areas of exposed soil and I'm aware that the area around the bus stop had been changed during that time, with further road movement and change. However, at and around that area, there were considerable amounts of exposed soil, bare soil. Now, I can't say that that would have been there in 2015. However, the areas that were at the edge of the road, at about the circle number 2, all that area had bare soil at the border, so the herbaceous border where it's not covered over and

there are significant amounts of soil exposed and there were exposed areas around the mature trees, so the circumference where herbicide is probably sprayed to avoid competition with the trees, that was bare soil, it was muddy, it was quite fine textured. So looking at that material I would say that, certainly in 2022, those areas would be conducive with transferring to anyone walking on them.

Q. Now, no samples were taken back in 2015 and you explain in your report that it was not standard procedure in 2015 for soil samples to be collected at the scene of an incident such as this. Has the standard procedure changed since 2015?

A. It probably would still be the same, if it was a similar situation, that it's unlikely that soil or vegetation would be collected.

Q. Did you take samples at the time of your visit last month?

A. No. I was not instructed to take any samples at all and having discussed it with counsel, it was decided that because there could be so many changes that could have happened in the period between 2015 and 2022 that any reference samples -- they might not represent that soil because all the influence of additional fertiliser, additional pesticides, all the vehicles that would have

transferred and travelled -- it must be thousands of vehicles that potentially would have transferred and travelled over that road surface, that any reference sample taken from the road would be not -- would not be representative of that road in 2015.

Q. So should we understand that, in your view, there simply wouldn't have been any value in taking samples now?

A. Because of this -- no value because of this potential of change that would have introduced to those reference soils over time.

MS THOMSON: Sir, I'm mindful of the time?

LORD BRACADALE: Yes. We will take a break for 20 minutes at this point.

(11.32 am)

(Short Break)

(11.55 am)

LORD BRACADALE: Now, Ms Thomson.

MS THOMSON: Sir.

Professor Dawson, before the break we were exploring whether there would have been any value in taking any samples from Hayfield Road now in 2022 and you offered the view that there wouldn't be any value because of the changes over the intervening seven years and because people have driven along the road and presumably walked along the footpaths and so any samples would likely be

materially different.

You also identified earlier in your evidence that there has been a change to the hard standing path that cuts the corner at Hayfield Road between 2015 and 2022.

A. Yes.

Q. Might the replacement or repositioning of that path have brought about some degree of change to the composition of the soil in that area?

A. It's unlikely the path itself would have affected the already established areas of borders and grassland, apart from the area just adjacent to that new path which would have been dug up as part of its construction.

Q. But for the reasons you gave before the break there wouldn't have been any value in taking samples at seven years' remove?

A. There would be limited value, unless you were wanting to actually identify where soil could have transferred and that would have to have involved an extensive amount of sampling across all potential locations of potential contact.

Q. One matter I want to ask you about before we turn to the work that you carried out on behalf of the Inquiry. We discussed Locard's Exchange Principle this morning and I ought to have asked you at that time about the concept of secondary transfer. Can you explain to us what is

meant by secondary transfer within the world of forensic science?

A. So when an item is transferred from, let's say, an exposed area of soil to the sole of an item of footwear, that is a primary transfer, so from the location to the item.

Now, if that person that's wearing those items of footwear go into a car to drive that car, there's secondary transfer from the soil from the sole of the boot to the pedal, then if we recover soil from the pedal, that is a secondary transfer trace, or indeed the soil we talked about that's in the footwell is likely by secondary transfer, so primary from the scene to the boot, secondary from the boot to the footwell or the driving pedal.

Q. You spoke earlier in your evidence about the importance of the passage of time in terms of the time that may elapse between a transfer taking place and the questioned sample being seized and submitted for analysis. From your perspective, may we take it that the sooner the better in terms of recovery of samples?

A. Absolutely. The period of time from when a transfer has taken place and recovery into an evidence bag should be as short as possible.

Q. The Chair has before him evidence that the lady officer,

Nicole Short, left Hayfield Road in a car to go to hospital where she was examined by a doctor and there's evidence that she required to remove her clothing, including her vest, for the purposes of that examination.

She then dressed and was taken again by car to Kirkcaldy Police Station where she went to the canteen along with all of the other officers who had been present at Hayfield Road.

Within the canteen, the vest was taken off and left lying on the floor and was not recovered until some hours later. From your perspective, is that an ideal set of circumstances, or less than ideal?

A. It depends what information is known about what has happened to that item in that intervening period and whether there was any opportunity for transfer and if we look back onto what allows it to transfer, a casual brushing past would not allow the transfer of that -- those particular trace material on the vest, it requires an element of force to get soil material, so if there was a period and there was information that there had been an alternative route of contact with some degree of force of material to the vest, then we cannot exclude that period as being a period when material transferred to the vest.

Q. And leaving secondary transfer to one side, from the point of view of preserving the integrity of the vest, was the journey of the vest and the passage of time between the alleged incident at Hayfield Road involving Constable Short and the vest being seized some hours later, from the point of view of the integrity of the vest was that ideal or less than ideal?

A. The minimum time period again for the integrity of the item is the shortest period at all possible and to have that being witnessed so that the least could have occurred to that questioned item in the intervening time, that's the ideal situation.

Q. I want to move on now to ask you some questions about the work that you carried out at the request of the Inquiry. Am I right to understand that at no time since 2015 had you been asked by the police to carry out soil analysis on items from Hayfield Road?

A. I was never asked to carry out work by the police for this, no.

Q. Nor were you asked to carry out work by the Police Investigations and Review Commissioner?

A. No.

Q. Nor were you asked to carry out work by the Crown?

A. No.

Q. So the first and only request for any such analysis came

from the Inquiry?

A. That's correct.

Q. Can we return to the PowerPoint please, slide 13. I should begin by asking you to look at the vest itself and to confirm that this is the vest that you received and examined.

A. Yes, that is the vest.

Q. On slide 13 we see two photographs of the vest. The left-hand photograph was taken after the incident in May 2015 and the right-hand photograph says "PC Short's vest from 2022. Photograph taken at Cellmark Forensic Services."

Now, we may hear that Cellmark carried out an analysis of a possible treadmark on the vest and that work was carried out before your own analysis and this photograph was taken at the Cellmark lab.

I wanted to be clear that I understood why it was important for the Cellmark analysis to be carried out before your work?

A. In any investigation where there involves multiple forensic sciences then it's very important that they're done in the most appropriate sequence of analysis and in recovery of soil, so the part that I would take to recover the samples that I was to look at, involves removing it, so removing soil or any other trace

material from the vest, so that would -- that would mean that any potential mark would be affected by the removal of the soil, so -- on the other hand, it wouldn't affect my recovery at all, the work that would be done to examine the trace. So the priority order was the examination of the marks and then recovery of the soil.

Q. And if you had done your work first is there a possibility that that might have got in the way of Cellmark's own analysis?

A. It might have affected the quality of the marks that they were to examine.

Q. When you examined the vest did it look as it does in the right-hand photograph, the one taken at Cellmark's laboratory in 2022?

A. Yes, that is correct.

Q. What is the black staining all over the vest?

A. We believe it to be fingerprint powder and chemicals used to extract and recover any potential finger marks from the vest.

Q. How did you go about your examination of the vest?

A. So it was a joint examination. I went down to Cellmark Forensic Services laboratories in Chorley. I have worked with them before on several cases in England and Wales and in their laboratories they've got multiple forensic laboratories where it can be absolutely

guaranteed that no two items come into contact, so there's no potential risk of contamination from one item to the other and this examination was done -- Paul was also there, Paul Hargreaves, so that he looked at the vest first, opened it up in one discrete laboratory and myself and a forensic laboratory examiner, we then both went in to to look at it at the time when Paul had taken it out of the evidence bag on the bench so that we could look at it before anything was done, without touching it. However, we then completely changed our clothing, it's strict protocol that they adhere to in the forensic examination of the items, and then after Paul had done his work then we went back and did the examination of the vest following strict, again, protocols for examination of forensic items.

Q. So do you begin with a visual examination of the vest?

A. It initially commences with photography so that you record everything before anything is done to the item, inside first of all, inside back, inside front, the sides, the top, and then to do on a separate sheet the outside of the item, so all parts of an item are examined separately and then described and at that time decide on a strategy for sampling, before any sampling is done, and so we looked at it, described it and identified areas where there potentially were soil

traces still adhering to the vest.

Q. Where were those areas?

A. The -- there were three areas. One here (indicating) at the lower edge -- so this is the back, right-hand side of PC Short's vest, at the top of the silver reflective strip, so at the boundary between the silver strip and the lower yellow fabric there was what appeared to be a strip of soil material.

Then at the top of that same strip there was also a discrete portion which, with magnifying lenses we saw there was what appeared to be substrate-like soil.

And the third one was on the actual yellow fabric and that was the one that looked most soil-like, it looked the best trace of the three that could possibly be soil material and that was part of -- if you look at the image on the left, before any fingerprint powder had been applied, that was part of the trace that you see that stands out with the dark colouration here.

Q. So the three areas that you identified as having possible soil present fit within the print, if you like, or the shape of the mark that we see on the left-hand photograph?

A. Yes, and indeed the -- there is areas there you can see the same three areas that we identified in 2022 were there in 2015.

Q. If we can remove the circles, please. The mark that you have drawn to our attention that we see on the back of the vest in the 2015 photograph is less readily apparent in the 2022 photograph.

A. That's correct.

Q. Can you help us to understand why?

A. I think the main reason would be this application of the fingerprint powder and anything that was required to remove the fingerprint powder to obtain a trace for examination of the finger mark, so that it's additional to any marks, plus any removal and I'm not sure if it was tape lifts or how they recovered the marks, but any of that process will likely have removed some of the material that was there in 2015.

Q. So how readily were you able to see such material as still remained on the vest in 2022? You mentioned using a magnifying glass.

A. Yes. We had to use a hand lens to go over the whole of the fabric to find any areas that had potentially soil on them and you can see in the right-hand image that -- I can't really point, but if you look at the triangle between the upper right-hand reflective material and this right-hand -- if you look at the junction in this very centre there at number 3, you can see there that the same shaped marks with three or four ridges,

three or four marks, are the same three or four that are there in 2015, but much fainter --

Q. Much fainter?

A. -- and not so obvious.

Q. Would your job have been easier if the vest hadn't been stained with fingerprint powder?

A. Yes, absolutely. We did look at and we had in our possession the photograph that was taken in 2015 and that helped us relocate these potential stains.

Q. Can we move on to the next slide, please, and here we see the three areas that you described a moment ago using the circles, where you identified potential traces of soil on the vest and you have called them area 1, which is at the bottom of the silver band; area 2, at the top of the silver band; and -- thank you, area 3 is on the yellow fabric itself, just above the silver band.

A. That's correct.

Q. And all of these areas are to the back of the vest, right-hand side, beneath the armpit?

A. That's correct.

Q. Did you notice soil deposits anywhere else on the vest?

A. No. We thoroughly examined the vest inside and out and we also examined the evidence bag itself because sometimes if trace material falls off items, that can end up in the inside of the evidence bag.

Q. And was there any trace material in the evidence bag?
A. No.
Q. Can we move on to slide 15, please. What do we see here, Professor?
A. This is a magnified image of the same part of the right-hand side of the back of the vest and it's showing in greater magnification the three individual samples where we recovered material from the vest.
Q. Can we move on to the following slide, slide 16, and again, what do we see here?
A. Again, this is with enhanced lighting, but you can see this is the area 1 at the lower end of the fluorescent strip and that was area 1.

Moving up, at the top end of the silver strip this was area 2, and on the yellow fabric of the right-hand side of the back of the vest, this was area 3.

Q. The little red or orange triangles, are those just the tips of the pointer markers shown under the microscope?
A. That is correct.
Q. Moving on to slide 17, please. What do we see here?
A. That is the magnified image of area 3 and again, as you say, the red triangle is the tip of the marker for area 3 when we took the photograph under the microscope.
Q. So this is area 3, it's the top-most of the three areas, so this is the yellow fabric of the vest rather than the

silver band.

A. That's correct.

Q. Can you describe the appearance of the staining that you see here?

A. It was light brown in colour. It was of a fine textured appearance and it was embedded within the weave of the fabric.

Q. So the sample was ingrained then, rather than superficial, would that be correct?

A. That's correct.

Q. And can you draw any conclusions as to the nature of the transfer where soil is ingrained or embedded rather than lying superficially on a surface such as this?

A. If it's superficial, it would likely fall off. If material is embedded in fabric then you get that retention of soil within a fabric-type of material.

Q. Can we move on to slide 18, please. So this is area 2, the middle most of the three samples and this is the top edge of the yellow strip, is that correct?

A. Yes.

Q. And can you describe the appearance of the staining here?

A. This was recovered, it was sampled, but it had a different colour. It was much darker brown and coarser in appearance to the one on the yellow fabric.

It looked more superficial than embedded.
Q. And this was on the silver high visibility strip --
A. Yes.
Q. -- on the back of the vest.
A. That's correct.
Q. Are you able to say what that strip was made from?
A. It's a reflective plastic-type material for its fluorescent purposes and it's much smoother in composition than that of the fabric.
Q. Are you able to comment on how readily or otherwise soil will adhere to a surface of that type?
A. Soil would not persist on such a type of material as readily as it would to a weave of a material like the yellow fabric.
Q. Can we move on to the next slide, please. What do we see here?
A. That is area 1 at the lower edge of the silver fluorescent strip and you can see a little bit of the yellow fabric beneath it and that had some appearances of fine textured brown material, but it also had some of this darker material also in it and it looked as if it had been wiped or something. I don't know, but there was certainly a difference to the immediate appearance of this one as well.
Q. Can you describe what it was that caused you to think

that the appearance was suggestive of it having been wiped?

A. It's this sort of regular appearance at the top, or there's a strip that is above the deposit that appears like something has been there that is no longer adhering to that fabric.

Q. And again, this was on the high visibility plastic-coated strip?

A. Yes, that is correct.

Q. Can we move to slide 20, please. Can I ask what quantity of soil was present on the vest?

A. All of the three trace stains were very small, they were trace amount. They could not have been recovered by a brush, or by a scalpel, or any other means that if you've got a discrete clod of material that you can recover. It had to be removed by a way that would extract from the material any soil traces.

Q. So how did you remove the soil?

A. I used the sticky side, so here it's a scanning electron microscope stub, so deciding that the most appropriate method for the examination and analysis of these traces was using scanning electron microscopy. It was decided that we would take the sample directly onto the platform where the sample would be viewed, so it was using the sticky side, you lift off that clear bit of acetate and

underneath there is a sticky surface, so when it's pressed onto an item for recovery, the particles adhere to the sticky tape and then that can go immediately under the microscope stage.

Q. You said that you had already taken the decision by this point that the most appropriate type of analysis was going to be the scanning electron microscope. Now, we will talk in detail later on about what that work entailed, but at this point in time can you help us to understand what caused you to conclude that this was the best method of analysis for the particular sample that you had?

A. Because the only three areas that could potentially be soil that was on the vest were very, very small and trace in amount and embedded, or at least area 3 was embedded within the fabric, that the best way to recover those very small samples was to use scanning electron microscopy, because there wouldn't be enough to do any analytical methods such as gas chromatography or x-ray diffraction. Those methods require at least a grain of rice size of sample. These were hundredths of a grain of a rice of a size of a sample. They were very small.

Q. You said earlier in your evidence that if the sample size is small, that can limit your options, and is that essentially what happened here?

A. Due to the limited sample size, the only appropriate analytical method that could be used was electron microscopy.

Q. We will return to that later in your evidence and talk about what that does and how you went about your task.

So in terms of removing the soil from the vest, you have explained that the little square of clear acetate that we can see on the stub is removed to reveal a sticky surface that you simply press into the fabric and we see from the scale that the stub is about 2.5 centimetres in diameter, it's quite a small thing?

A. Yes.

Q. Can we move to slide 21, please. You have spoken about your initial examination of the vest; I would like to ask you some questions now about your initial examination of Mr Bayoh's boots, and if I can begin by asking you to view the boots and confirm that they were the same boots you received for examination and analysis.

(Pause).

A. Yes, those were the boots of Mr Bayoh.

Q. Those were the boots. And the photograph on slide 21 shows the right boot and the left boot. If you could very briefly describe the condition of the boots as they were when you examined them.

A. They were in a good general condition, good wear. They were muddy. There was -- particularly on the left boot here we can see mud adhering to what is called the welt of the boot, so that suggests that the boot had come into contact with a slightly deeper soil, not just the surface of the soil where it adheres to the sole. There also were deposits on the soles, but there was soil up the side of these boots. There was also soil which had fallen off in the evidence bag. We didn't analyse that sample but we did recover it. So these were actually muddy boots, yes.

Q. Can I ask why you didn't analyse the sample that had fallen off into the evidence bag?

A. We were briefed to take the best samples for comparison and we were able to recover two good single source samples, or what appeared to be single source samples from the boots that were directly on the boots.

There's always an issue if you go to material within a bag, it's always best to get the questioned sample directly from the questioned item itself.

Q. I see. And before we move on, you referred to a part of the boot which you label as 1 and 2 in the right-hand photograph, as the welt. What is the welt?

A. That's that -- the plastic bit of the sole that attaches to leather or fabric uppers, so in describing -- in

a similar way there's a protocol to describing footwear. Again, it's description from inside first and then outside, the inner, the outer, the sole, the front, the back, and each portion of the boot is described for its degree of wear and then also whether there are traces adhering and again, a protocol was followed and a strategy was decided between myself and Hannah for the areas where there was the best areas for sampling and recovery.

Q. And some of those areas -- we will hear about this shortly I think -- were the welt of the boot?

A. That's correct.

Q. So just to be clear, the welt is to the side of the boot where the leather or other fabric meets the rubber sole?

A. That's correct.

Q. As opposed to the underside of the sole?

A. That's correct.

Q. If we can move on to the next slide, please. Can you explain what we see here?

A. So on the left-hand top image, that is the front toe of Mr Bayoh's right boot, and you can see that there's an area here with granular material and this is it magnified with each -- the scale bar there representing each grid 1 millimetre in width and the soil is adhering up the side of the rubber toe of the right boot.

Q. So again, this is not the underside of the sole, it's part of the welt, this time at the front rather than to the side of the boot.
A. That's correct.
Q. And sorry, I interrupted you. To the right-hand side? What do we see on the right-hand pictures?
A. On the right-hand image the boot was very muddy, so this was all areas of mud that was adhering to the sole. This is the underside of the boot and this image here is magnified up before the soil was recovered and again, that was that light brown coloured fine textured soil that was adhering to the soles of the boot. Again, the marker indicates marker number 2 at the red marker point.
Q. Moving on to slide 23, please. Soil on Mr Bayoh's left boot. What do we see here?
A. So the top left image we can see a considerable amount -- that would be probably 300 milligrams, so that together would be well over a grain of rice size of material and it's on that welt area which is the area on the inner -- the inner, so that's the inside of the boot, but the inner and upwards, so it's vertical part of the boot, and this is it magnified up before recovery of the sample.
Q. And to the right-hand side?

A. This also is the left boot and this is the sole, so again, along the sole there were several areas where soil was still adhering. A considerable amount -- again, this would be 400 milligrams, so a couple of grains of rice size, and there was a substantial sample to recover there, so again, reinforcing that these were muddy boots.

Q. So you chose to sample areas from the right and left boot. From the right boot it was the right toe at the welt and the heel of the sole, and from the left boot it is the welt of the mid-section and the inner aspect of the -- the toe area of the sole?

A. That's correct.

Q. Those were the four areas that you sampled and you have described the quantity of soil present in terms of grains of rice, and you have compared that -- or you said earlier in your evidence that the quantity of soil on Constable Short's vest was hundredths of the size of a grain of rice?

A. That's correct.

Q. Dealing with this relatively larger soil sample size, how did you go about recovering the soil from these boots?

A. So because there was discrete clods, so these could be recovered with sterile tweezers directly into a small

production vial and it didn't need to go directly onto the stub, because what you have to do with this is disperse it so that it's of an equivalent single grain depth to go onto an SEM stub, scanning electron microscope stub. So it was recovered discretely into a vial in the laboratory at Cellmark.

Q. Would that be using brushes, tools of some sort?

A. Sterile tweezers.

Q. Tweezers?

A. Disposable tweezers, so single-use tweezers, so for each source recovery, the tweezer was put in the evidence bag with the sample, so again, minimising any potential contamination from one sample to another and I should just reiterate that these were all sampled individually, in individual labs, so that there was no risk of contamination from one item of footwear to another.

Q. Ultimately you needed to get the sample onto the stubs.

A. That's correct.

Q. How did you transfer it from the vial onto the stub in order to analyse it using the scanning electron microscope?

A. The sample was recorded, the recovery. The sample was put into a sterile petri dish so that it could be, with a sterile spatular, dispersed to be a single grain amount and then that was sprinkled onto the stub and the

stub shaken off so that loose material was removed and the material on there was as representative of the source soil on the footwear as possible.

Q. Thank you. Can we move on to slide 24, please. I'm going to ask you now about your examination of Constable Walker's boots and the first thing I will do again is ask you to look at the boots and confirm that they were received by you and examined by you.

(Pause)

A. Those were PC Walker's boots.

Q. So returning to your presentation, slide 24 shows us images of the left and right boots. Can you describe the condition of Constable Walker's boots?

A. These were in good condition. Some wear on the uppers but they were relatively clean, so there were very few traces of material, soil or vegetation on the upper or welt of these boots. These were clean.

Q. Was there anything in the evidence bags?

A. There was nothing in the evidence bag.

Q. Moving on to 25, please. What do we see here?

A. These are the soles of the boots worn by PC Craig Walker and although in general there was not much soil adhering to them, there were two areas, one on the left boot and another area on the right boot, where we could recover enough soil for analysis. It was more difficult because

there was very little material on these boots and the material that was there -- again, these are the magnified images before the soil was recovered -- it was fairly recent and there was discrete bits of dead vegetation embedded in that soil and it was a lighter brown colour and coarser in size of grain than the other soils that we had looked at previously.

Q. You mention there being discrete fragments of vegetation; do we see such a fragment within circle 3?

A. Yes, that's correct.

Q. And also within circle 4?

A. That's correct.

Q. So the image to the left is the sole on the toe of the left boot, and the image to the right is the heel of the right boot?

A. Yes, and those were the only areas that we had enough material to sample.

Q. So that would explain why you took only two samples from Constable Walker's boots, whereas you took four samples from Sheku Bayoh's boots?

A. That's correct.

Q. How were the soil samples recovered from these boots?

A. They were recovered into an individual production vial, put out into a sterile glass petri dish. The vegetation was removed because they could not be identified and

would obscure the analysis. As much as possible we recovered the discrete bit of vegetation and again, the material was sprinkled onto the SEM stub as in the same way we did for the other samples.

Q. Just to be clear, should we understand that each individual sample -- so that's four from Mr Bayoh's boots and two from Constable Walker's boots -- each individual sample was handled in the way that you have described and made its way ultimately onto a stub?

A. Correct. They were all handled as individual productions.

Q. So they weren't grouped together?

A. No.

Q. Okay. Can we move to slide 26, please. As you have already explained, Professor, your chosen method of analysis here was the scanning electron microscope and you have explained that you were essentially limited to this one type of analysis because of the very small sample type taken from the vest.

A. That's correct.

Q. So we see here an image of the scanning electron microscope and I want to ask you some questions about how this works and what it can do. Am I right to understand that one of the things that this piece of equipment can do is produce an image of a sample?

A. That is correct.
Q. And is that what we see in the bottom left-hand corner here, an image of a soil sample as seen under the scanning electron microscope?
A. That's correct.
Q. And how does examining a visual image -- an image of this sort help you in your analysis of soil samples?
A. Well, after we have looked at any individual sample using the light microscope, which allows us to magnify up to anything up to 100 times, what the scanning electron microscope does is it allows us to magnify up to thousands and thousands of times in magnification, so we can look at the grain shape and size at a much wider range of field of view, and instead of using light to clarify your image, the scanning electron microscopy uses an electron beam scanning across the sample to recreate, through secondary electrons emitted from the sample so the detector picks up those secondary electrons and recreates it as an image that we can see with our eye.
Q. When it comes to carrying out a comparative exercise then and comparing different soil samples, can the SEM give you an advantage over using a regular light microscope?
A. Yes, it can, and it has also got the advantage that you

can quantify what is there. You can look at it at greater depth of field, at greater magnification than you can with a light microscope.

Q. And am I right to understand that the SEM has another function too, something called energy dispersive x-ray analysis, EDXA?

A. That's correct, and that is when a sample is bombarded with electrons, the elements in that sample get energy and as they lose that energy, that gives out x-rays and those x-rays are dependent on the number of electrons in that element and so that where you see the output of that analysis with the X axis, along that X axis that represents the elements that are in that sample, so each element has a different position along the X axis and up the Y axis at number 5, that gives us the relative amounts of each of these elements in a sample.

Q. So the EDXA will help you to understand the relative elemental composition of a given sample?

A. That is correct.

Q. And by relative, does that mean that everything will add up to 100%, it's effectively percentages of the different elements?

A. That is correct. It's a composition up to 100% of the sample that you're looking at, or the portion of the sample that you're analysing.

Q. And the data is produced in a format, in the format that we see in the bottom right-hand corner here, as a graph with peaks on it?
A. That is correct.
Q. And each peak will represent a different element?
A. Some elements have two peaks, but the software in the system calculates how much that relative proportion of the whole of that sample is.
Q. And when we talk about elements, are we talking about the elements of the periodic table?
A. That is correct.
Q. So the sort of thing that you might see on the wall in a chemistry laboratory in a school?
A. That's correct.
Q. And perhaps for the benefit of us who haven't -- those of us who haven't seen one of these since we were at school, can you refresh our memory as to what is meant by the elements; what are the elements?
A. It's the basic language of chemistry, so all of matter is characterised by elements, and the representative -- they are represented in their atomic number and mass and number of electrons in each element, so there's a whole range of different elements and they've got different properties and the periodic table divides them into different groups, dependent on those different

properties, so, for example, the radioactive elements are all together in one part of the table, hydrogen has one -- atomic number of 1, for example. They've got characteristics and when we try to work out how different chemistries go on, we look at the characteristics of each element, so how many electrons, neutrons that they've got and what happens when they bind with another element, for example, hydrogen and oxygen when they combine make H2O, but they are two elements that have combined to make a compound and it allows chemists to understand the properties of these elements and how they behave.

Q. Are certain elements more commonly found to be present in soils than others, generally speaking?

A. Yes, absolutely. There are a suite of elements that are commonly found in soils. There are also a suite of elements which are unusual elements of soils as well.

Q. Which are most commonly found in soils?

A. So quartz is made of silica and oxygen and most soils have quartz in them to some degree. So quartz is a mineral and the elements silica and oxygen are the two elements that make up that mineral, and that's one of the most common minerals in soil.

You also get -- so they are primary minerals that have come from the parent material, the bedrock that we

talked about. But there are also secondary minerals which are often the clay minerals, so they're the ones that have come from the breakdown product of the primary minerals. And we get different types of minerals, different types of clays, we get kaolin, for example, which is an unreactive clay, or we get smectite, which is a multi-layered clay and has got lots of potassium and sodium also in it, so it makes a very fertile soil.

Now, clays are made of aluminium and silica, so they are very common in soil because that's the basic building block of a clay: layers of aluminium and silica.

Q. Thank you. Can we move on to the next slide, please. So you have explained, Professor, already that each of the samples, that's three from the vest, four from Mr Bayoh's boots and two from Constable Walker's boots, were transferred onto stubs in order to be examined under the SEM. Now, in this slide we see six blue rectangles on the face of the stub. What are those?

A. Those are representative areas of the sample, so that we get multiple replica analyses of any individual sample, because within a sample, there can be heterogeneity, so there can be different elements, so there can be a part of the sample which is more quartz and a part that might have more mica, more iron or aluminium, so to best

represent a sample, it's advised to take several replica analyses of that individual sample.

Q. And are these individual areas sometimes referred to as replicates?

A. That's correct.

Q. So each of the samples from the vest and from the footwear, you took six replicate samples from each; is that right, for the analysis?

A. For the analysis and for examination, yes.

Q. Can we move on to slide 28, please. What do we see here?

A. On this slide it shows again the image on the left-hand side of the three areas where we recovered a sample from from the vest. The images on the right are the scanning electron micrograph image of that surface of the sample.

Q. Can you describe what you see in each of the SEM images on the right?

A. So area 1, which is at the foot here, you can see there is a mixture of fine grained particles, so they are the very small particles which it's very difficult to see at this particular magnification their shape and size, but you can also see that there are larger more angular particles also within that sample.

You can see in the area 2, this area at the top edge of the reflective strip, that it was dominated by

different shape, different size particles than the other two that were from the vest, so this sample looked more different, as we had already identified in the macro description of that trace.

And sample area 3, there are a lot of very fine clay material, as I said, that fine grain material that was in that particular sample.

Q. So having conducted this initial analysis, the visual analysis using the SEM of the soil samples from the vest, are you starting to form any sort of view or impression as to how these soils potentially relate to one another, or not?

A. Yes. Through the whole process of examination and analysis we are going through a process of excluding things that look different and then following it up with exclusion with data and evaluating at the early stages whether there are differences or similarities between samples.

Q. So what conclusions, if any, did you feel able to draw, however tentatively, in relation to these soils, having looked at them visually under the SEM?

A. Area 1 did appear as if there were -- could potentially be more than one source for that particular sample.

Area 2, starting to think that it wasn't a soil because you couldn't see the individual grains that you

would normally see in a soil, you couldn't see the smaller particles of clay. They were much more rounded in nature, so that didn't, to me -- it wasn't stacking up with the characteristics that I would expect to see with the soil.

Area 3, were the circles 7 and now 9, this appeared to be more like a single source soil. It had a wide range of particle types and in particular these fine clay sized particles within that sample.

Q. Let's move on to slide 29, please. So we have looked at the images of the soil sample taken from the vest under the SEM. Let's now look at the samples taken from Mr Bayoh's right boot. Can you describe what we see here?

A. These were -- on the left these are the same images of the right boot. Here is the toe at the welt sample and that's the SEM image of the toe at the welt sample and it's much more a single grained uniform sample, rather than having this mixture that you would expect within a normal soil, so that was a single grain type sample. It didn't look more -- it didn't have the appearance of being a soil with multiple particles within it.

The soil on the heel of the sole of the right boot, that was much more representative of what would appear like a soil with sand grains, silt grains and clay

particles within it.

Q. Okay.

A. And that's the SEM image on the right-hand side, aligned with the sample from the heel of the sole.

Q. Thank you. Moving on to slide 30 which should be the SEM images of the samples taken from Mr Bayoh's left boot. Again, can I ask you to explain what we see here?

A. So this was the inner welt area of the left boot which had a substantial amount of soil along that welt area and again here we've got the wide range in the SEM image of sand, silt and clay particles characteristic of a natural soil.

And in the sole of the left boot, towards the toe area, and the SEM image, again, we've got that range of particle sizes in that sample, including the finer clay-textured size particles.

Q. So having examined the four samples taken from Mr Bayoh's boots under the SEM, what impressions were beginning to form in your mind?

A. So the two recovered soils from the left boot, they appeared to be -- they were soil material and on the right boot, the one on the front toe wasn't quite so characteristic of soil and it looked more different physically to the other one on the right boot, the one that was on the sole.

Q. Moving on to slide 31, let's look now at the SEM images of the samples taken from Constable Walker's boots. Again, can you describe what we see here.
A. So again, the left image -- here we've got the sole of the toe of Mr Walker's boot and this is the corresponding SEM image and these are single -- they're very well sorted. They don't have that wide range of particle sizes that we would characteristically see in a classic soil. It looked more like debris deposits that you would get that hasn't come from a natural -- a soil. And here we've got soil on the heel and that also had that similar well sorted appearance where you didn't have a wide range of particle sizes, but you had the larger size of those particles present in that sample.
Q. So having looked at the samples taken from Constable Walker's boots under the SEM, what impressions were you starting to form?
A. That they were different to the soils -- certainly three of the soils that we saw on Mr Bayoh's boots and they were -- they didn't have the classic soil appearance. It's more like urban debris that you get from road edges, that type of environment, rather than soil surface.
Q. Having carried out this visual examination with the aid

of the SEM, I understand that the next stage of your analysis was to carry out the EDXA. So you had three samples from the vest, four from the boots, two from Craig Walker's boots, each on a stub, and you were looking at six replicate areas within each stub?

A. That's correct.

Q. Now, am I right to understand that you also sampled the black fingerprint powder onto a stub?

A. That is correct.

Q. What was the purpose of doing that?

A. We took it as an elimination swab so that we could eliminate any elements that had come from the black powder, so that we weren't analysing an artificial contaminant and we therefore excluded them in any subsequent analysis because they could have been introduced from that powder itself.

Q. What was the composition of the fingerprint powder?

A. It was mainly carbon, oxygen and iron, so that we just excluded all of those elements from subsequent examination.

Q. Is that something you're able to do using the software that operates this machine?

A. That was run as a separate stub on the analysis and the full profile of all the elements in that stub were characterised, and those were the three elements that

were present in that background powder. That was taken from another area, I should say, of the vest, away from any of the area where the soil was, or the trace material was recovered from.

Q. So did you then go on to measure the relative composition of all of the elements in each replicate within each sample, leaving out of account the carbon, the oxygen and the iron?

A. Within the software you can exclude certain elements and this reason -- there was a reason to exclude the carbon, oxygen and the iron from that.

Q. Am I right to understand that you also excluded silica and aluminium?

A. Well, we still looked at the silica and aluminium, and the full data set, including the silica and aluminium, was used for the data set for the statistical analysis. The reason for presenting the results in both ways, both with the silica and the aluminium, and with those removed, was so that we could look at the more minor elements because, as I said, silica is one of the dominant elements within soil, as is aluminium, and they dominate any graph that is produced because they're sort of 40%, 50%, 60% of the composition. So to allow us to look at the more trace elements within that sample, we also plot it with just those elements present.

Q. And as you say in your report, this allows you to see the differences in the lesser represented elements?
A. That is correct.
MS THOMSON: Sir, I'm about to explore the results of this analysis, and I wonder if this might be a convenient time to break?
LORD BRACADALE: If that's a convenient spot, we will stop for lunch. So we will sit again at 2 o'clock.
(12.58 pm)
(The luncheon adjournment)
(2.00 pm)
LORD BRACADALE: Yes, Ms Thomson.
MS THOMSON: Professor Dawson, before lunchtime we were talking about the samples that you analysed using the SEM microscopy and the EDXR --
A. XA.
Q. Thank you. And I would like to move on now to ask you about the results of your analysis and you have prepared a number of slides that visually represent the data which you received as a result of using this particular type of analysis. I wonder if we might go to slide 32, Ms Kell.
So this slide is headed up "Trace elemental composition, silver strip, area 1", so area 1 was the bottom of the silver strip on the back of the vest?

A. That's correct.
Q. "PC ... Short's vest compared with all footwear samples." So that's Mr Bayoh's four samples and the two from Constable Walker's shoes, "(all replicates)".
A. That's right.
Q. So that's six replicates per sample, so one vest sample compared with all of the footwear samples.
Can you explain to the Chair what it is that we see on this graph?
A. So if we look along the Y axis, so that is up the Y axis, that gives us the relative amounts, so in terms of composition, of the various elements that were found within each individual sample analysed, so if we focus here on the X axis, if this -- sorry, if you could remove the last circle.
Q. Professor Dawson, we can also do arrows if that would help you?
A. Arrow might be better.
Q. I wonder can we use the arrow function. I think what you do is put your finger on the screen and drag -- I think.
A. Okay. I will try that. So the Y axis is the relative amounts, so the larger -- the higher the bar is, the more relative of that particular element there is in the sample.

Along the X axis -- and here we've got the six replicates from area 1 on PC Short's vest, so the lower edge sample, at the bottom of the silver strip, and within each of the six -- so if we get a little number 3, if the cursor -- if you could point to those six samples above number 3 -- above the number 3. So those -- that is one of those rectangular areas that were analysed from the area 1 silver strip and there were six of them analysed and for each of those six they are represented by nine different coloured bars. Each bar represents an element. So the dark blue one on the left is sodium; orange is magnesium; grey is sulphur; yellow is potassium; blue is calcium; green is titanium; dark blue is copper; brown is phosphorus and purple is manganese, and it's always in that same order, so for each of the six replicates which is denoted by the number 2 arrow, that's the six replicates, you can see each one of them potentially have any number of elements present and they are represented by different colours.

I think you can see by looking at the silver strip sample area 1 that within that same sample, there's a lot of variation, so not all subsamples, not all replicates look the same. You can immediately see that the first four are more similar to each other by the relative amounts of the colour and which elements are

represented than the last two, replicates 5 and 6.

Replicates 5 and 6, where the number 4 is sitting, are different to the first four replicates, so that is a heterogeneous sample which might lead us to conclude that it could be a mixture of sources, that particular sample from the vest, and by looking at these profiles, the four look more like a soil, they've got a range of elements that are commonly found in soil, while the replicates 5 and 6 have got -- they're dominated by the elements sulphur and some sodium and calcium, so we have to look for similarities in patterns between these range of elements, between this sample and all the other samples from the footwear.

So I think you can see, hopefully, that if we focus on those last two, these samples here (indicating), those two replicates here, they are similar to these replicates here but also they are similar to some of the material here (indicating), so this suggests that these also might have mixtures within those samples, and if we look then at the more soils, the replicates 1, 2, 3 and 4 from the silver strip, they are more similar to some of these replicate samples there, so we're looking at each individual area that is measured and looking for commonalities of patterns in terms of the elements that are present in those samples.

So this leads me to conclude that this questioned sample area 1 is a mixture of sources, probably two sources, with there being some of that material likely sharing a common origin with some of the material from the heel of the sole, welt, inner or toe of the sole of Mr Bayoh's boot, while the replicates 5 and 6 shared a common origin with the welt at the toe of Mr Bayoh's boot, but also with some of the sample replicates from the toe of the sole of PC Walker's left boot.

Q. Thank you. Looking at the replicates for area 1 on the vest, as you have already explained, 1 to 4 have certain characteristics in common, 5 and 6 look different, and 5 and 6, I think, have relatively high contributions of sodium and sulphur, as do some of the other replicates that you have drawn a comparison with, namely those at the welt of the toe of Mr Bayoh's right boot and the toe of the sole of PC Walker's left boot.

A. That's correct.

Q. Can you offer a view as to what might have caused these relatively higher contributions of sodium and sulphur within some of the replicates?

A. Well, sulphur is an element that is emitted in the exhaust of vehicles and it's known to accumulate within organic matter on the road or on the soil, so it adheres to that and it's higher in a city environment. It's

found much less in urban environments where you don't get vehicle traffic.

Sodium is also found in road-type materials, road salt, for example, sodium is a component of sodium chloride, so those could have come -- we can't say definitively where they have come from, but they could well have come from that type of anthropogenic, human-induced origins.

Q. So where we see these high peaks of blue for sodium and grey for sulphur, a possible explanation is that these particular replicates have a degree of influenced from the road surface itself?

A. That is correct.

Q. In your report you explain that replicate 6 from area 1 on the vest is what you call an outlier. I wonder if you could explain, what is an outlier?

A. An outlier is a replicate that is different to most of the other examples within that population, so it's more different, and statisticians often disregard them -- I mean, I presented all the data here, but they often decide that they are an oddity that is not explained by the rest of the data, so they can sometimes decide to exclude them from further analysis because they're different, they could be an artifact or something.

Q. Is it unusual to have an outlier within your replicates?

A. No, I'm not surprised that there is an outlier. It just suggests there's a heterogeneous sample and it's not likely a single source sample.

Q. So the sixth replicate you consider is likely an outlier. The fifth may have an influence from the road surface itself and, as you have already said in your evidence, within area 1 of the vest replicates 1 to 4 are visually more similar when we look at the data as it is presented in this graph in front of us and you explain in your report that the first four replicates have wider elemental profiles that are more characteristic of soil?

A. That's correct, and they've got the wider range of particle sizes, sand, silt and clay, as we saw from the morphology, and also these elements that we see there, the magnesium, potassium, calcium, titanium, they are found in elements -- they are the elements that are in certain minerals that are in basaltic parent material. If we go back to the geology and actually the drift material is based on a basaltic bedrock around the area of Kirkcaldy, so it doesn't surprise me that we're seeing these particular elements in this soil at that location.

Q. Okay. You have explained that there are similarities between replicates 1 to 4 from area 1 on the vest with

the samples from the heel of the sole of Mr Bayoh's right boot, the inner welt of his left boot and the toe of the sole of his left boot.

A. That's correct.

Q. And we can see that, can't we, just by looking at the data as it is presented in front of us? However, replicates 1 to 4 are different from the sample taken from the welt at the toe of Mr Bayoh's right boot, the toe of the sole of Mr Walker's left boot and the heel of the sole of PC Walker's right boot?

A. That's correct.

Q. And you said earlier that the conclusion that you would draw from this data, as it is presented, is that replicates 1 to 4 of area 1 from the vest may share a common origin with the heel of the sole of Mr Bayoh's right boot, and the two samples taken from his left boot?

A. That's correct.

Q. You also in your evidence drew a comparison between replicates 5 and 6 and those at the welt of the toe of Mr Bayoh's right boot and the toe of the sole of PC Walker's left boot, and would you consider that this data allows you to conclude that they too may have shared a common origin?

A. That's correct.

Q. Am I right to understand that your analysis involves both the assessment of the data produced as a result of this elemental compositional analysis and also the conclusions drawn during your visual examination of the soils, in particular, using the SEM?
A. Yes, that is correct.
Q. And so far as replicates 5 and 6 are concerned, looking at this data alone, you have drawn a comparison between those replicates and the toe of the sole of Constable Walker's left boot. Does that analysis stand after you take into account the visual characteristics, as you viewed the soil samples under the microscope?
A. Well, when we look at the morphological characteristics of that sample, the toe of the sole of PC Walker's left boot, it was much more restricted, it was more sorted, there were larger grains within that sample, there were none of the finer clay or silt-sized fraction, whereas the soil material, for example, on the heel of the sole of Mr Bayoh's boot, had a wide range of characteristics including the finer grain particles, which also -- those areas 1 to 4 on area 1 in the silver strip had that wide range of morphological grain sizes.
Q. So should we understand then that replicates 1 to 4, which you have compared to the heel of the sole of Mr Bayoh's right boot and both samples from his left

boot, not only have a similar elemental compositional profile but they were also visually similar when looked at under the microscope?

A. That's correct.

Q. Whereas replicates 5 and 6 from area 1 on the vest, although they appear to bear some similarities to the sample from the toe of the sole of Constable Walker's left boot, they were distinguishable visually when you looked at the samples under the microscope?

A. There were only two of the replicates on the toe of the sole of PC Walker's boot that shared those characteristics. The other replicates didn't, but yes, I would say as well that those were morphologically different to the ones on area 1 silver strip.

Q. Thank you. Can we move on to slide 33, please. Here we see trace elemental composition silver strip area 2, so that's area 2 of the vest compared with all of the footwear samples, so this graph is exactly the same as the one that we have just been looking at --

A. Yes.

Q. -- except for the fact that the replicates from area 1 on the vest have been -- thank you -- replaced by the replicates from area 2 on the vest, is that right?

A. Yes, that's correct. It's the upper bit of the silver reflective strip.

Q. So when viewing these results, what can you tell us about area 2 on the vest?
A. Area 2, again, we've got one which might be termed an outlier here in the third replicate in that it has a very restricted profile. It only has representation of the sodium and the sulphur, whereas the other replicates 1, 2, 4, 5 and 6, are all relatively similar to each other. So apart from that one outlier, as it were, the other replicates are fairly similar to each other. So we can conclude from that that it is likely, in general, a single source sample rather than a mixture.
Q. Did this data allow you to compare the soil from area 2 on the vest with the footwear samples?
A. Yes, that was the purpose of comparing now the results for the profile from area 2 with all the samples of soil that were recovered from the footwear.
Q. And what conclusions were you able to draw?
A. I concluded from this examination -- which considered also the morphology and the grain size and shape, as well as the elemental composition data -- that none of the traces of soil could have come from any of the -- the soil on that vest at area 2 could not have come or shared a common origin as any of the footwear samples that we looked at. They were different.

Q. Can we move on to slide 34, please. So we see here trace elemental composition, the silver strip edge of yellow fabric, that's area 2, and again, this is a comparison of Constable Short's vest, area 2, with all of the footwear samples but using mean values, that's mean as in average values?
A. That is correct.
Q. Can I begin by asking why you didn't prepare a graph like this in relation to area 1?
A. Because I concluded that that was likely a mixture, so that -- means are not a good way of representing what is a mixed sample. I would only present and interpret a profile that was a mean profile if it was predominantly a single source sample.
Q. And you told us earlier that you reached the view that area 2 was likely to be a single source sample?
A. That's correct.
Q. So what do we see here?
A. It just makes it a bit simpler to compare the profile of that area 2 sample with all the other profiles: the four that were from Mr Bayoh's boots here and the two that were from Mr Walker's boots here, and the soil on the area 2 is different to all the other mean profiles that you see here.
Q. So this is just a simplification, essentially, of what

we saw in the previous slide using the mean data rather than looking at the replicates individually?

A. That's correct, yes.

Q. Can we move to slide 35, please. "Trace elemental composition", area 3 on the vest, that was the yellow fabric, and it's a comparison of area 3 with all footwear, all replicates. So we have seen this graph before, twice, and the only difference is that we are now looking at area 3 of the vest rather than area 1 or area 2. There we are, the area 3 replicates. Thank you very much.

On viewing these results, what can you tell us about the soil sample taken from area 3 of the vest?

A. So if we look at the six individual plotted replicate profiles, the second replicate is slightly tending towards being different, but you would still include it within the analysis, but in general, those are relatively all similar to each other, so this is a homogeneous sample, which again leads to a conclusion or an interpretation that it could well be a single source sample, so it's likely not a mixture of sources.

Q. Is that what homogeneous means, that it's a single source?

A. Yes, that's correct.

Q. And on viewing these results, are you able to compare

the soil sample taken from area 3 with the soil samples taken from the footwear?

A. That's correct, and what we look for are differences in relative heights and composition of the elements and if we look at the welt of the toe of Mr Bayoh's right boot, you can see that they are all different, the relative amounts are different, the different elements there are different, so I would conclude that you can exclude that soil as sharing a common origin with the soil from the fabric, area 3.

Similarly, you can look at the toe of the sole of PC Walker's left boot and again, you can exclude that as sharing a common origin with the soil from the yellow fabric, area 3, because these profiles are consistently different and if you look at the heel of the sole of PC Walker's right boot, again, that profile is different, and I would conclude that you can say that it does not share a common origin with the soil from the yellow fabric, area 3.

Q. Okay. So on the basis of this data as presented before us today, you are able to exclude both of the soil samples from Constable Walker's boots as sharing a common origin with the soil taken from area 3 of Constable Short's vest?

A. That's correct, both on the elemental profile

composition and also on the morphology of those samples being different.

Q. What then of the remaining three samples from Mr Bayoh's right boot and the two samples from his left boot? How do they compare to area 3?

A. They are similar to the replicates from the yellow fabric area 3 and cannot be excluded as sharing a common origin with that soil, in both the chemical profile compositions that we see here, and also in the morphological grain size composition that we saw earlier.

Q. When you say they cannot be excluded as sharing a common origin, is that another way of saying that they could have originated from the same source?

A. Yes, but in soil -- forensic soil science we can't say things match because, as I said, there is -- as you can see there is variation within soil so you would never get a physical match. That's why we exclude things as sharing a common origin, or say the evidence supports that they could have shared a common origin.

Q. And does the evidence support there being a common origin?

A. Yes, that is correct.

Q. You say you cannot exclude the three samples from Mr Bayoh's boots as sharing a common origin with the

sample of soil on area 3 of the vest and in your report you say:

"However, it is possible that soil sample vest area 3 may be similar to soils from other places and comparison with other soils can put the comparison to questioned samples in the context of alternative source locations. This was not possible in this case due to the passage of time since the incident."

Can you explain what you mean by that?

A. So when we're comparing a questioned sample, the soil from the yellow fabric area 3, so we don't know its origin, we're comparing it with the soil from any of the alternative propositions of the soils from the two pairs of footwear, so an alternative proposition is that could the soil that was on the vest in this area 3 have come from similar origin, or indeed, the soil that was from the heel of the sole of Mr Bayoh's right boot, the welt of the inner of Mr Bayoh's left foot and the toe of the sole of Mr Bayoh's left boot, or alternatively, have come from the soil from PC Walker's left or right boots, that's our only alternative proposition that we have available to us to consider.

Now, that's because we cannot say that that soil definitely came -- on the vest came from Mr Bayoh's boots because there could have been other sources of

that soil on the yellow vest. There could have been another source -- we can't categorically say it matches. We can say it shares the morphological and the elemental compositional characteristics and that it could have shared a common origin, but we can't say it's come from there. We can only comment on the traces and their characteristics. We cannot actually say that it's definitely come from that place.

Q. So the most that you can say is that the soil on area 3 of the vest is consistent with having come from the heel of the sole of Mr Bayoh's right boot or either of the samples from the left boot?

A. That's correct.

Q. Can we move on to the next slide, please. What do we see here?

A. So that is just focusing in on the soils -- the soil from the vest in area 3 and comparing it with the four soils that were recovered from Mr Bayoh's boots, so it's narrowing down on that source comparison and you can see that the soil from the welt at the toe is different, while you can see again in more detail that there's a high degree of similarity, or comparability between the soils that were on the heel of the sole of Mr Bayoh's right boot, the welt of the inner of Mr Bayoh's left boot and the toe of the sole of

Mr Bayoh's left boot with the yellow fabric area 3 on PC Nicole Short's vest.

Q. Can we move to slide 37, please. So trace elemental composition, area 3 of the vest compared with all footwear samples and again using the means, which is possible for the reason you explained earlier that it appears that area 3, the area 3 sample is homogenous, it's from a single source?

A. That is correct.

Q. What does this data, presented in this particular format, help us to understand?

A. It just simplifies that profile so that you can see that this sample can be excluded because it is different to that of the yellow vest on the left and these two are different, so they've got a different profile and different relative amounts of several of the elements present in those samples are different, whereas the three samples here (indicating) are similar to that of the yellow fabric in area 3 from PC Nicole Short's vest.

Q. So this is just a simplified visual representation of the data that we looked at a moment ago using the means rather than the individual replicates?

A. That's correct.

Q. Can we move to slide 38, please. "Mean trace elemental compositions" from area 3 on the vest, compared with the

samples from Mr Bayoh's right boot, the two samples there. Again, what does this information -- which I understand is the same information as we have already considered, represented as a pie chart rather than as a bar graph, what does this help us to understand?

A. Having the data represented in a bar chart, because it is compositional, allows us to look at the relative contribution of the different elements to that sample and you can see with the same colours represented for each of the elements that were found in these samples that the sample from the welt at the toe of Mr Bayoh's right boot is different. It's got a different composition, much more of sulphur within it and much less of the magnesium, the soil-bearing elements in it compared to the area 3, PC Short's vest.

However, when we look at the pie chart of the heel of the sole of Mr Bayoh's right boot you can see that most of the elements there have got a similar proportional representation as the elements within PC Short's vest area 3.

Q. So does the information displayed in this particular way help us to understand the similarities between area 3 of the vest and the sample taken from the heel of the sole of Mr Bayoh's right boot in particular?

A. That is correct.

LORD BRACADALE: While you are on that, can I just ask you about the yellow fabric. It appears to have two additional elements. Do you have any comment to make about that?

A. Yes, and that was on only a couple of the replicates that those elements were found in and it could well be that they have come from some exterior source, so that vest was -- it was treated with chemicals, it was washed, and during that process, some of these could have been introduced to that sample, so there would never be an absolute -- as I say, an absolute match of all the same elements and they were found in a relatively -- a very, very small amount, a trace amount, so it could have been that someone brushed past it, or another piece of clothing brushed past it. It was a small amount and it wasn't in all the replicates.

LORD BRACADALE: Thank you.

A. So yes, thank you for picking that out. That's a very valid point.

MS THOMSON: I think, Professor, it's phosphorus and manganese. Are those the two additional elements that we see in the pie chart --

A. Yes, that's correct.

Q. -- for the vest?

A. And that could have also been on the vest prior to this

as well, from out on operations, particles of gunshot residue, all that sort of thing could easily have pre-contaminated areas of the vest.

Q. So should we understand that the absence of phosphorus and manganese from the welt at the toe and the heel of the sole of Mr Bayoh's right boots doesn't concern you, nor does it undermine the conclusions that you have drawn?

A. Yes, because they're at such trace levels.

Q. Can we turn to slide 39, please. I think we're turning to the microscopy here. Can you explain what we see in this slide?

A. So these are the morphological images using the scanning electron microscopy, and these are images from -- on the left-hand side, the left boot of PC Walker, and at the foot of the left-hand side the right boot of PC Walker and, as you can see, these again are well sorted samples so that we only have the larger particle size grains in that sample, so these are the sand-type size particles present on PC Walker's boots, on the soles of his boots, whereas Mr Bayoh's boots, the left boot, had a wide range of particle sizes, from the sand size through the silt, right through to smaller than you can see at this magnification and also on the left boot this was the other sample. Again just those two for representation,

but again, this is not a well sorted, it's a wide range of particle sizes and when we compare all those four, for example -- and we did this with every image that we took across every of the six replicates for each of the analyses and they were consistent, this was the sample from the vest and it had this wide range of particle sizes from the sand, right through to the fine clay in the vest sample. This was vest area 3. Whereas the fine particles were not in box number 1 and 2 on the boots of PC Walker.

Q. So what should we take from this visual representation of some of the samples?

A. Well, that's an independent confirmation that because of the differences in the morphology of the particles that were on Mr -- the traces found on PC Walker's boots, that they were different to the morphology of the particles that we saw from the yellow fabric on PC Short's vest for area 3, while the soils that were recovered, all four traces from Mr Bayoh's boots had that wider range, including the clay fraction on those samples.

Q. So we have discussed the analysis that you carried out and you have talked us through the conclusions that you felt able to draw, based on a combination of a visual study or comparison of the images seen using the

microscope, and also the relative elemental compositional analysis.

Before we turn to your final concluding slides which set out your conclusions succinctly, I wonder if I could ask you a few questions about the involvement of a statistician in this case, because I understand that having carried out the visual examination and having considered the relative elemental profiles of the samples and reached the conclusions that you shared with us, you instructed Dr Nicholas Schurch, a statistician, to analyse the elemental compositional data and I'm keen to understand why you thought that was necessary or appropriate in this case?

A. Well, as we have seen, we have observed -- we have observed physical characteristics and also chemical characteristics of these wide range of samples, but potentially that's me interpreting and you interpreting by eye when you look at these visual representations of the data and of the images. Statistics are an important objective way of looking at that same data, but without any interpretation of the visual representation. It takes the data as it is. The reason I didn't do the statistics myself, which I often do if we've got gas chromatography data, for example, is because it's fully quantitative, absolute amounts of different compounds

across a whole range of compounds, and compare that multi-dimensional data, a questioned sample with a known sample. However, in this case, it was complex data because it was compositional data and therefore I thought it was much more value to the Inquiry that a senior statistician would independently look at my data and evaluate it using a quite sophisticated statistical model.

Q. Is this something that you have done in previous cases, brought on board a statistician?

A. Yes. When there's quite extensive data or where it involves complex data then I would ask my statistical colleagues if their expert knowledge could be brought to bear and to carry out that appropriate statistical evaluation, and they would act as independent expert witnesses in the relevant court cases.

Q. What information did you make available to Dr Schurch?

A. I shared with him all the data, including outliers, absolutely all the raw data he had available to him.

Q. So he had access to the elemental compositional data --

A. Yes.

Q. -- from all of the samples?

A. That's correct.

Q. Did you provide him with images like the ones we see on the screen in front of us of the samples underneath the

microscope?

A. No, he only had the actual raw elemental composition data.

Q. And did you provide him with your thoughts or conclusions as to whether any of the samples might have shared a common origin?

A. No. I felt it best to do the analysis totally independently so that he knew nothing of my conclusions when he was carrying out his examination.

Q. As we discussed at the outset, Professor, Dr Schurch has prepared a report and also given a statement to the Inquiry. They are available to the Chair and the Assessors and they will be published on our website and so we don't need to concern ourselves with the detail of those documents, but what I would like to ask you is this: how did Dr Schurch's conclusions, which I understand were fed back to you, how did they fit with your own conclusions?

A. On the whole, they supported my conclusions in the general evaluation and in particular, the strongest comparison and evidence was that from area 3, the yellow fabric on the vest, with support for that sharing a common origin with certainly two of the source samples from Mr Bayoh's boots and with some support from a third trace from Mr Bayoh's boots, and excluding the soil from

PC Walker's boots as being the source of that soil on the yellow fabric.

Q. Thank you. Am I right to understand that there might have been one point of difference between you in relation to the soil recovered from area 1 of the vest insofar as you found similarities between area 1 and the soils on Mr Bayoh's right boot, and you also noted some similarities with soil recovered from Constable Walker's left boot, and Dr Schurch reached the same conclusion in relation to the soils on Mr Bayoh's right boot, but also considered there was a similarity with the soil on Constable Walker's right boot?

A. And that was because Dr Schurch was taking only the elemental data and I think he also concurred that that was likely a mixed sample, it was a heterogeneous sample and if we think back to the charts that were presented for area 1 where that was a mixture with the replicates being quite different, with two of the replicates having the high sulphur and high calcium, I believe, they also shared those high -- those characteristics of being high, so a couple of the replicates from PC Walker's boots had those similar characteristics, so some of the replicates from Mr Walker's boots did share the similar profile to that of area 1, as did some of the profiles of Mr Bayoh's boots, but what -- so I think that

explains it because it's a mixture, so that there was a contributory factor from two sources to the soils that we're seeing, or even more, that we're seeing in this particular investigation, but what Mr Schurch didn't have was information about the morphology and the differences in the grain size and shape that we could see between the soil on Mr Walker's -- PC Walker's, excuse me, soil and that of the soil that was on the vest. They were different.

Q. So were you able to resolve that difference between you on the basis that you had additional information which informed your analysis, namely the visual images such as those on the screen before us, whereas Dr Schurch was dealing with raw statistical data?

A. That is correct.

Q. And whereas he might have identified a similarity on the basis of that raw data as between the soil on Constable Walker's right boot and the soil on area 1 of the vest, you were able to exclude them as sharing a common origin on the basis of them being morphologically different?

A. Yes, that is correct.

Q. I want to move on now to your concluding slides in which you set out your overall opinion, having examined the samples in the way that we have discussed visually and

under the microscope, having the benefit of the relative elemental compositional analysis and also Dr Schurch's statistical analysis, so if we could begin with slide 40, please.

Can I ask you simply to read out this first opinion slide.

A. So this, first of all, is in relation to area 1, the soil from the silver strip on the vest at the very foot of the silver strip on the back of the vest worn by PC Nicole Short:

"The characteristics of some of the soil from Area 1, from the silver strip of the vest, worn by PC Nicole Short, is consistent with having originated from soil from the toe at the welt of the right boot and from soil from the heel of the sole of the right boot of Mr Sheku Bayoh."

Q. What characteristics are you referring to?

A. That is the characteristics of the elemental compositional data and also the particle size and shape.

Q. And when you say the characteristics of some of the soil, is that because there were two replicates within that soil sample that were different from the other four?

A. That is correct. This can only be based on four replicates because two of the replicates were different

and likely because it was a mixture.

Q. Let's move on to slide 41, please. Again, can I ask you to read this?

A. So again, this relates to the soil now at the top -- sorry, this is the soil from area 1 at the foot of the silver strip, still the same area, this is area 1:

"The characteristics of the soil from Area 1, from the silver strip of the vest, worn by PC Nicole Short, is not consistent with having originated from soil from the boots of PC Craig Walker."

Q. And again, the characteristics will be the morphology as viewed under the microscope and also the relative compositional elemental analysis?

A. Both those aspects were different, yes.

Q. Let's move on to slide 42.

Again, Professor, can you share this conclusion with us?

A. We're now moving on to the middle of the three traces on the vest, that of area 2, at the top of the silver reflective strip on the vest worn by PC Nicole Short:

"The characteristics of the soil from Area 2, from the silver strip near the edge of yellow fabric, of the vest worn by PC Nicole Short, is not consistent with having originated from the boots of Mr Sheku Bayoh or from the boots of PC Craig Walker."

Q. So should we understand then that the fabric -- sorry, the soil taken from area 2 on the vest is different, both morphologically and in terms of the elemental profile from all of the footwear samples that you examined?
A. That is correct.
Q. And that allows you to exclude the possibility that the soil on area 2 of the vest shared a common origin with the soils on Mr Bayoh's boots?
A. Correct.
Q. And you can similarly exclude the possibility that the soil on area 2 shared a common origin with the soil on Constable Walker's boots?
A. That's correct.
Q. Thank you. Can we move to slide 43, please. This is your opinion in relation to the soil on the yellow fabric that is area 3. Again, can I invite you to share this conclusion with us.
A. So this is now the sample that came from the back of the vest of PC Nicole Short and it's the material that came from the yellow fabric, area 3:

"The characteristics of the soil from Area 3, from the yellow fabric, of the vest worn by PC Nicole Short, is consistent with having originated from soil from the toe of the sole of the left boot, and soil from the heel

of the sole of the right boot worn by Mr Sheku Bayoh."

Q. Now, you brought it to my attention that it may be that there should have been a reference to another of the samples in this slide. Can you help me with that?

A. So I think that should include all three traces that came from Mr Sheku Bayoh's boot, so the heel of the sole of the right boot, but also -- the sole -- the toe of the sole of the left boot, plus the other trace from the left boot were all consistent with having originated from the same soil as that of area 3.

Q. So that would be the welt of the left boot?

A. That is correct.

Q. It may be that I caused a little confusion because of course in your report you use laboratory reference numbers for all of the samples, such as GAY016 and GAY017 and what I asked you to do in preparing the slide presentation was to call the items by their descriptive terminology, so I might have introduced a little confusion there --

A. Apologies.

Q. -- I apologise if I did.

Let's move on to slide 44, please. Again, can you share this conclusion with us.

A. So this again is the area 3 on the yellow fabric:

"The characteristics of the soil from Area 3, from

the yellow fabric, of the vest worn by PC Nicole Short is not consistent with having originated from the soil from the boots of PC Craig Walker."

Q. So again, on the basis of the morphology and the elemental profiles that you have examined, you consider that you can exclude Constable Walker's boots as having been the source of the soil found on area 3 of Nicole Short's vest, whereas you consider that the soil on area 3 is consistent with having shared a common origin with three of the samples from Mr Bayoh's boots as we saw in the previous slide?

A. That's correct.

Q. I want to ask you just a few questions around the limitations of the analysis that you were able to carry out here.

So you conclude that characteristics of the soil taken from both areas 1 and 3 of the vest are consistent with the soil having come from one or other of the samples taken from Mr Bayoh's boots.

A. That's correct.

Q. Now, members of the public watching your evidence might wonder whether you are saying that the soil on areas 1 and 3 of the vest did come from Sheku Bayoh's boots. Is that what you are saying?

A. I think we're saying that it's consistent with having

come from there; we can't categorically say that it came from Mr Bayoh's boots. We can't link one specific soil trace to another; we can only comment on the characteristics of those traces. It's not a categoric science, it's a probabilistic science and that's why we use statistics to give likelihoods and probabilities as to whether a soil came from a particular place or not.

Q. And again, members of the public watching your evidence might wonder whether you can offer a view as to how likely it is that the soil on areas 1 and 3 came from Mr Bayoh's boots. Is that something that you are able to do?

A. You can calculate what are called likelihood ratios, so the likelihood of the soil on the vest having come from Mr Bayoh's boots, but that requires the alternative proposition and alternative data to do that likelihood ratio calculation and in this case we didn't have that database, we didn't have that wider data that would allow us to calculate likelihoods.

Q. So again, the most that you can say is that the soil from areas 1 and 3 on the vest is consistent with having come from Mr Bayoh's boots?

A. That's correct.

Q. Just a few final questions before we conclude. We spoke earlier about the best practice manual to which you were

a contributing author. Was all of the work that you carried out in connection with this case carried out in accordance with the best practice set out in the manual?

A. Yes, it was.

Q. I would like to turn to your report. There's no need to put this on screen. You may wish to have the hard copy before you, Professor. It's page 13 of your report and it is under a section headed "Transfer and persistence" which we have already touched on. Do you have that?

A. Yes.

Q. At the top of page 13 you say:

"The main factors that determine the transfer and persistence of soil are length of time after the contact, nature of contact surface, amount of force and duration of contact and external disturbances following contact."

And you quote a paper there, Stella et al 2020:

"Soil transfer is typically more effective when soils are wet and saturated."

You quote another paper, Procter et al 2019.

Now, we have spoken about transfer and persistence already and we have spoken about the nature of the contact surface, in particular, the fabric of the vest comprised both a woven fabric and a plastic coated hi-vis strip. We have spoken about that to an extent

already but I note that in quoting this paper you make reference to the amount of force as being a relevant consideration and a factor that will be in the mix in terms of determining the transfer and persistence of soil.

You offered a view earlier in your evidence that the plastic reflective strip would perhaps not be the best or the most adhesive surface for the transfer of soil?

A. Yes.

Q. And you also observed that, so far as the soil in area 3 that was on the yellow woven fabric of the vest was concerned, you described that soil as being embedded or ingrained and this may not be a question that you can answer, and please tell me if you can't, but can you comment at all on the degree of force that would be required for a transfer onto a woven surface that would result in the soil becoming embedded or ingrained within the weave of the fabric?

A. That particular area of transfer to different fabrics, I personally haven't carried out much research in that area at all, or published in it, but other people have and the literature would suggest that it requires a fair degree of force.

Now, I don't know and I can't quote the amount of force, but the literature would suggest that it requires

a force for soil to transfer and embed within fabric, but I personally cannot give you any opinion on that because I myself haven't carried out that research.

MS THOMSON: That's very fair. Can you bear with me a moment please.

(Pause)

I have no further questions. Thank you, Professor.

A. Thank you.

LORD BRACADALE: Now, there were no written Rule 9 applications. Are there any oral ones? No.

Well, thank you very much, Professor Dawson, for coming to give evidence to the Inquiry. In a moment I shall be adjourning and you will be free to go.

Now, we adjourn until Thursday, is that right, Ms Grahame?

MS GRAHAME: Yes, that's correct. We had anticipated that perhaps we would need extra time with Professor Dawson. That's not proved to be the case, so we don't have any witnesses scheduled for tomorrow.

LORD BRACADALE: Very well. I will adjourn until Thursday at 10 o'clock.

(2.58 pm)

(The Inquiry adjourned until 10.00 am on Thursday, 8 December 2022)

INDEX

PROFESSOR LORNA DAWSON (sworn) 1

Questions from MS THOMSON 1