IESF Société des Ingénieurs et Scientifiques de France

Newsletter

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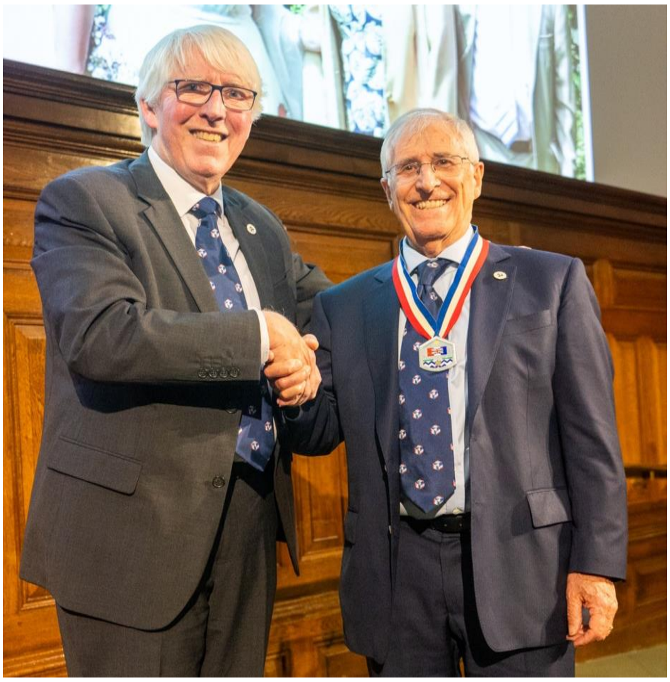
Dr Chris Foster, IESF President 2024



Outgoing President, Lester Sonden hands over the Presidential Medal to Chris Foster

Forensic Fire Investigation – The Underpinning Fire Science and Investigative Methodology

President Chris Foster's inaugural lecture on the subject of fire science and the investigation and methods used to determine the causes of fire was very sobering. We all acknowledge the importance of identifying the causes of fires but I suspect few appreciated the complex forensic work needed to determine the causes with certainty.

The lecture was split into two main topics, the science of fire and forensic investigative techniques.

Chris began with a very impactful film which demonstrated the speed at which a fire can spread from a very small origin to engulf a room – ignition to flash over in three minutes. A flame occurs only when the combustible material is gas or has been converted to gas - the ignition phase. When sufficient energy is transferred a self-sustaining reaction takes place. For liquids this happens when it is vapourised and for solids when chemical decomposition breaks down the material into small molecules. The result produced can be either flame or smoulder (this latter may persist, undetected for hours).

The ease of ignition of solid matter depends on its "thermal thickness" (or thermal inertia) which comprises of thermal conductivity, density and heat capacity.

Liquids generate sufficient vapour to ignite when raised to the flashpoint temperature. If a wick is present, it can act as a capillary, drawing up liquid and allowing the fuel to ignite at a temperature below its flashpoint.

The tragic example of the Kings Cross fire in November 1987, which resulted in the deaths of 31 people illustrated this effect, showing the way the fire had taken hold and its subsequent spread.

Grease and fibres under the escalators

When Chris assessed the site, he discovered thick layers of grease combined with fibrous material and much other detritus in the escalator mechanism which functioned as a wick – the escalator having been suspected as the origin of the fire.

Through experimentation on site, he was able to witness how a lighted match dropped on to the grease layer caused it to ignite readily and spread the fire rapidly in the early stages.

In an investigation, it is important to identify any potential sources of ignition, ranging from spontaneous ignition to externally applied sources. Fire investigators are provided with useful lists of the minimum temperature for auto ignition, referencing typical materials which emit radiant heat, and similarly, examples of other ignition sources.

Radiant heat is known to be potent for timber but not for vapour and gases whereas a spark is potent for gases but not for solids.

Once the source of ignition has been identified, Chris's investigation can then focus on how the fire spread and the rate of the spread. There are three aspects to consider – the chemical properties of the fuel, and the physical properties, which could include the placement of furniture in a room, and environmental factors such as air flow.

The orientation of the fuel can have a profound influence on the rate of flame spread where upward spread increases significantly when the fuel is at an angle to the horizontal greater than about 20°

HSE experiments carried out on a replica of the Kings Cross escalator showed how the rapid flame spread occurred through a combination of the angle of the escalator and the "trench effect".

A "trench effect" occurred when air was entrained from below the escalator and this explained how in only 9 minutes the flame had travelled from one side of the escalator to the other and then the flame had been forced upwards at 10m/sec into the booking hall.

The type and disposition of the fuel present determines the rate of growth together with other factors such as ventilation. Where these conditions become critical, a fire can reach a flash over point - where flames reach a ceiling for example, radiation from hot smoke is redirected downwards which can lead rapidly to further ignition.

In his work as a forensic investigator, Chris has to follow a full programme of investigation. He first must look at site safety and carry out risk assessments. When this is completed, it is important to speak to any witnesses and fire officers as soon as possible. The next step is to collect any available evidence whilst following the 'no disturbance rule'. This allows the forensic team to form working hypotheses which are refined as further evidence is collected and will include any less easily accessible evidence. The initial hypotheses are then subjected to rigorous testing, by the application of forensic knowledge of fire science. Finally, all evidence is considered and evaluated and any further work on site carried out as necessary.

Site based evidence will look at the origin and direction of spread. Did the fire damage only affect certain parts of the building?

For example, a roof space fire collapses into rooms below providing an easy escape route for hot fire products that do not vent from windows, whereas smoke and flame from a fire developing in a room will vent through windows before spreading to other compartments.

Tarry smoke deposits on smooth surfaces are typical effects of prolonged smouldering fire.

Fire effect	Observations	
	Visible	Measureable
Temperature estimation	✓	
Mass loss	✓	✓
Char	✓	✓
Spalling	✓	
Colour change	✓	✓
Melting of materials	✓	✓
Thermal expansion and deformation	✓	✓
Oxidation	✓	
Deposition	✓	
Clean burn	✓	
Calcination	✓	✓
Window glass	✓	
Furniture springs	✓	
Victim injuries	✓	
Light bulbs	✓	
Soot and fire product deposition	✓	

This table lists fire effects that assist the investigator in learning about the characteristics and spread of a fire.

After the on-site investigation has been completed, the removal of items can help expose the likely cause of ignition. At many sites, items have already been removed during clearing up. These items also have to be examined and in some cases a reconstruction of the site is possible. So, what features of a fire might alert the investigator to the possibility of arson - deliberate fire raising?

1. Knowledge that the pre-fire site had no combustible materials that explains its origin
2. Combustible materials may have been rearranged
3. Do the premises show evidence of forced entry?
4. Did the fire start in more than one place?
5. Did the fire spread unusually quickly?
6. Was there an explosion preceding the fire?
7. Had the usual security measures changed?
8. Were any locked doors or windows forced?
9. And, of course, had there been any changes in human behaviour?

Chris gave the example of a pet parrot who lived in a business premises but for one night only was taken to the pub – coincidentally that night the business was destroyed by fire – still, at least the owner loved his pet, so it wasn't all bad!

Once all the suspicious actions have been considered, the evidence pointing to arson can then be assessed. Is there a physical trail? Are there any signs of delayed ignition devices? Can inferences be drawn from the pattern of burning? Always remembering that the sites are potential crime scenes and evidence must be carefully collected to avoid any contamination.

A tragic case in which Chris was instrumental in identifying a murderer included the collection of latent fingerprints, analysis of melting and singeing of fibres on clothes and shoes and a smoke chemical analysis test. This test had been developed by Chris and showed that all the chemical components present at the scene were also present on the murderer's clothes. Chris related his part **in** this investigation with great modesty, but his work was clearly crucial in a successful prosecution.

Many of the incidents illustrated in the lecture have also led to a great number of changes in regulations regarding fire safety which in turn have led to the saving of many lives.

So yes, this was a sobering lecture but certainly reminded the audience of the vital work of Chris and his colleagues.

Fire – a good servant but a bad master.

The vote of thanks was given by Norman Train.

Liz Jefferson

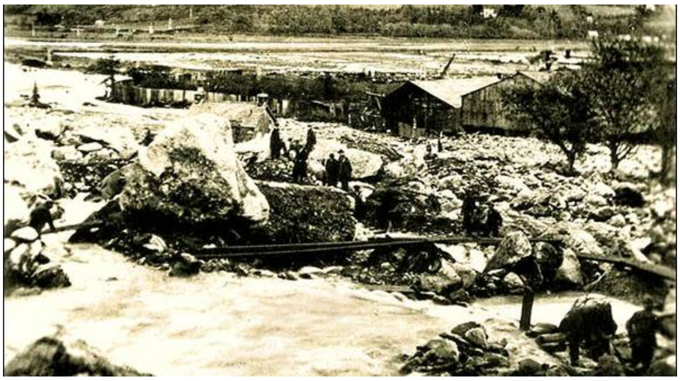
A Brief History of Dams by Richard Coackley

Richard gave us a tour de force on the history of dams from the first recorded evidence of a dam at Sadd el-Kafara, "Dam of the Pagans", 10km from Cairo built nearly 5000 years ago, together with the evolution of dams, mainly achieved by learning from dam failures.

Dam of the Pagans built circa 2850 BCE

He commenced by summarising the history of dam safety legislation in the UK.

The need for regulation of structures that impounded water was identified at the inquest into the Dale Dyke Dam failure in 1864. It concluded that there should be legislation to ensure that there were frequent, regular and sufficient inspections of all reservoirs. Even though 265 lives were lost in the disaster, no legislation was enacted at the time. The issue of dams safety came back into public attention in 1925 when two catastrophic failures occurred; one in Dolgarrog in North Wales and the other in Skelmorie in North Ayrshire.



Dolgarrog Dam disaster – Nov 1925

These failures led to the introduction of the Reservoir (Safety Provisions) Act in 1930 which required any reservoir with a capacity in excess of 5 million gallons (~22,700 cu m) to be inspected at least every 10 years by a qualified engineer (Inspecting Engineer). The Act was updated in 1975, introducing the requirement to appoint a Supervising Engineer for all reservoirs with a capacity over 25,000 cu m. The number of reservoirs of this capacity is 2892. However with Scotland and Wales reducing the capacity to 10,000 cu m this rises to 3547. If the rest of the UK enacts this lower capacity, the number of reservoirs to be inspected will rise to 3900.

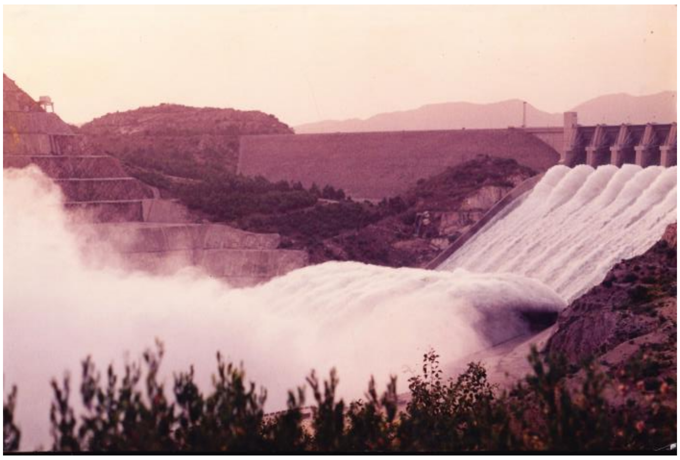
Richard then explained the two types of Reservoir Panel Engineers. In law, dam owners are wholly responsible for their safety. They must appoint a Supervising Engineer to look after the dam's safety on a daily basis and an Inspecting Engineer (Panel Engineer) to inspect the dam at least every ten years. Currently there are 135 Supervising Engineers and 30 Inspecting Engineers.

Richard then went onto describe the three types of dam: arch, gravity and buttress. One of the most famous dams in the world is the arch/gravity Hoover Dam on the Colorado River. The concrete dam took four and a half years to complete, founded on a 660ft base, 139ft below the bed of the river and 726ft high.

Hoover Dam on the Colorado River, USA

The structure incorporated pipework to control the heat of hydration of the concrete. It has been estimated that without this cooling the dam would have taken 200 years to construct!

The Tarbela Dam in Pakistan is the world's largest earth and rock dam, 470ft high and 9000ft long incorporating 138 million cubic yards of fill. The dam's two spillways are on the adjacent auxiliary concrete dams rather than the main dam.



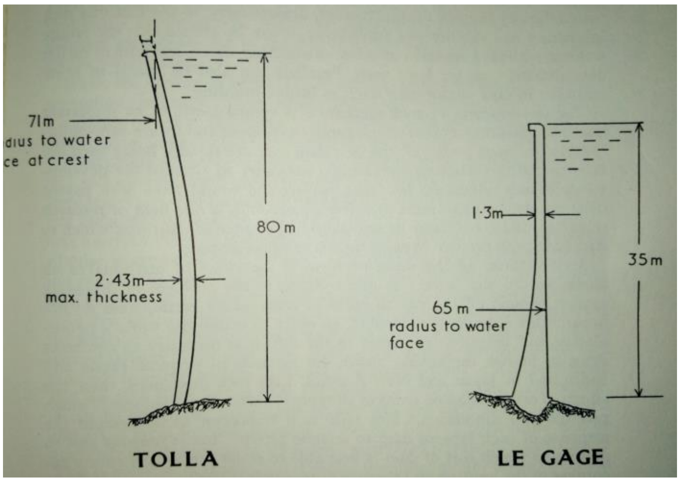
Tarbela Dam's main spillway

Buttress type dams were built after WW2 in Britain to provide storage for hydroelectric power schemes particularly in Scotland.

Buttress dams require substantially less material, either concrete or masonry, than equivalent gravity built dams.

Cruachan Dam, Scotland with concrete buttresses

At the other end of the scale, the French designed and built slender arch type dams.



Slender Arch Dams, France, Le Gage 1955, Tolla 1961

The designer Andre Coyne designed the Malpasset Dam which failed in 1959, not due to the slender arch design but to the lack of drainage in the two rock faults under the left hand abutment. This resulted in the introduction of the science of Rock Mechanics into the design of dams. As Richard ironically said, what drives better design is failure!

In 2019, the auxiliary spillway on Toddbrook Dam in Derbyshire began to disintegrate requiring the downstream face to be reinforced with rockfill and the reservoir behind to be progressively lowered to reduced the pressure on the dam.

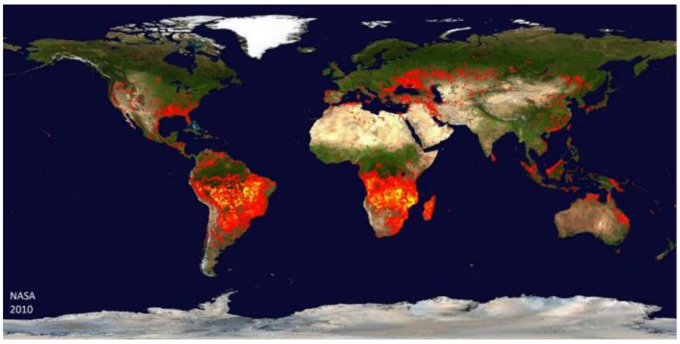
Researchers, using data from the £5 billion Copernicus Satellite, subsequently have shown that the spillway began to show deformation a year earlier. The use of this data as part of an annual survey would cost about £1000, far cheaper than a a visit by a survey team.

Rockfill on the right side the Toddbrook Spillway

Richard ended his lecture by reminding us all that an additional 4 billion litres of water/day will be required by 2050 in England to avoid severe draught. This will need to be partially achieved by substantially reducing the leakage rates as well as the public reducing its use by 25%. The balance will require the Country to spend £20 billion of investment over the next 15 to 20 years or £40 billion for emergency maintenance of water supplies to avoid an 1-in-4 chance of a severe water shortage before 2050. It is anyone's guess which option will be chosen!

Protection from Wildfires by Prof Guillermo Rein from Imperial College, London

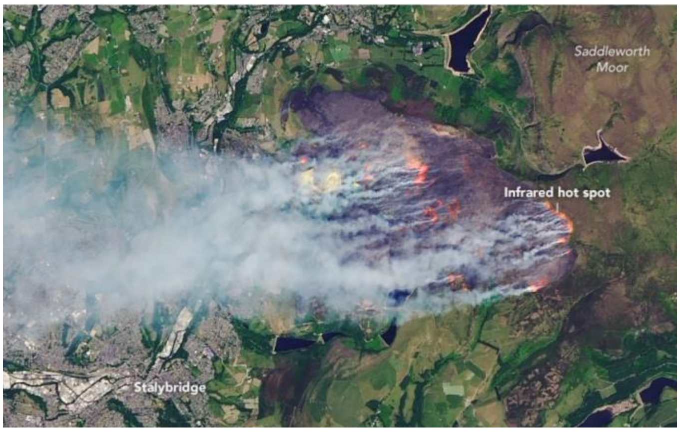
Prof Rein opened his lecture with the statement that wildfires are not new and have existed well before mankind appeared.



Areas in Red show regions that have always been prone to Wildfires.

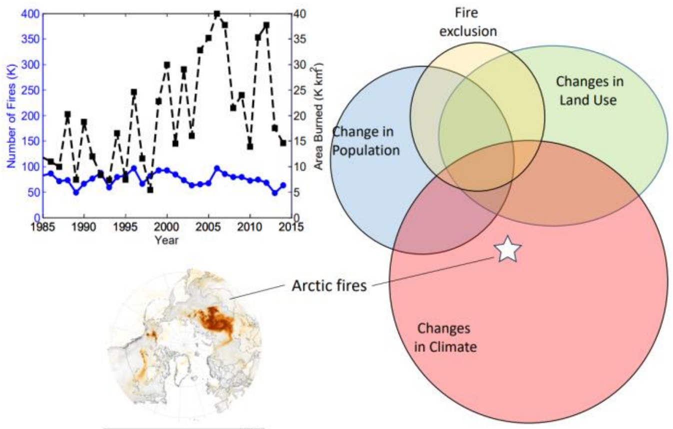
Wildfires may be more intense nowadays but their main worry to the general public is when they encroach on human occupation,ie homes. Tens of thousands of buildings are lost every year and about one million people evacuate their homes worldwide because of wildfires.

Wildfires do occur in the UK; one famous one in recent years was the Saddleworth Moor fire in 2018 which not only threatened homes but also the water supply that derived from the moor.



Aerial view of the Saddleworth Moor Wildfire

A survey of the Arctic region over the last 30 years has shown that the number of wildfires has remained fairly constant but the intensity of the fires and consequently the area burnt has increased.

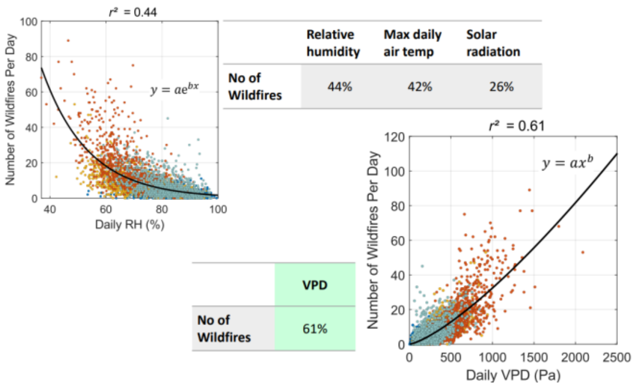


The Changes causing Wildfires

Climate change is a factor in the intensity of wildfires but there are also other man-made reasons such as change in land use and population growth.

London Fire Brigade (LFB) record all fires including wildfires and this data can be used to assess the probability of predicting wildfire occurrence. In a similar vein, the Met Office have comprehensive records of weather data. Can, asked Prof Rein, we relate the two sets of data to predict potential wildfires?

The Met Office has daily records for relative humidity, max air temperature and solar radiation. When comparing these records against the number of wildfires in London from the LFB's records, the scatter is too great, at best a 42% prediction related to the relative humidity. However if the Vapour Pressure Deficit (VPD), which is derived from an empirical formula using the air humidity and air temperature, is used a closer correlation with the number of wildfires can be made. The higher the VPD the more wildfires.



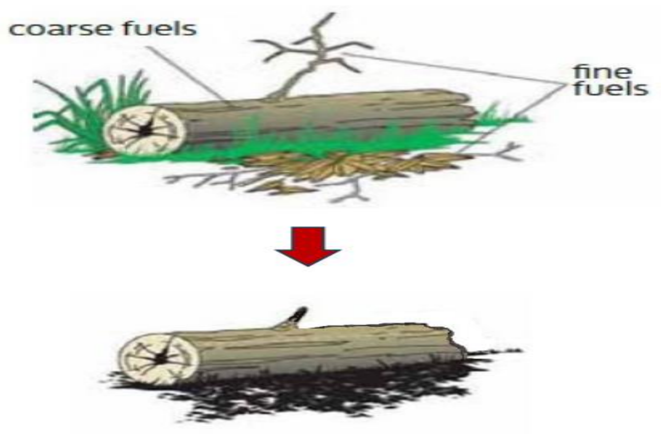
Relating Met Office data to number of wildfires

The Met Office define 3-days exceeding 28 degC as a heatwave. This unfortunately cannot predict firewaves which are the connecting up of numerous outbreaks of wildfires. However, LFB records show that there is a relationship with VPD records; 10 very dry days of high VPD can indicate a potential for firewaves.

The last potential firewave in London was on the 19th July '22 after a very dry spell ie at least 10 days of high VPD. Although there were numerous wildfires around the Capital, no firewave developed due primarily to the lack of wind which prevented adjacent outbreaks from joining together.

The study of fire science is the relationship between the Intensity and the Severity of a fire. Intensity measures the rate of energy released whilst the Severity measures the degree of damage caused by the fire. In wildfires the intensity is related to the length of the fireline, the flame height and the rate of spread. Wildfire severity has both an ecosystem, say landscape change, and a social impact such as loss of life and/or property.

To understand wildfires a knowledge of the fuel characteristics is requires. Fine fuels such as leaves, needles, grass, twigs etc when dry burn quickly. Coarse fuels such as branches, logs and soil when dry burn slowly. Native Americans used controlled burning of the floor litter to prevent major forest fires.



Fine fuels	Coarse fuels
Up to **6mm** in diameter	More than 6mm in diameter

Prof Rein advised that wildfires will always occur, what we must do is to minimise their effect.

There are six step for wildfire protection

1. Prevention – avoid ignition
2. Detection – as soon as possible
3. Suppression – put out the flames
4. Compartmentation – keep fire away from other forests
5. Evacuation – run and get away
6. Damage Resistance – design strong buildings

Prof Rein ended his lecture by stating that wildfires have always contributed carbon into the atmosphere, however if this carbon can be recovered in seven years its effect on the climate will be negligible. A thought provoking statement in regard to climate change!

New Members

John Baron is a Member of the Institution of Civil Engineers and before retirement Integrated Management Systems Manager at TPS Consult.

EUR ING Bernard Bourdillon is a Chartered Engineer, Member of the Institution of Engineering and Technology and currently a consultant at, and before retirement, a Partner at Dr J H Bourgoyne and Partners LLP.

Charles Dendy is a Member of the Institution of Civil Engineers and before retirement, General Manager for the DBFO scheme operating company, Direct Route Fermoy Construction Ltd.

Damian McClelland is a Fellow of the Royal College of Surgeons Edinburgh (FRCS), Member of the Faculty of Sports and Exercise Medicine Ireland and UK (MFSEM-RCS and RCSI)

EUR ING Colin Newsome is a Fellow of the Institution of Civil Engineers and Fellow of the Permanent Way Institution and before retirement was Chief Track and Switches and Crossings Engineer at Network Rail.

Dr Hooi Lee is a Member of the Institution of Civil Engineers and currently Asset Management Project Management Consultant with Egis Group UK.

EUR ING Philip Holliday is a Fellow of the Institution of Civil Engineers, Member of the Canadian Society for Civil Engineering and currently Pre-Construction Director with Balfour Beatty Major Projects and Highways.

RIP

Barbara Muller A thanksgiving Service was held in Nov '23 for Barbara, wife of IESF Past President, Michael Muller both of whom were great supporters of IESF.

IESF Members and partners were well represented at the Thanksgiving Service. Unfortunately, Michael passed away on 18th Dec '23.

Gerry Clarke was a Member of the Institution of Civil Engineers, the Institution of Structural Engineers and the Concrete Society. Before retirement he was a Director at the Ove Arup and Ptrs office in Paris. He joined IESF (Paris) in 1974 and transferred to the British Section in 1987.

Dr Ian Smith was a Member of the Institution of Civil Engineers and the Institute of Marine Engineering Science and Technology. Before retirement he was Managing Director at Global Maritime Holdings Group of Companies.

Michael Muller FREng was a Fellow of the Institution of Civil Engineers and before retirement a Director at W S Atkins. He was the President of IESF in 1996.

Our thanks are due to those who have contributed to this newsletter. The editor welcomes contributions on matters that relate to the objectives of the Société. Email:paulgerrard24@gmail.com