FOREWORD

Recognizing the importance elements in the investigation and enforcement of the Department of Environment (DOE), a plan called Environmental Forensic Plan of Department of Environment Malaysia has been developed.

The plan contains objective, strategies and activities that will be implemented to ensure the success of environmental forensic plan. The plan contains seven (7) major objectives to ensure forensic elements can be applied in the investigation and enforcement works successfully. With this plan, the Department of Environment will carry out activities that have been lined up within a set time frame to achieve specified objectives.

It is hoped that with the publication of The Environmental Forensic Plan , it could be understood and implemented with the full commitment of all DOE staff whether at the headquarters, states and branches.

"Conservation of the Environment, Our Shared responsibility"

Dato Halimah Hasan
Ketua Pengarah Alam Sekitar
Jabatan Alam Sekitar Malaysia
Kementerian Sumber Asli dan Alam Sekitar
Oktober 2015

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Table of Contents

1.0 BACKGROUND

The Department of Environment (DOE) will place greater emphasis on the precautionary principle approach as one of the key considerations towards enhancing the environmental protection legislative framework of Malaysia. The precautionary principle enables rapid response in the face of possible danger to human, animal or plant health, or to protect the environment. The principle may be invoked when a phenomenon is identified by scientific or objective evaluation to have potentially adverse effects; case-in-point environmental contamination that resulted in severe environmental damage.

The use of scientific and objective evaluation to ascertain the source of pollution leading to the identification of the responsible party for the purpose of remedying the damage is also the fundamental principle of environmental forensics. The necessity to provide defensible evidences for any type of pollution requires the establishment of a solid team of forensic experts and a specific guideline for enforcement.

DOE has taken a proactive approach to begin the process of equipping their officers with the necessary skills, upgrading of infrastructure support, and also linkages with relevant institutions, to address the changes that are expected in the forthcoming environmental legislation. The Environmental Forensic Plan (EFP) is thereby developed to ensure the necessary actions are taken systematically.

This document describes the EFP and is prepared based on the following inputs:

- Review of environmental forensic implementation in five developed countries (USA, EU, Australia, Japan and Korea)
- Review of current DOE organisational structure, competencies and facilities in relation to environmental forensic implementation
- Review of local institutions relevant to the establishment of the field of environmental forensic in DOE
- Review of Act 127 and relevant legislation in the country in relation to legal provisions for inclusion of environmental forensic in court cases
- Review of scientific and technical literature on environmental forensic

2.0 OVERVIEW OF THE ENVIRONMENTAL FORENSIC PLAN

The structure of the EFP is divided into sections that represent one or more of the elements of environmental forensics required in the value chain of activities of an environmental crime scene investigation and litigation as shown in Figure 1.

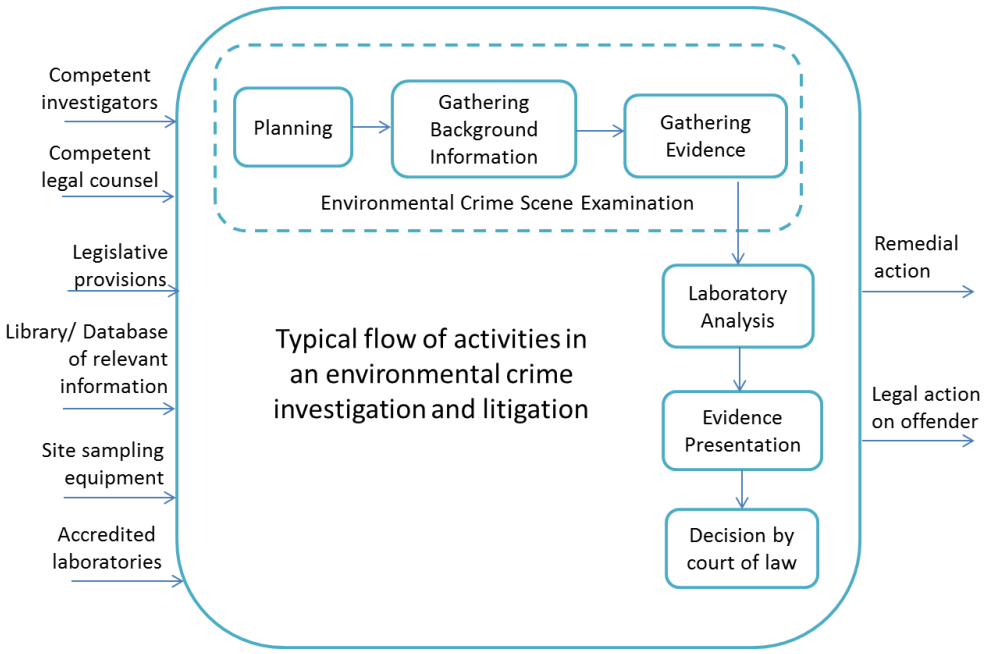

Figure 1: Elements of environmental forensics to produce defensible data for litigation purpose to recover cost of remedial actions.

The Sections of the EFP are:

- Overview of the EFP
- Legislative Provisions for Inclusion of Environmental Forensic in Prosecution
- Manpower Development for Competent Investigators and Competent Legal Counsels
- Information Support for Environmental Crime Scene Investigation
- Equipment for Site Measurement and Sampling at Crime Scene
- Laboratories for Analysis of Crime Scene Samples
- In-house Accredited Facilities for Environmental Forensic
- Formal Arrangement with Designated Institutions
- Implementation of Remedial Actions

The Logical Framework Approach (LFA) was adopted to guide the development of the EFP from planning to monitoring and evaluation (for improvement even during the course of

implementation). The initial LFA is attached as Appendix A and will be used as one of the guiding tool for feedback from stakeholders during consultation on the EFP.

2.1 Targets and Scope of the EFP

The owner of the EFP is DOE who will take full responsibility to implement or provide avenue for related institutions to implement the actions over a 5-year period leading to the establishment of environmental forensics in investigation and enforcement activities.

The overall objective of the EFP is:

To reduce local and transboundary environmental crimes through wider adoption of environmental forensics by DOE

The overall objective of the EFP can be achieved through the following specific objectives:

- To strengthen ACT 127 with additional clauses that is directly related to application of environmental forensic and clean-up programmes.
- To establish an Environmental Forensic Section within a new division at DOE Headquarter
- To increase the number of DOE officers that are competent in the science, technology and legal aspects of environmental forensics.
- To enhance site measurements and sampling facilities at DOE for environmental forensic application.
- To enhance laboratory facilities at relevant institutions for environmental forensic application.
- To establish a DOE environmental forensic laboratory to house facilities that are not available or are insufficient at the associated institutions
- To establish formal linkages between DOE and designated institutions for implementation of environmental forensic work in the country.

The deliverables or outputs (expected results) of implementing the EFP are:

- Application of new clauses or regulations on environmental forensic in court cases
- Establishment of an Environmental Forensic Unit that will handle all environmental forensic cases
- Competent DOE officers in environmental forensics available at HQ and Branch Offices
- Availability of defensible data obtained directly from measurements at contaminated sites or affected sites

- Availability of defensible test data obtained from accredited laboratories of designated institutions
- Establishment of an environmental forensic laboratory at DOE to cope with testing requirements that cannot be delivered by associated laboratories
- Faster response time and more comprehensive environmental crime investigation

The formal definition adopted for environmental forensic in the context of the EFP is as follows:

"Environmental forensics is the systematic and scientific evaluation of data obtained from field measurements or laboratory analysis, and historical information of an environmental crime scene for the purpose of developing defensible scientific and legal conclusions regarding the source or age of a contaminant released into the environment."

Environmental crime scene refers to the occurrence of an environmental contamination or pollution that causes environmental damage where the source and extent of the pollution has not been ascertained, unlike the Non-compliance cases where the point source is known and found to exceed regulatory limit(s).

Environmental damage in the context of a prosecution case or any proceeding will refer to the evidences collected at or from the surroundings of the environmental crime scene, and the analytical results will be compared with the values determined as environmentally hazardous as provided under the approved Code of Practice(s) [such as Air Pollution Index, National Water Quality Standard, Marine Water Quality Standard, Groundwater Standard and Background Soil Profile, etc.], whichever is relevant to the affected environment.

3.0 DETAILS OF THE ENVIRONMENTAL FORENSIC PLAN

3.1 Legislative Provisions for Inclusion of Environmental Forensics in Prosecution

Similar to many countries, the existing environmental protection or pollution control legislation in Malaysia, in particular the EQA Act 127 has embedded some elements of environmental forensics without explicitly mentioning their use.

The EQA Act 127 contains a number of clauses that are sufficient to prosecute offenders of environmental crimes but the severity of the penalties may not be sufficient to cover the cost of the remedial actions. The regulations that have been established under the Act however have more clout in this respect and should be sufficient to prosecute and recover the remedial costs. The clauses that can be considered for enhancement in terms of severity of penalties are described in the subsequent sections.

3.1.1 Identified clauses of Act 127 for expansion to include elements of environmental forensics

As shown in Table 1, a number of clauses in Act 127 are sufficient to prosecute offenders and can be expanded to enhance the visibility of environmental forensic elements as shown.

Table 1: Clauses in Act 127 with prohibition orders and penalties

No.	Clause in Act 127	Possible Expansion
A.	PART IV PROHIBITION AND CONTROL OF POLLUTION	PART IV PROHIBITION, INVESTIGATION AND CONTROL OF POLLUTION
1.	Sections 22 Restriction on of the atmosphere	• Sufficient to prosecute for offence on emission to the atmosphere • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
2.	Sections 24 Restriction on pollution of the soil	• Sufficient to prosecute for offence on discharge to the soil • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
3.	Sections 25 Restriction on pollution of inland waters	• Sufficient to prosecute for offence on discharge to inland waters • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
4.	Sections 27 Prohibition of discharge	• Sufficient to prosecute for offence on discharge of

	of oil in Malaysian waters	oil in Malaysian waters • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
5.	Section 29 Prohibition of discharge of wastes into Malaysian waters	• Sufficient to prosecute for offence on discharge of wastes in Malaysian waters • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
6.	Section 29A Prohibition on open burning	• Sufficient to prosecute for offence on open burning • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
7.	Section 29B. Owner or occupier of premises liable for open burning	• Sufficient to prosecute owner or occupier of premise for open burning
8.	Section 31 Power to require owner or occupier to install, operate, repair etc.	• Sufficient to prosecute owner or occupier to carry out some form of remedial action • No mention of the extent of remedial action as in restoration to the baseline value
9.	Section 33 Power to prohibit or control licensed persons from discharging etc. of wastes in certain circumstances	• Sufficient to prosecute any licensed persons who contravenes a notice to abate emissions, discharges etc. • Fine does not cover cost of remedial action or clean-up programme and has to link to Sections 46 and 47
B.	PART IVA CONTROL OF SCHEDULED WASTES	
1.	34B Prohibition against placing, deposit, etc. of scheduled wastes	• Sufficient to prosecute any person who has contaminated the environment with scheduled wastes • Fine does not cover cost of remedial action or clean-up programme
C.	PART VA PAYMENT OF CESS AND ENVIRONMENTAL FUND	
1.	Section 36E The fund shall be administered for the purpose of- (b) recovering of waste, removing, or dispersing, destroying, cleaning, disposing of or mitigation pollution; (c) preventing or combating the following occurrences: (i) spillage, discharge or dumping of oil (ii) a discharge, deposit or dumping, of environmentally hazardous	• Possible source of funds for implementing remedial actions • Clause on when the fund can be applied in the absence of a conviction on any possible offender

	substances; or (iii) a discharge, deposit or dumping, of waste;	
D.	PART VI MISCELLANEOUS	
1.	Section 40 Evidence	• The evidence referred to in this clause applies more to the issue of licenses and does not cover defensible evidences of data and information for litigation purpose. • Clause on evidence collection and presentation in relation to environmental crime scene investigation • Clause on time frame related to relevance of scientific evidence • Clause on tracking
2.	Section 46E Compensation for loss or damage to property	• Sufficient to cause convicted person to pay for loss or damage of property to the affected party • Include extent or scope of recovery such as linking to baseline conditions or condition stipulated by the enforcement agency
3.	Section 47 Power of recovery of costs and expenses	• Sufficient to recover remedial costs and expenses from the convicted party • Include extent or scope of recovery such as linking to baseline conditions or condition stipulated by the enforcement agency

Section 40 of the Act on 'Evidence' has the highest scope for expansion to include presentation of evidences obtained from environmental forensic investigation for prosecution purposes. Sections 37 and 38 already provide sufficient clout for DOE to force owners or occupiers to furnish information or power to examine premises and vehicles. If necessary, some additional clauses can be added to strengthen their authority.

Suggested expansions include the following :

To include provision for Minister to approve the relevant Code of Practice(s) exemplified by clauses such 37 (Approval of Industry Codes of Practice), s38 (Use of Industry Codes of Practice in Proceedings) and s60 (Onus of proving limits of what is practicable).

1. OSHA Act 1994: **Approval of industry codes of practice**

   a) The Minister may, upon the recommendation of the Council or the Director General, approve industry codes of practice comprising such directions as may appear to him to be necessary or proper for the guidance of persons in complying with the requirements of the provisions of this Act.

b) The Minister may, upon the recommendation of the Council or the Director General, from time to time revise the industry codes of practice by amending, deleting, varying or adding to the provisions of the industry codes of practice.

   i. An industry codes of practice may—
   ii. consist of any code, standard, rule, specification or provision relating to the environment approved by the Minister; or

c) apply, incorporate or refer to any document formulated or published by anybody or authority as in force at the time the industry code of practice is approved or as amended, formulated or published from time to time.

d) The Minister shall cause to be published in the Gazette the approval of an industry code of practice and the amendment or revocation thereof.

2. To include provision for the use of the approved Code of Practice(s) in proceedings; and

Use of industry codes of practice in proceedings (taken from OSHA 1994)

In any proceedings under this Act or any regulation made thereunder in which it is alleged that a person has contravened or failed to comply with a provision of the Act or any regulation made thereunder in relation to which an approved industry code of practice was in effect at the time of the alleged contravention or failure—

a) the approved industry code of practice shall be admissible in evidence in the proceedings; and
b) if the court is satisfied in relation to any matter which it is necessary for the prosecution to prove in order to establish the alleged contravention or failure that—
   i. a provision of the approved industry code of practice is relevant to the matter; and
   ii. the person failed at any material time to observe the provision of the approved industry code of practice,

the matter shall be taken as proved unless the court is satisfied that in respect of the matter the person complied with a provision of the Act otherwise than by way of observance of the provision of the approved industry code of practice.

The above two clauses presents the possibility to develop the Environmental Forensic Guideline as the equivalence of the codes of practices (COPs) used by OSHA as admissible documents and outputs from the COPs as admissible evidence for environmental forensic cases.

In the implementation of remedial actions, another clause of the OSHA Act that can be adapted to determine the level of clean-up of a contaminated or polluted site through a provision on the onus of providing limits of what is practicable:

- **Onus of providing limits of what is practicable** (taken from OSHA 1994)

  In any proceedings for an offence under this Act or any regulation made thereunder consisting of a failure to comply with a duty or requirement to do something so far as is practicable, or to use the best practicable means to do something, it shall be for the accused to prove that it was not practicable to do more than was in fact done to satisfy the duty or requirement, or that there was no better practicable means than was in fact used to satisfy the duty or requirement.

3.1.2 Identified clauses of Regulations and Orders for expansion to include elements of environmental forensics

There are a total of thirty-six (36) regulations and orders currently enforced under the EQA 1974 by DOE. Within these regulations and orders are found clauses applicable to environmental forensics as listed in Table 2. An important consideration is the Orders pertaining to the delegation of powers to investigate offences related to specific sections of the Act in the context of environmental forensic investigation.

Where the regulations permit actions to be taken in relation to contamination related to the specific type of pollutant, the regulation should be studied to ensure the elements of environmental forensics are embedded or explicitly mentioned.

Table 2: Regulations of Act 127 with prohibition orders and penalties

No.	Regulations/ Order	Possible Expansion
1.	Environmental Quality (Clean Air) Regulations 2014	
1.1	Regulation 8 Failure in operations of air pollution control system	• Applicable for action to be taken against offender identified for an environmental contamination due to failure in operations of air pollution control system
1.2	Regulation 13 Limit values and technical standards	• Applicable for action to be taken against offender who have been found to exceed regulatory limits
1.3	Regulation 15 Hazardous substances	• Applicable for action to be taken against offender who have contaminated the atmosphere with hazardous substances
1.4	Regulation 21 Accidental emissions	• Applicable for action to be taken against offender for who have contaminated the atmosphere due to accidental emission
2.	Environmental Quality (Sewage) Regulations 2009	

2.1	Regulation 12 Prohibition against sewage discharge through by-pass	• Applicable for action to be taken against offender who have contaminated any soil or inland waters with sewage discharge
2.2	Regulation 13 Spill or accidental discharge of sewage	• Applicable for action to be taken against offender who have contaminated any soil or inland waters with spill or accidental discharge of sewage.
2.3	Regulation 14 Prohibition against sewage discharge of sludge into inland waters or Malaysian waters	• Applicable for action to be taken against offender who have contaminated inland waters or Malaysian waters with sludge from sewage treatment systems
2.4	Regulation 15 Restriction on the disposal of sludge onto land	• Applicable for action to be taken against offender who have contaminated soil or any surface of land with sludge from sewage treatment systems
3.	Environmental Quality (Industrial Effluent) Regulations 2009	
3.1	Regulation 18 Prohibition against industrial effluent or mixed effluent discharge through by-pass	• Applicable for action to be taken against offender who have contaminated any soil or inland waters with effluent and mixed effluent discharge
3.2	Regulation 20 Spill accidental discharge or leakage of industrial effluent or mixed effluent	• Applicable for action to be taken against offender who have contaminated any soil or inland waters with spill or accidental discharge of effluent and mixed effluent discharge.
3.3	Regulation 23 Restriction on discharge or disposal of sludge	• Applicable for action to be taken against offender who have contaminated soil or any surface of land, inland waters and Malaysian waters with sludge from production or manufacturing process, any industrial effluent treatment system or water treatment plant.
4.	Environmental Quality (Scheduled Wastes) Regulations 2005	
4.1	Regulation14 Spill or accidental discharge	• Applicable for action to be taken against offender identified for an environmental contamination in any environmental compartment related to scheduled wastes. • Expand waste generator's role on top technical expertise to the contractor, including possible joint responsibility of the clean-up programme.
5.	Environmental Quality (Delegation of Powers on Marine Pollution Control) Order 1993	
5.1	Paragraph 2 Delegation of powers to investigate certain offences	• Possible expansion to provide avenue for presentation of forensic evidence through the delegated powers in the event of a litigation
6.	Environmental Quality (Delegation of Powers) Order 1999	
6.1	Paragraph 2 Delegation of powers under sections 31 and 37 of the Act	• Possible expansion to provide avenue for presentation of forensic evidence through the

		delegated powers in the event of a litigation
7.	Environmental Quality (Delegation of Powers) (Investigation of Open Burning) Order 2000	
7.1	Paragraph 2 Delegation of powers	• Possible expansion to provide avenue for presentation of forensic evidence through the delegated powers in the event of a litigation
8.	• Environmental Quality (Delegation of Powers) (Perbadanan Putrajaya) Order 2002	
8.1	Paragraphs 2 and 3 Delegation of powers	• Possible expansion to provide avenue for presentation of forensic evidence through the delegated powers in the event of a litigation
9.	Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations 2009	
9.1	Regulation 17 Prohibition against leachate discharge or release through by-pass	• Applicable for action to be taken against offender who have contaminated soil or inland waters and Malaysian waters with leachates from solid waste transfer station or landfill
9.2	Regulation 19 Spill, accidental discharge or leakage of leachate	• Applicable for action to be taken against offender who have contaminated soil or inland waters and Malaysian waters with leachates that are spilled, accidentally discharge or leaked from solid waste transfer station or landfills.

3.1.3 Other legislation with possible direct link to the field of environmental forensics

Another eighteen (18) laws in the country contain clauses that have direct association with environmental protection as provided by the definition of "element" in the EQA which in relation to the environment means any of the principal constituent parts of the environment including water, atmosphere, soil, vegetation, climate, sound, odour, aesthetics, fish and wildlife. The Malaysian laws are:

a) *Fisheries Act 1985 - www.moa.gov.my
b) Land Conservation Act 1960 - www.jkptg.gov.my
c) Local Government Act 1979 - www.jkt.gov.my
d) *Merchant Shipping (Oil Pollution) Act 1994
e) National Forestry Act 1984 - www.forestry.gov.my
f) National Park Act 1980 - www.wildlife.gov.my
g) Plant Quarantine Act 1976 - www.moa.gov.my
h) Pesticides Act 1974 - www.moa.gov.my
i) Protection of Wildlife Act 1972 -www.wildlife.gov.my
j) *Radioactive Substance Act 1968 - www.mosti.gov.my
k) Sewerage Services Act 1993 - www.jpp.gov.my
l) Sarawak Biodiversity Centre Ordinance 1997
m) Sabah Biodiversity Enactment 2000
n) Sarawak Natural Resources and Environment (Amendment) Ordinance2001
o) Sabah Environment Protection Enactment 2002
p) Sabah Forest Enactment 1968

q) Sarawak Forest Ordinance 1954
r) Town & Country Planning 1978

Three of the laws, marked in asterisk in the above list contain potential applications of environmental forensics to prosecute polluters in particular on the inclusion and exclusion of penalties and fines as described in Appendix B. The enforcement of the three laws and the mode of investigation are described briefly herewith in Table 3.

Table 3 : Elements of enforcement and investigation in three laws that may have association with environmental protection

Act	Enforcement Agency	Mode of Enforcement and Investigation
Fisheries Act 1985	Department of Fisheries (Administration and management of fisheries)	Issuance of license requires licensee to mitigate overexploitation and conflicts among user groups. The overfishing resulting from open access to fish resources is regulated with restriction of vessel operations, setting of minimum fish-size limits, time and area closures and quotas. User conflicts are often addressed with gear prohibitions or restrictions and zones to separate user groups, typically controlled through monitoring, surveillance, and enforcement.
Merchant Shipping (Oil Pollution) Act 1994	Marine Department of Malaysia	Liability for any pollution damage caused by the ship as a result of the incident in area of Malaysia is explicitly spelled out in the Act (described in Appendix B) e.g. the liability of damage does not apply to categories of people are described clearly.
Radioactive Substances Act 1968	Atomic Energy Licensing Board (AELB)	Governs radioactive materials or ionizing radiation in medical field. AELB enforces the waste management policy through its licensing procedure and conditions of license issued to the licensee. **Waste Management Requirements by the AELB** a) Users of radioactive materials are responsible for the waste. b) Required to be registered and licensed by AELB c) Store or return to supplier d) Users without infrastructure and expertise can request third party organization for services that are licensed/ recognized by AELB.

The other laws for example The Pesticide Act which covers applications of pesticides that are potentially toxic pollutants should they enter the environment discriminately, is however not addressed from the angle of environmental forensics but more on contamination in food and accidental death due to ingestion.

3.2 Manpower Development for Competent Investigators and Competent Legal Counsels

An environmental forensic investigation that requires the results of the whole value chain can never be carried out by one or two individuals. A typical case in environmental crime requires knowledge in many fields within science, technology and law. Hence the environmental forensic team should comprise of DOE officers and also associated personnel from designated institutions with a mix of knowledge of engineering (chemical processes and technology, field techniques and instrumentation), chemistry (laboratory sample analysis, chemical reactions and processes) and law (environmental regulations). Specialists or experts in fields of DNA, microbial and isotopic printing may be required in some cases but may not be regular requirements for most environmental crimes. Aside from specialists, IT background staff may be required in gathering background information and data mining even through the extensive amount of information that is now available in the public domain. The appropriate team members and experts that will be formed depend on the type of case being investigated and the personnel resources available.

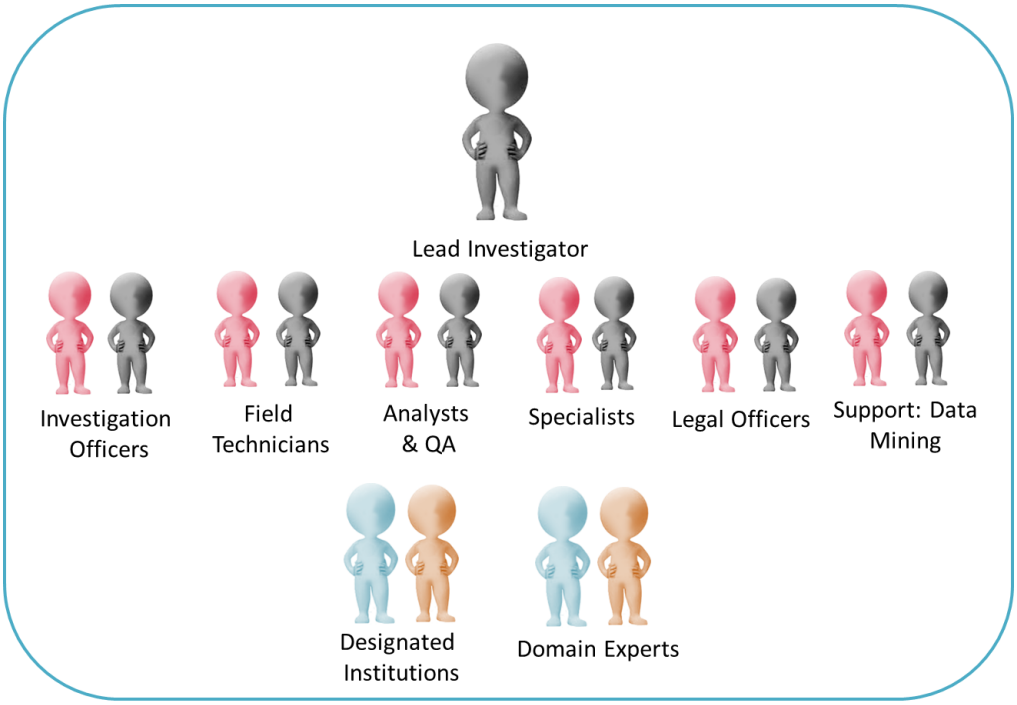

Figure 2: General composition of an environmental forensic investigation team

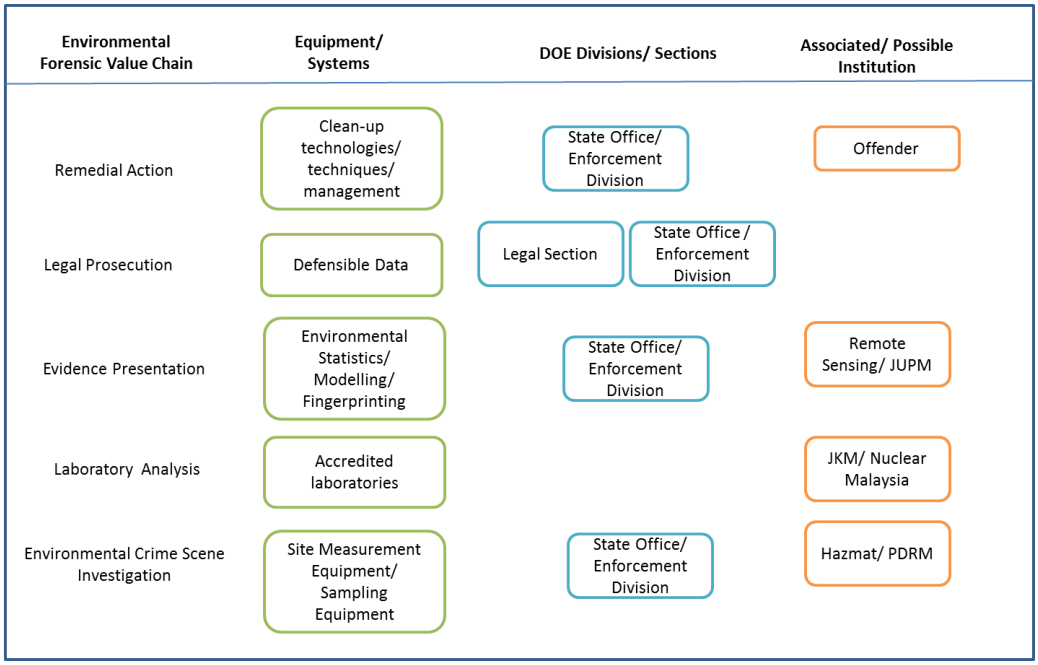

Figure 3: Preliminary mapping of resources required for implementation of environmental forensic investigation under the purview of DOE.

Figure 2 is the composition of a typical environmental forensic team formed to implement the whole value chain of environmental forensics up to the clean-up stage. The range of competencies needed in a team will likely be beyond the organisation structure of DOE as shown in Figure 3. DOE will host the key human resources needed and establish formal linkages with specific individuals in the designated institutions in particular experts that are not needed as full-time salaried staff of the organisation.

One of the best examples of the placement of the Environmental Forensic Unit or Section within the organisation structure of an environmental protection agency is the USEPA. In the USEPA, HQ Office of Enforcement and Compliance Assurance (OECA) is in charge of the the Office of Criminal Enforcement, Forensics and Training (OCEFT) that in turn also house the National Enforcement Investigation Centre (NEIC) as shown in Figure 4.

A similar line of reporting can be adopted by DOE as a start to the establishment of environmental forensic investigation in the Department. In the current DOE organisation structure, a small group of staff has been assigned to the Environmental Forensic Section that was set up under the HQ Enforcement Division. The existing arrangement can be expanded to form a Section or Unit under a new Division proposed as the Environmental Forensic and Intelligence Division according to the structure shown in Figure 5.

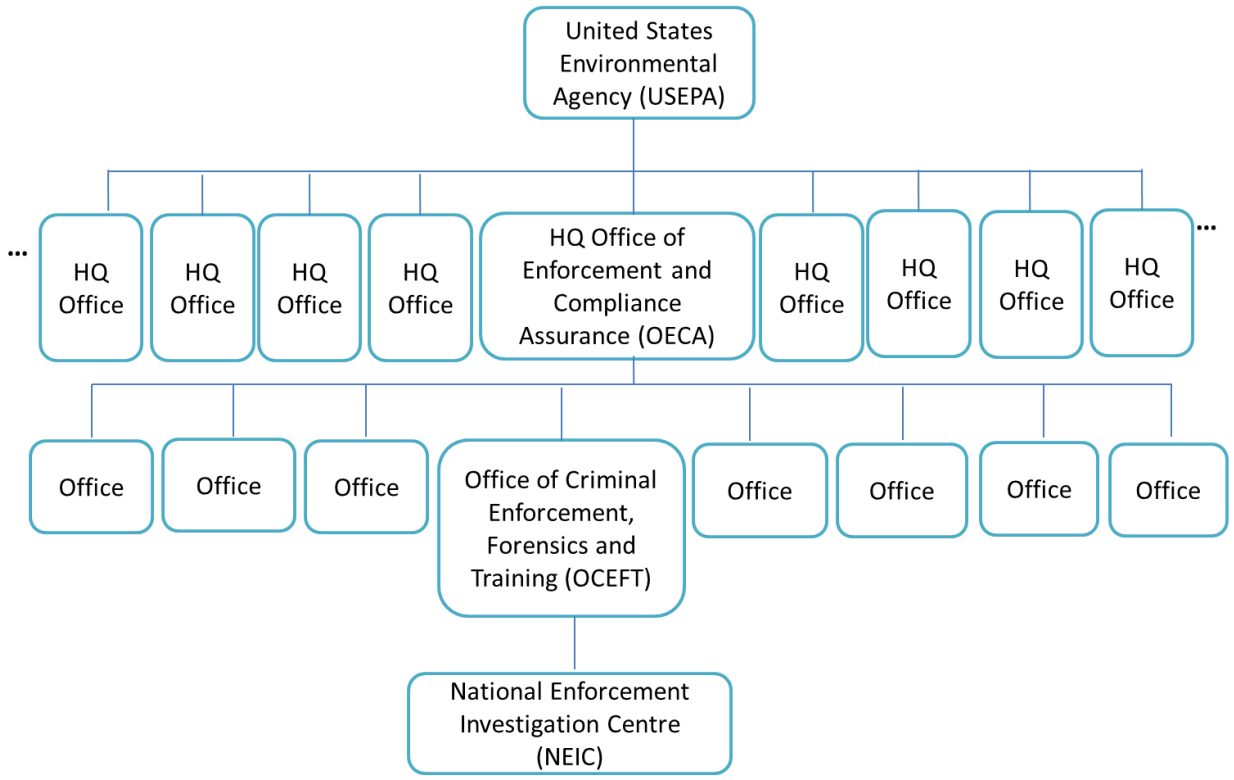

Figure 4: The link between NEIC as the environmental forensics centre under the Office of Enforcement and Compliance Assurance of the USEPA

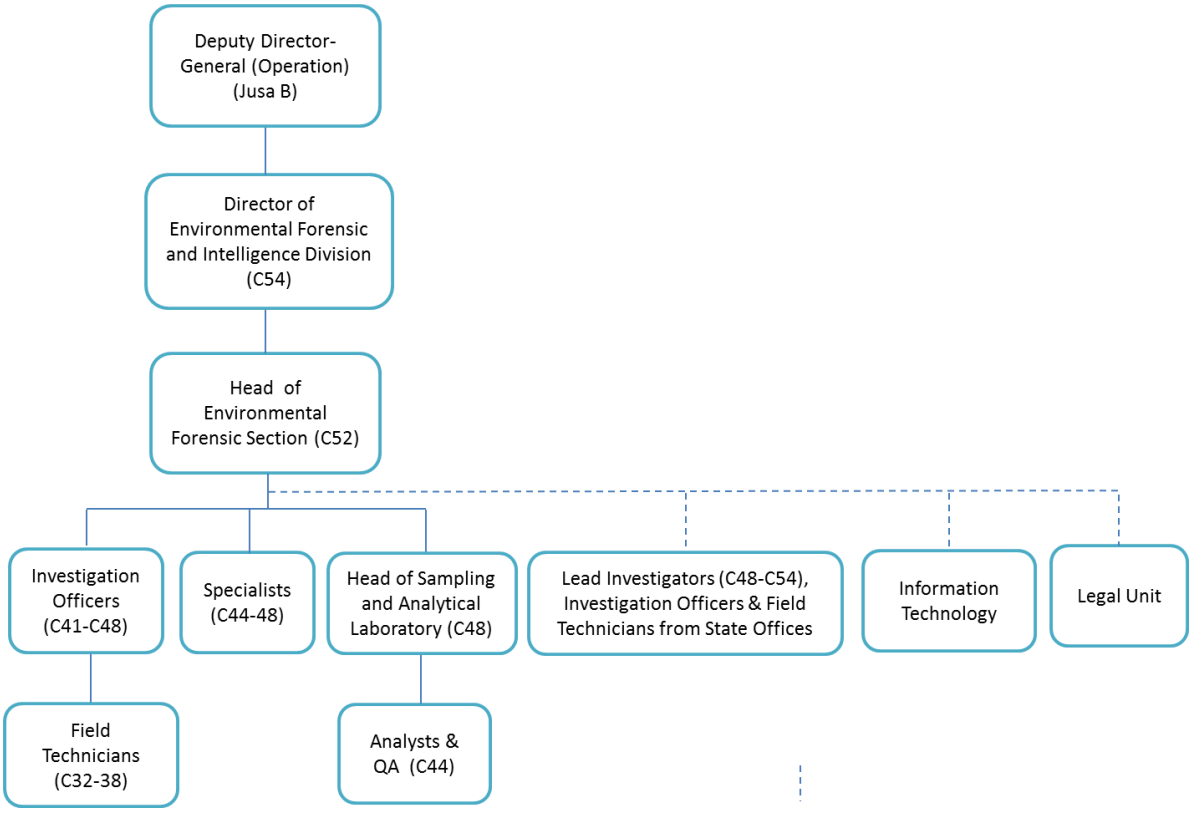

Figure 5: Positioning of the Environmental Forensic Section under the proposed new Environmental Forensic and Intelligence Division

Role and Functions of the HQ-Environmental Forensic Section are listed herewith:

- To be a one-stop centre for all environmental forensic investigation of DOE
- To identify the composition of the environmental forensic team for every environmental crime
- To plan for the development and expansion of the environmental forensic activities in terms of manpower, facilities and infrastructure
- To monitor success rate of solving environmental crimes in the country
- To coordinate training needs of DOE officers in the area of environmental forensics
- To conduct or coordinate research activities that will strengthen the environmental forensic capacity of DO

The subsequent sections describe qualifications and competencies required to establish a pool of environmental forensic investigators that will be hosted under the Environmental Forensic Section of the proposed Environmental Forensic and Intelligence (EFI) Division, with staff input from the State Offices as needed for a particular investigation.

The Environmental Forensic and Intelligence (EFI) Division should be headed by a Director (C54) of similar standing and function as Directors of other Divisions and State Offices of DOE in carrying out the standard responsibilities such as planning, monitoring, management and administrative approvals of staff assigned to them. He/ She will also take on the role of lead investigator as appointed by the Deputy Director General (Operation). The line of reporting directly to the Deputy Director General is recommended to facilitate enlisting the appropriate Subject Matter Experts (SMEs) or specialists in the shortest time possible when an environmental crime has taken place.

The Head of Environmental Forensic Section should hold a senior ranking grade (C52) and reports to the Director of EFI Division. The other staff members of the Section include Investigation Officers (C41-C48) and Field Technicians (C27-C32) for field work, Head of the Laboratory (C48) and Analysts and QA (C44) for laboratory work, and Specialists (C44 onwards) such as statistician and fingerprinting competent persons.

The other competencies such as legal, and information storage and retrieval are shared services that need not be housed under the Environmental Forensic Section although they should have certain level of priority accorded to any environmental forensic investigation initiated by the Environmental Forensic Section.

Whenever an environmental crime has been detected or reported, the Director of EFI in consultation with the Head of Forensic Section will recommend a lead investigator for formal appointment by the Deputy Director-General (Operation). The lead investigator can come from within the Section or from the state office based on the location or nature of the crime. The lead investigator will form the investigation team to conduct the investigation from site visit to site measurements and collection of samples to laboratory analysis, interviews, data analysis and statistical treatment until the source is identified, and the evidences collated for submission to the legal officer for prosecution. The sequence of activities is presented in a simplified flow chart in Figure 6 and the line of reporting and responsibility from steps 1 to 9 is proposed as follows:

Step Number	Responsibility
1	Head of Environmental Forensic Section receives all reports on environmental crime from public through the hot line or through leads coming from DOE state office
2	The Lead Investigator who is appointed by the Deputy DG (Operation) in consultation with the Director of EFI and Head of Environmental Forensic Section sets out to analyse the complaint/ possible environmental crime
3	The Environmental Forensic Team for the specific case is formed at the recommendation of the Lead Investigator and informed/ appointed through the Deputy DG (Operation) for DOE staff who are not part of the Environmental Forensic Section
4	The members of the Environmental Forensic Team conduct investigation under leadership of Lead Investigator
5	The completed investigation report is forwarded to the Prosecution Officer to bring the offender to justice
6	The offender receives sentence of conviction as recommended by the Prosecution
7	The court issues order for clean-up of the contaminated site
8	The Environmental Investigation Team monitors the remedial action
9	The Head of Environmental Forensic Section on the advice of the Lead Investigator will work at recovering all cost associated with the remedial action

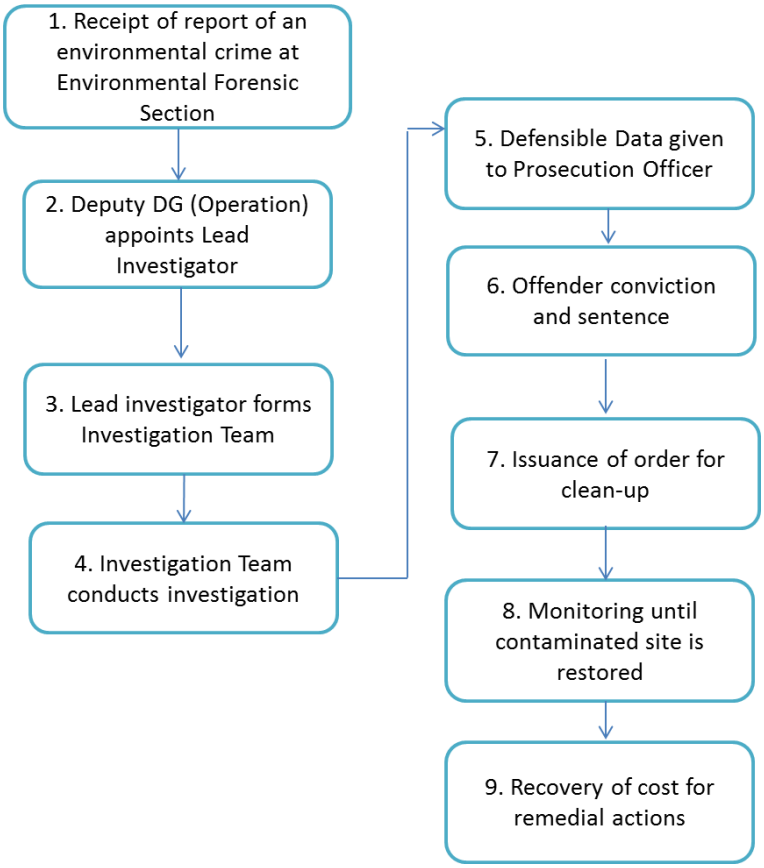

Figure 6: Flow chart of activities at the operational level of an environmental forensic investigation.

3.2.1 Basic job description of members in an environmental forensic investigation team

The brief outline of the required competencies for a DOE officer prior to taking on assignments in the environmental forensic team are additional to the standard in-house training that all DOE officers will go through as basic requirements for performance of their job as enforcement officers. The suggested arrangements should be translated into typical career and job description documentation that is already practised in DOE.

It is also expected that DOE will implement quality management systems in particular accreditation of their field service, namely site measurements and sampling, to ensure these data are defensible in court cases.

Brief job descriptions are provided herewith but the lists should be viewed as exemplary and not exhaustive.

i. Lead Investigator
- Principal accountability
  - ✓ In charge of the overall process of investigating an environmental crime.
  - ✓ Able to develop an understanding of allegations of criminal activities, and decide the types and range of evidence needed to ultimately prove the case.
  - ✓ Develop the overall plan of investigation for implementation by various parties within and outside DOE
  - ✓ Present final reports and evidence to the Legal Office for development of litigation cases
  - ✓ Signs off acceptance of outcome of remedial action
- Competencies:
  - ✓ Scientific or engineering background
  - ✓ Environmental forensics including legal knowledge
  - ✓ Organisational skill
  - ✓ Communication skill
  - ✓ Track record in enforcement experience (minimum 20 years)
- Proposed position grade: C48-54

ii. Investigation Officer
- Principal accountability
  - ✓ Assist Lead Investigator in performing relevant activities to support the investigation of an environmental crime including writing reports
  - ✓ Implement field work that will include development of sampling plan, coordinating the site duties of Field Technicians and transfer of samples to laboratories
  - ✓ Perform information search based on characteristic of crime scene
  - ✓ Liaison with identified organisations outside DOE or Subject Matter Experts or Specialists in consolidating the necessary data and information as required in the forensic plan
- Competencies:
  - ✓ Scientific or engineering background
  - ✓ Environmental forensics including legal knowledge
  - ✓ Coordination skill
  - ✓ Communication skill
- Proposed position grade: C41-48

iii. Field Technicians
- Principal Accountability
  - ✓ Responsible for collection of site data and site information according to a sampling plan, if relevant, using the appropriate instrument and equipment

- ✓ Responsible for collection of samples according to a sampling plan, if relevant, using the appropriate instrument and equipment
- ✓ Responsible for recording all crime scene observations

- Competencies:
  - ✓ Scientific or engineering background
  - ✓ Basic concepts of environmental forensics
  - ✓ Handling and maintenance of site-measurement and monitoring instrument and equipment (as described in Section 3.4)
  - ✓ Sampling according to standard methods requirement including tracking system and transfer to laboratories for analysis
  - ✓ Statistical and data treatment and presentation as materials of evidence
  - ✓ Use of Personal Protective Equipment (PPE) for different exposure (sampling for hazardous or radioactive substances)
  - ✓ Responsible for mob/demob of all site measurement and sampling instrument
- Proposed position grade: C32-C38

iv. Head of Sampling and Analysis Laboratory

- Principal Accountability
  - ✓ Responsible for overall management (planning, supervision, operational management, and development) of the laboratories that will be established to support environmental forensic work
  - ✓ Responsible for ensuring laboratories (staff and facility) achieve the ISO17025 accreditation required for scopes relevant to the forensic work
  - ✓ Responsible to coordinate the distribution of samples and consolidation of data received from designated institutions, including oversea laboratories if required.
  - ✓ Can handle the work of identifying the parameters, test methods and accredited testing laboratories for samples that are collected from the crime scene (The Head of Laboratory need not be the only one responsible to determine the type of answers coming from the laboratory, e.g. whether qualitative or quantitative but is capable of performing the duty when required)
  - ✓ Well-versed with sampling according to standard methods requirement including tracking system and transfer to laboratories for analysis
- Competencies:
  - ✓ An analytical chemistry background is preferred
  - ✓ Trained in environmental forensic science
  - ✓ Trained in ISO17025 laboratory quality management system
  - ✓ Well-versed in the analysis and testing of environmental samples for different pollutants
- Proposed position grade: C48

v. Analysts and Quality Assurance (QA) Personnel

- Principal Accountability
  - ✓ Responsible for identifying the parameters, test methods and accredited testing laboratories for samples that are collected from the crime scene as assigned by the Head of Laboratory or if already identified to participate in a specific forensic investigation case.
  - ✓ Responsible to develop, operate and maintain specific equipment for specific analysis and test methods
  - ✓ Required to support Head of Laboratory for QA procedures and work instructions to maintain a quality management system according to the ISO 17025 accreditation standard
  - ✓ Responsible to support Head of Laboratory to coordinate method validation (especially when standards methods need modification) at the designated testing laboratories
  - ✓ Responsible to provide all evidence of integrity of data obtained from site and designated testing laboratories
- Competencies:
  - ✓ Background in chemical and biological sciences
  - ✓ Basic concepts of environmental forensics
  - ✓ Handling and maintenance of site-measurement and monitoring instrument and equipment (as described in Section 3.4)
  - ✓ Sampling according to standard methods requirement including tracking system and transfer to laboratories for analysis
  - ✓ Laboratory quality management system (for site sampling and measurements) based on ISO17025
- Proposed position grade: C44 (can start at C41 for those who are recruited with laboratory experience)

vi. Support Personnel (IT Personnel)

- Principal Accountability
  - ✓ Establish a forensic-specific library that can be printed or online, comprising a network of information sources and databases for easy access and search while investigating an environmental crime. Among others, the information can include:
    - Legal and regulatory database of statutes, regulations and past case information
    - Information on facilities, companies and industrial processes
    - Technical literature, standards and analytical methods including listing of field procedures
    - Historical aerial photographs
    - Experts listing

- ✓ Provide support to management of computerised data treatment from sampling, site measurement and analytical teams as required in the Accreditation scheme.

DOE is well-equipped with the basic Geographical Information System (GIS) capabilities, namely ArcGIS version 10.2 is available not only at HQ but at every state office. Handling the ArcGIS software for spatial mapping is quite an established activity at DOE. The GIS capability is one of the key areas that are fundamental to environmental forensic investigation.

- Competencies:
  - ✓ IT background
  - ✓ Basic concepts of environmental forensics
- Proposed position grade: C44

vii. Specialists (specialists in certain fields within DOE that may not be required full-time in an environmental crime investigation but expertise is still sought to deliver some aspects of the case, could be the Subject Matter Experts (SMEs) of DOE)

- Principal Accountability
  - ✓ Responsible for providing specialist's input on specific topics, including data treatment and interpretation from site measurements or laboratory analysis in areas such as:
    - Statistical treatment e.g. multivariate statistical analyses
    - Environmental modelling (fate analysis of chemicals, air dispersion modelling, hydrological modelling)
    - Data visualisation (3D display of fingerprinting data or of movement of chemicals in environmental compartments generated from measured or analysed data)
    - Geographical Information System
    - Photogrammetry (specialists in using and interpreting information from aerial photographs and other imaged data e.g. remote sensing.
    - Fingerprinting approaches
    - Risk assessment
- Competencies:
  - ✓ First degree and preferably post-graduate degree in the fields or related fields identified above for specialists
  - ✓ Knowledge on environmental forensics including legal knowledge
- Proposed position grade: C48

viii. Domain Expert (most likely outsource to specific individuals or organisations)

- Principal Accountability

- ✓ Responsible for providing expert's knowledge and opinion on specific topics, including data interpretation from site measurements or laboratory analysis that is not available within DOE.
- ✓ May be required to support DOE in court appearance as expert witness

- Competencies:
  - ✓ Proven from past records working in the same field for an acceptable period of time e.g. at least 10 years for specialised fields such as:
    - Soil scientist
    - Mineralogist
    - Geochemist
    - Atmospheric chemist
    - Marine biologist
    - Microbiologist
    - Molecular biologist
    - Other specialist areas as needed by the specific environmental forensic investigation

The Legal person participating in the environmental forensic investigation team will have the same requirements of competencies and responsibilities as any other legal personnel employed by DOE.

A sample of the Job Description of an environmental forensic investigator is attached as Appendix C.

3.2.2 Capacity-building to strengthen environmental forensic investigation

There are seventeen (17) local higher learning institutions that offer a range of environmental science courses but none specifically in environmental forensics as shown in Appendix D. The Appendix also lists a number of foreign institutions that offer full-fledged courses in environmental crime investigation, as well as non-educational organisation where possible attachments for on-the-job training could possibly be secured. Some Master degree courses may offer the subject as electives. Hence there is a need for DOE, and specifically **Institut Alam Sekitar Malaysia** (EiMAS) to develop such as course. EiMAS has conducted 18 courses and 16 courses in 2014 and 2013, respectively. Although most of these courses are not referred to in the context of environmental forensics, they are nevertheless knowledge of direct relevance to the field of environmental forensic investigation. The titles of the training courses or programmes are:

i. Practical Enforcement I – Methods of Sampling and Preservation
ii. Practical Enforcement II – In Situ Measurement

iii. Protocol and Standard Practices of Sampling for Scheduled Wastes
iv. Course Identification, Characterisation and Classification of Scheduled Wastes
v. Pengurusan dan Kawalan Tanah Tercemar di Malaysia
vi. Practical Enforcement Course For DOE's Enforcement Officer
vii. Digital Forensics (First Respondent)

EiMAS has two practical training laboratories namely:

i. Water Quality Hands-On Centre where participants are trained on in-situ measurement equipment and analytical instrument for the analysis of raw and treated effluent.
ii. Air Pollution Control Equipment and Fuel Burning Equipment Models

The future plan of EiMAS is to introduce a course on Environmental Forensics based on the following syllabus:

i. Introduction to Environmental Forensics
   - Legal framework in environmental forensics
   - Definitions of environmental forensics
   - Applications of forensic science in environmental forensics investigation
   - Environmental forensics and importance of source identification
   - Methods in environmental forensics
ii. Source Identification, Investigation and Gathering Evidences
   - Collection of evidences
   - Physical evidences – Crime scenes, photography, microscopy
   - Chemical evidences – Collection of samples and preservations
   - Biological evidences/approaches
   - Laboratory analysis
iii. Techniques and Tools for Collecting Evidences
   - Chemical methods
   - Fingerprinting
   - Biological methods
   - Source idenification
iv. Examination of Evidences
v. Statistical Evaluation, Modelling and Data Accumulation
vi. Evaluation and Interpretation of Information
vii. Completing and Recording the Investigation
viii. Case Studies

It is recommended that enforcement officers from all state offices including HQ from C44 to C52 onwards to attend, i.e. after they have gained experience in conducting the normal monitoring and checks on the point source of emissions and discharge for at least five years.

At the same time, the **Guideline on Environmental Forensics for Enforcement** will be produced as one of the output from the Study on Development and Establishment of Environmental Forensic Elements in Enforcement containing the contents as follows:

Development and formulation of the Guideline for Environmental Forensics in Enforcement

The Guideline on Environmental Forensics in Enforcement is intended to be a quick reference for DOE officers who are assigned to investigate an environmental crime and want to refresh some of the key aspects of their assignment. All DOE officers who are ready to conduct environmental forensics would have completed the formal courses conducted at EiMAS.

The contents of guidelines :

a) Introduction to Environmental Forensics
   - Concept of Environmental Forensics
   - Structure of Environmental Forensics in Enforcement Activities
   - Environmental Forensics Approaches

b) Environmental Forensics Investigation

Phase 1 – Planning
   - Evaluation and implementation of forensic activities
   - Gathering background information (check for historical information, use of picture photos, satellite images, equipment and involved parties0
   - Variant scale in pollutant concentration in soil/sediment
   - Risk associated with variants
   - Source – network and receptor (correct source, network and area of impact)

c) Phase II: Crime Scene Investigation

   - Invasive sampling and identification (indicators/ signature)
   - Sampling programme directed at marker determination
   - Measurements using hand held instrument and other appropriate methods

d) Phase II: Laboratory Analysis
   - Equipment facilities
   - Sample identification
   - Sample extraction
   - Analytical methods (Fundamental methods for inorganic and organic analysis)
   - Quality assurance and quality control

e) Various Statistical Variants
   (application of diverse complex chemical data to confirm the potential responsible industry or individuals)
   - Geostatistics (determine pollutant source and distribution)

- Preparation of analytical data platform
- Assessment of environmental damage
- Legislative framework

f) Case Studies
- Practical experiences of environment forensic experts
- Collection of environmental forensic cases in polluted areas

3.2.3 Manpower planning

The scale of expansion of environmental forensic investigation as determined by the Management Team of DOE will determine the manpower planning strategies and implementation. Prior to determining the manpower requirement, the existing staff size and structure is considered as shown herewith in Figure 7.

Of the 800 technical and professional staff, about 40% are chemists and the remainder 60% are from applied science and engineering background. According to input from the Human Resource representative, the coming recruitment emphasis will focus on academic qualifications such as environmental science, biological science and engineering

A manpower mapping in terms of competency and numbers should be done prior to developing the capacity-building programme. The existing number and field of expertise of the Subject Matter Experts (SME) in DOE are presented in Table 4. Within list, competencies that are directly relevant to environmental forensic investigation are identified with two asterisks. Based on this existing expertise, further human resource development to establish the competencies described in Section 3.2.1 is needed to beef up the environmental forensic investigation capability at DOE.

Other considerations that will affect the manpower planning in terms of numbers and timing are:

- Rate of increase of environmental crimes in the country
- Success rate of identifying source of pollution
- Success rate of litigation cases on environmental crime
- Analysis on limitations in the current approaches toward crime scene investigation

To enhance the establishment of the environmental forensic activities in the country, the Environmental Forensic Section in DOE should also create a Strategic Planning sub-section that will oversee the advancement of environmental forensics in the country, especially in keeping tabs with technological and litigation developments in other countries.

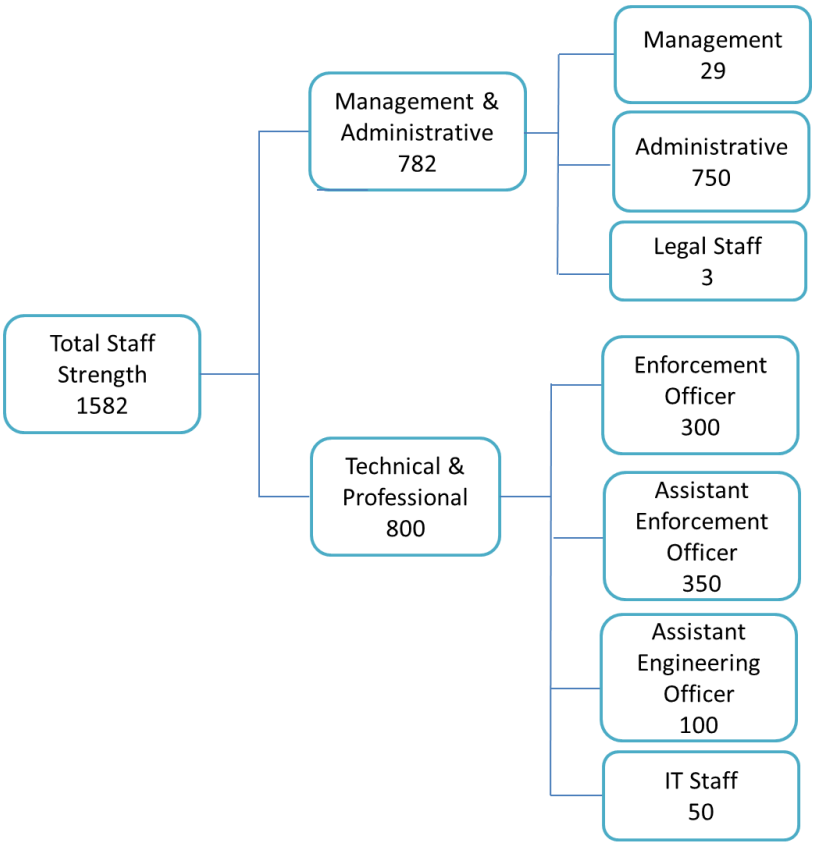

Figure 7: Existing human resource structure of DOE

Table 4: Subject Matter Experts at DOE

No.	Field of Expertise
1.	**Perundangan dan Penguatkuasaan**
1(a)	Perundangan dan peraturan yang spesifik di bawah Akta Kualiti Alam Sekeliling, 1974 mengikut bidang)
1(b)	Konvensyen, undang-undang dan perjanjian antarabangsa (berkaitan air marin, penambakan laut, ozon, pergerakan buangan terjadual, kawalan *transboundary haze, climate change,* merkuri, bahan kimia dan sebagainya)
1(c)	Undang-undang dalam negara dan luar negara yang berkaitan alam sekitar
1(d)	Prosedur penguatkuasaan dan penyiasatan (EIA, Punca tetap, PYDT, PBYDT, punca bergerak)
1(e)	Prosedur mahkamah dan pendakwaan
1(f)	Akta Zon Ekonomi Ekslusif (ZEE)

1(g)	Forensik alam sekitar
1(h)	Risikan (Intelligence)
2.	**Teknikal dan pengurusan alam sekitar – Kualiti Udara**
2(a)	Kawalan pelepasan udara dari kenderaan bermotor
2(b)	Teknologi Proses
2(c)	Sistem Kawalan Pencemaran Udara Industri (Air Pollution Control System, APCS).
2(d)	Pemantauan pelepasan ke udara secara berterusan (Continuous Emission Monitoring System, CEMS dan Predictive Emission Monitoring System, PEMS)
2(e)	Pengawasan a) Kualiti udara b) Bunyi bising dan gegaran
2(f)	Pemodelan a) Kualiti udara (*Air Quality Modeling*) b) Bunyi bising
2(g)	Kawalan pencemaran bau
2(h)	Kawalan bahan pemusnah ozon (BPO)
2(i)	Perubahan iklim
3.	**Teknikal dan pengurusan alam sekitar – Kualiti Air**
3(a)	Teknologi proses
3(b)	Sistem Pengolahan Efluen Industri (Industrial Effluent Treatment System, IETS)
3(c)	Sistem Pengolahan Kumbahan (Sewage Treatment System)
3(d)	Sistem Pengolahan Air Larut Resap (Leachate Treatment System)
3(e)	Sistem Pengolahan Efluen Kilang Kelapa Sawit Mentah
3(f)	Sistem Pengolahan Efluen Kilang Getah Asli Mentah
3(g)	Pemodelan Kualiti Air (Water Quality Modeling, WQM)
3(h)	Oil Spill Trajectory and Analysis

3(i)	Pengawasan Kualiti Air (Sungai/ Marin/ Air Tanah)
3(j)	Total Maximum Daily Load
3(k)	Hydraulic Modelling
3(l)	Hydrology Modelling
3(m)	Integrated River Basin Management
3(n)	Coastal Zone Management
3(o)	Pengurusan Bencana Tumpahan Minyak (Oil Spill Management)
3(p)	Ground Water Protection
4.	**Teknikal dan pengurusan alam sekitar – Penilaian**
4(a)	Perancangan alam sekitar
4(b)	Aktiviti Yang Ditetapkan – sila nyatakan Aktiviti Yang Ditetapkan berdasarkan kepada Jadual Pertama dan Jadual Kedua di bawah Perintah Kualiti Alam Sekeliling (Aktiviti Yang Ditetapkan) (Penilaian Kesan Kepada Alam Sekeliling) 2015
4(c)	Kawalan hakisan dan sedimen *(erosion and sediment control, ESC)*
4(d)	Penilaian risiko
4(e)	*Economic Valuation On Environmental Impacts*
4(f)	*Health Impact Assessment*
4(g)	*Ecological impacts*
4(h)	Hidraulik/ hidrodinamik
4(i)	Nadir bumi
4(j)	Prosedur EIA
4(k)	Audit EIA / Audit Alam Sekeliling / EMS 14000
4(l)	Environmental disaster management – ERP
5,	**Teknikal dan pengurusan alam sekitar – Pengurusan buangan dan bahan berbahaya**
5(a)	*Identification and classification of Scheduled Wastes*

5(b)	Proses Pemerolehan Kembali Buangan Terjadual (*recovery process*)
5(c)	*Co-Processing* Buangan Terjadual
5(d)	Pengurusan Khas Buangan Terjadual
5(e)	*Waste minimization, green industry/ technology, clean production*
5(f)	Pengurusan Tanah Tercemar
5(g)	Pengurusan Bahan Kimia (*Environmentally Hazardous Substances*)
5(h)	Konvensyen Basel - Pergerakan buangan berbahaya yang melibatkan import, eksport dan transit buangan berbahaya dari satu negara ke negara *party*
6.	**Bidang sokongan kepada bidang pengkhususan utama**
6(a)	*Geographical Information System (GIS)*
6(b)	*Strategic Negotiation in Environmental Issues*
6(c)	Analisis Statistik
6(d)	Latihan • *Trainer* – (e.g. mempunyai sijil TTT atau setaraf) • Kemahiran menilai keberkesanan latihan (e.g. mempunyai Sijil EET - *Evaluation Effectiveness of Training) Master Trainer,* Sijil *Master Trainer*, *Cert* IV atau setaraf) • Kepakaran Membangunkan Modul Latihan (*Module Designer/ Developer)* • Pembangunan Latihan / Modal Insan • Kepakaran dalam menyediakan Analisa Keperluan Latihan (*Training Needs Analysis*) • Penyediaan training road map • Penyediaan *profiling* kakitangan Jabatan

3.3 Information Support and Retrieval for Environmental Crime Scene Investigation

Since access to diverse types of information is one of the critical success factors in environmental forensics, considerations should be given on the most practical mode of sharing information that is not intended for public viewing. The DOE Library web page is a well-informed site for information on status of environmental quality, news and updates intended for general public viewing. The information support required by the environmental forensic investigation team requires a lot more technical information that maybe contained only in prints in the library.

One of the approaches that can be taken is to expand the EKMC (Enviro Knowledge Management Centre) for a specific category on Environmental Forensics to contain all the information and database links on environmental forensics. Among the proposed contents for the online information support is:

- Material Safety Datasheet Database
- Environmental Fate Database (possibly a link to the USEPA Environmental Fate Database)
- E-Books on specific technical topics relevant to environmental forensics
- Historical aerial photographs
- Fingerprints of chemicals
- Integrated Model Evaluation System (IMES)
- Databases of polluted/ contaminated environmental media
- Others

Some of the materials may require investment or organisational formal arrangements for link and access.

3.3.1 Information Storage

A good storage system for hard copies and physical evidences should be made available since testimony for litigation purpose typically occurs long after the technical work is complete. The investigation file may contain records of interviews, photographs, recordings, field project plans, sketches, laboratory quality assurance project plans, correspondence, field notes, chain-of-custody records, laboratory bench sheets, reports and other pertinent records. Information storage for environmental forensic investigation has to be one of the key items in the scope of the organisation quality management system.

3.4 Equipment for Site Measurement and Sampling at Crime Scene

Gathering evidence at the crime scene constitute a very critical stage of the environmental forensic investigation. The successful prosecution of an environmental case involve four major steps:

i. Collection of the appropriate evidence.
ii. Maintenance of legal continuity of the evidence.
iii. Organization and documentation of evidence.
iv. Presentation of the evidence to the various audiences (police, prosecutors, judges and the court).

Evidences include information from physical and chemical field measurements, field sampling for collection of samples for subsequent laboratory analysis, and interviews. Collection of the appropriate evidence and maintenance of its legal continuity require use of appropriate tools and techniques, including appropriate instrumentation and equipment.

As shown in Figure 3, DOE should be equipped with the necessary tools, instruments and equipment for collection of samples and follow the necessary protocols to maintain integrity of samples and ensure data produced from the samples are defensible evidence.

Section 3.2.1 has highlighted the role of field technicians who will conduct the sampling which has to be done according to established methods in particular the quality assurance and sample tracking, already adopted by DOE e.g.

- Standard Methods for the Examination of Water and Wastewater
    - Chapter 1020 Quality Assurance
    - Chapter 1020B Quality Control
    - Chapter 1060 Collection and Preservation of Samples

- Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods: EP SW846 Test Methods
    - Chapter 1 Quality Control
    - Chapter 9 Sampling Plant
    - Samping Methods

Aside from achieving quality assurance, it is equally needful to developing tracking software including traceability system such as bar coding equivalence for the samples, and spatial distribution identification and representation that can be used based on GIS and GPS.

Examples of some environmental sampling and disposable in-situ screening apparatus are:

- Detector tubes (for air and water samples)
- Bailers for groundwater sampling
- Tedler bags

Appendix E1 has also provided some examples of portable or hand-held instruments that can be used for site measurements such as:

- Handheld X-ray Fluorescent (XRF) Analyser for metal analysis and identification
- Handheld Spectrometers for identification or verification of organic chemicals in the environmental compartments of air, water, soil/sediments and industrial wastes
- Portable GC-MSD for organic analysis of gaseous, liquids, solids or vapours in diverse types of samples

- Portable TOC analyser for low level total organic carbon in water samples
- Portable FTIR analysers for identifying components in organic and inorganic gases
- Others

One of the technological developments that have become more prominent is recent years is the deployment of drones to capture aerial photography closer to the ground and also difficult to access places. Monitoring of technological development to support environmental crimes that are increasingly complex should be the function of the proposed Strategic Planning sub-section within the Environmental Forensic Section.

3.5 Laboratories for Analysis of Crime Scene Samples

Most of the laboratory analysis of environmental samples collected by the Forensic Technicians can be carried out locally. As highlighted in the preceding sections, environmental forensics is just not about high-end instrumentation and techniques but rather a systematic approach that starts with detail planning from site investigation to collection of the environmental samples and a range of laboratory analysis that can eventually be translated into the fingerprint.

The forensic fingerprinting techniques can be broadly categorised into five groups namely:

- Chemical fingerprinting
- Isotopic fingerprinting
- Geochemical fingerprinting
- Mineralogical fingerprinting
- DNA fingerprinting

A host of analytical methods that can be mix and match to establish any one of the above fingerprints means it is not possible in some cases that only one testing laboratory will provide all the data needed. At this stage, Jabatan Kimia and Malaysia Nuclear Agency are institutions that have laboratories that are directly linked to environmental analysis.

The Environmental Health Division and all the State Laboratories of Jabatan Kimia are already providing a range of environmental analysis through their accredited facilities. The Radiochemistry and Environmental Laboratory and the Isotope Ratio Mass Spectrometer Laboratory of Malaysia Nuclear Agency are facilities that can support the environmental forensic establishment in DOE. Appendix F contains further description of the two institutions.

The Mineral and GeoScience Department is another institution that can support DOE's aspiration to set up their environmental forensic investigation capability particularly in the area of GIS Application and carthography. Although DOE itself has established GIS facility and

competency right up to the state level, they can also tap on Mineral and GeoScience Department for more insights and interpretation of GIS data.

Other institutions with laboratory or investigative facilities that can contribute towards establishing environmental forensics at DOE include Jabatan Meteorology for aerosols, multigas and ozone; Genome Malaysia for DNA competency and DOSH for diverse site measurement equipment, especially with regards to possible exposure of a certain population living within the vicinity of a contaminated site .

3.6 In-house Accredited Facilities for Environmental Forensic

One of the strategies to enhance acceptability of measurement results in particular field and laboratory measurements produced by a test facility is through accreditation. In Malaysia, accreditation of testing facilities to ISO 17025 is carried out under the national laboratory accreditation scheme (*Skim Akreditasi Makmal Malaysia (SAMM)*) operated by the Department of Standards Malaysia (Standards Malaysia).

In view of the highly possible occurrence of demand for rapid site and laboratory measurements, DOE has plans to establish its own environmental forensic laboratory to support its forensic work.

The role of the Environmental Forensic Laboratory is proposed as follows:

- Implement a systematic approach of planning, conducting, documenting, and assessing environmental forensic data collection activities
- Act as the coordination point of delivery of outgoing samples collected by field officers for analysis in specific laboratories outside DOE, and receipt of results for subsequent treatment and analysis.
- Operate selected analytical and field measurement equipment to support investigation of environmental crimes
- Maintain laboratory facilities including instrument for field measurements in accordance with procedures established to meet the laboratory quality management system.

The criteria for identifying some suitable equipment/ instrument for the Environmental Forensic Laboratory are:

- Urgent analysis to establish next course of action
- Equipment not available with Designated Institutions
- Equipment/ instrument for field measurements that have to be on stand-by at all times

Based on the criteria mentioned above, it is recommended that DOE should invest primarily in instrument/ equipment for field sampling and field measurements as listed in Appendix E1.

Analytical instrument that may be of use include:

- Gas chromatography with various detectors
- High performance liquid chromatography with various detectors
- X-Ray fluorescence spectrometer
- Infra-red spectrometer
- Inductively coupled plasma spectrometer (ICP-OE)
- Light and polarized light microscope
- Sample preparation equipment

Aside from a high capital cost of at least RM30 million (if only one set of each equipment is procured) including the laboratory infrastructure, maintenance of the above instrument incurs high operation cost (covering calibration service, consumables, routine maintenance and replacements). Hence it is advisable that the setting up of the laboratory be carried out only after the environmental forensic investigation activity has become well-established, particularly in the human competency to do data treatment and interpretation.

In developing a quality management system for the Environmental Forensic Laboratory, it is not only getting well-equipped laboratories and site measurement apparatus but more importantly is the establishment of well-adopted standard operating procedures (SOPs) and work instructions (WIs). DOE has already developed several operational procedures that are appropriate for environmental crime scene investigation and can easily be incorporated into the accreditation of the Environmental Forensic Laboratory. Table 7 provides a list of the existing operation standards (*Arahan Tetap Operasi Penguatkuasaan*) that can be adopted completed or adapted to suit the requirements of environmental forensic investigation.

Table 7 : List of Arahan Tetap Operasi Penguatkuasaan

No.	Name of Directive	Description
1.	Arahan Tetap Operasi Penguatkuasaan (Punca Tetap)-Siri I Prosedur Tetap Operasi Pemeriksaan Dan Siasatan	Reference for DOE officers to conduct inspection and investigation of sources of pollution that are subjected to the enactment of Act 127 and associated regulations
2.	Arahan Tetap Operasi Penguatkuasaan (Punca Tetap) – Siri II Protokol Persampelan, Pengawetan dan pengendalian sampel effluent untuk tujuan penguatkuasaan.	Reference for DOE officers on the enforcement activities with respect to technical aspects such as sampling, preservation of samples and recording of samples.
3.	Arahan Tetap Operasi Penguatkuasaan (Punca Tetap) – SIRI III Prosedur Rakaman, Pengendalian & Penyimpanan Keterangan Gambar Digital	Reference for DOE officers for investigation of environmental criminal cases such as procedures for recording, control, storage and explanation of digital pictures.

4.	Arahan Tetap Operasi Penguatkuasaan (Punca Tetap) Siri IV Prosedur Penahanan Operasi Kelengkapan bagi maksud Siasatan di bawah seksyen 38(1)(a) Akta 127, Perintah Larangan , Gantung lesen/ Pembatalan Lesen.	Reference for DOE officers on the confiscation of equipment as permitted under section 38(1) of Act 127 on Restraining Order, Suspension/ Cancellation of License.
5.	Arahan Tetap Operasi Penguatkuasaan (Punca Tetap) – Siri V Penyediaan Kertas Siasatan	Reference for DOE officers on the procedures for preparation and submission of investigation papers.
6.	Prosedur Standard Operasi Penguatkuasan Terhadap Syarat – Syarat kelulusan EIA (2008)	Reference for DOE officers in the conduct of enforcement activities related to terms of approval of EIA projects particularly on earthworks
7.	Prosedur Tetap Operasi Persampelan Buangan Terjadual Di Bawah Seksyen 48AB, Akta Kualiti Alam Sekeliling, 1974	Reference for DOE officers on sampling of scheduled wastes
8.	Prosedur Tetap Operasi Penyitaan, Pelucuthakan, Pelupusan Dan Pelepasan Barang Kes Di Bawah Akta Kualiti Alam Sekeliling 1974	Reference for DOE officers for the conduct of Closure, Forfeiture, Disposal and Release of exhibits related to investigations under Act 127.

3.7 Formal Arrangement with Designated Institutions

It will take much resource to establish the complete battery of competencies, skill, infrastructure facilities and systems within DOE to establish environmental forensic investigation on a full-scale. The more practical approach would be to establish a formal arrangement with a network of laboratories and infrastructure that will support DOE in strengthening environmental forensics for enforcement work.

Formal arrangements with a number of institutions that will avail resources such as skill personnel and diverse instrumentation required in a particular environmental forensic investigation should be arranged based on advice probably from AG Chamber. A proposed name for these institutions can be ‘designated institutions’ where their representatives are also members of the Technical Committee on Environmental Forensic Development in DOE.

Among the institutions where formal arrangements are needed to establish an effective environmental forensic investigation structure are:

- Jabatan Kima
- Malaysian Nuclear Agency
- Malaysian Remote Sensing Agency
- Jabatan Mineral dan Geosains Malaysia

- Jabatan Meterology Malaysia
- Genome Malaysia
- Hazmat Malaysia
- Polis Di Raja Malaysia
- Department of Occupational Safety and Health
- Forestry Department
- Agriculture Department
- Department of Wild Life and Natural Parks (Jabatan Perhilitan – Jabatan Perlindungan Hidupan Liar dan Taman Negara)
- Ministry of Health
- BOMBA
- SIRIM
- Malaysia Rubber Board
- Malaysia Palm Oil Board
- Others

APPENDIX-A: LOGICAL FRAMEWORK OF THE ENVIRONMENTAL FORENSIC PLAN OF THE DEPARTMENT OF ENVIRONMENT (DOE)

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
Overall objective	*Environmental crime will be reduced through higher success rate of litigation cases with the adoption of environmental forensics investigation*	*Increase in success rate of litigation cases on environmental crimes by 30% in 2020 from baseline at 2015 where no formal forensic investigation approach is taken.* *Note: The annual targets from 2016 to 2020 can begin with 10, 20, 30, 50 and 90 cases solved out of 300 cases, respectively.*	*DOE records on environmental crimes that have been brought to court of law (excluded are notices and compounds)*	*The Environmental Forensic Plan is implemented from all aspects of legal provisions, manpower, facilities and linkages.* *The 2015 baseline is taken as 300 out of 6000 environmental crime cases reported annually that require forensic investigation*
Specific objectives	*1. To strengthen Act 127 with additional clauses related to environmental forensic investigation and clean-up programmes* *2. To establish an Environmental Forensic and Intelligence Division at DOE Headquarter that reports to Deputy DG (Operation)* *3. To increase number of DOE officers competent in environmental forensics (including legal aspects)* *4. To enhance site sampling and measurement facilities at DOE for environmental forensic application*	*1. New clauses or regulations added to Act 127* *2. Environmental Forensic and Intelligence Division established* *3. Number of DOE officers trained in environmental forensics* *4. Inventory of site sampling and measurement equipment at DOE*	*Act 127 amendment* *Organization chart* *DOE records (Registry of competent officers)* *DOE records*	*Environmental forensic implementation is established in DOE according to Environmental Forensic Plan* *The necessary budgetary allocation is available for implementation of activities to support the objectives*

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
	5. To enhance laboratory facilities at relevant institutions for environmental forensic application	*5. Inventory of testing equipment and test methods available at relevant institutions*	*DOE records*	
Specific objectives	*6. To establish a DOE environmental forensic laboratory to complement existing facilities* *7. To establish web-access information store house/ one-stop reference centre for all forms of information including databases to support forensic investigation.* *8. To establish formal linkage between DOE and designated institutions for implementation of environmental forensic work*	*6.. Environmental forensic laboratory established at DOE* *7. List of information materials and databases available from web site developed by DOE* *8. MOA among relevant institutions or through an Order of the roles and functions of designated institutions*	*Physical infrastructure of laboratory* *Web portal with information sources including databases that support forensic work* *Order, MOA or any documents describing the formal linkage*	*Availability of budget for implementation of the Environmental Forensic Plan at DOE and relevant institutions e.g. Jabatan Kimia, Nuclear Malaysia etc.*
Expected results	*1. Circumstantial evidences collected using environmental forensic are acceptable in court of law* *2. Establishment of an Environmental Forensic Division that acts as the one-stop centre for all environmental forensic investigation, and also overseer the Environmental Forensic Sampling and Testing Facility* *3. Competent DOE officers as Lead Investigators, Investigation Officers, Field Technicians, Specialists, SMEs and Prosecution Officers in environmental forensics available at*	*1. DOE records on court cases* *2. Environmental Forensic Division exists in DOE HQ with an initial staff of about 12 and expanding through capacity building of existing staff at State Offices* *3. Records of environmental forensic investigation reports produced by competent DOE officers*	*1. Court cases* *2. Organisation chart of DOE* *3. Environmental forensic reports at DOE/ Library of forensic reports*	*1. Legal officers of DOE are able to develop the clauses/ regulations for AG's chamber* *2. Approved budget secured to set up section* *3. Sufficient number of competent environmental forensic officers at DOE*

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
	HQ and State Offices			
Expected Results	*4. Generation of defensible data obtained directly from measurements at contaminated sites*	*4. Reports on site measurements and tracking of pollutants produced by DOE environmental forensic team*	*4. Environmental forensic reports at DOE/ Library of forensic reports including site measurement data in project files*	*4. Site/ In-situ measurement and sampling equipment are available and well-maintained for use*
	5 .Availability of defensible test data obtained from accredited laboratories of designated institutions	*5. Test reports for environmental forensic investigation*	*5. Environmental forensic reports at DOE/ Library of forensic reports including site measurement data in project files*	*5. Designated laboratories maintain their accreditation for tests related to environmental forensic investigation*
	6. Availability of defensible data obtained from environmental forensic laboratory at DOE for specific tests	*6. Records of laboratory infrastructure, equipment and instrument, and test reports*	*6. Environmental forensic reports containing data that originate from DOE laboratory*	*6. DOE laboratory able to achieve and maintain accreditation*
	7. Accessibility to wide spectrum of information sources including databases to support forensic work	*7. Web portal with list of information sources and accessible to DOE Forensic staff*	*7. Web-portal address*	*7. DOE able to create and maintain/ update portal*
	8. Faster response time and more comprehensive environmental crime investigation with accessibility to wider range of expertise	*8. Log records on receipt and response to environmental crime notification,*	*8. DOE Environmental Enforcement Records*	*8. Formal arrangement with designated institutions in place*

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
Activities	*1. Expansion of Act 127 to include environmental forensic consideration* *1.1. Form project team at DOE to draft legal requirements on environmental forensic application in Act 127 based on inputs provided by the study commissioned by DOE*	*a) Project Team membership and TOR* *b) Draft of amendments on additional clauses* *c) Letter to AG chamber on amendments to Act 127*	a) Membership list and minutes of *meetings* *b) Final draft as submitted to AG chamber* *c) Record of letter to AG chamber*	*Support and approval from AG Chamber*
Activities	*2. Establish Environmental Forensic and Intelligence Division* *2.1 Develop Job Description/ specification for the environmental crime scene investigation team, whether full time or on-call.*	*a) Organisation chart* *b)Staff assignment including state office* *c) Job description, qualification and career path of environmental crime scene investigator and related positions*	*a) HR Records*	*Budget to establish Environmental Forensic and Intelligence Division is approved*
	3. Human Capacity Development Programme *3.1 Develop module for environmental forensic course and identify a group of DOE officers who will undergo specific environmental forensic training*	*a) Training module/ course content on environmental forensics* *b) Manpower planning programme over a period of ten years*	*a) Environmental forensic training courses by EiMAS and other local institutions* *b) HR Records on competent persons*	*Adoption of recommendations in the study on Development and Establishment of Environmental Forensic Elements in Enforcement* *Manpower and funds are available to implement the listed activities*

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
	3.2 Develop manpower planning programme to achieve target number of competent DOE officers in environmental forensics *4. Establishment of Evidence Collection Facilities* *4.1 Form Project Team to coordinate planning and implementation for the setting up of an environmental forensic laboratory that will include engagement of a consultant to design and develop the physical laboratory. facility that should be compliant to ISO 17025* *4,2 Develop specification and procurement of equipment, instrument and apparatus, for sampling and measurement including PPE* *4.3 Develop quality management system for maintenance and up-keeping of equipment* *4.4 Develop tracking/ traceability system* *4.5 Develop spatial identification and representation system that can be based on GIS and GPS* *4.6 Develop routine hands-on 'refresher courses' on the handling of equipment*	*a) Project Team membership and TOR* *b) Laboratory design and specification* *c) Equipment specifications* *d) Equipment inventory list* *e) SOPs for operation, calibration, routine and specialised maintenance of equipment* *f) In-house or joint facility on spatial tracking system* *g) Directory of test methods and list of designated laboratories certificates* *h) Certification and accreditation*	*a) Appointment letters of Project Team, TOR including consultants if necessary* *b) Renovation and floor plans of laboratory* *c) DOE documentation of ISO9000 and ISO17025 equivalence work flow, processes and procedures* *d) Certificate and license for the quality management and accreditation recognition* *e) Other DOE documentation*	*Availability of facilities in (Pusat Pemeriksaan Semula Kenderaan Bermotor) that can be converted to become a full-fledged Evidence Collection Facilities (environmental sampling and site measurement laboratories)*

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
	4.7 Achieve accreditation status for site measurement, sampling and laboratory testing			
Activities	*5. Establish designated testing laboratories* *5.1 Develop criteria, protocols and procedures for appointment and monitoring of designated laboratories* *5.2 Develop directory of test methods and applications and designated laboratories scope* *5.3 Develop transfer protocols that will maintain sample and results integrity*	*a) Criteria, protocols and procedures for appointment of designated laboratories* *b) Directory of designated laboratories and their capabilities* *c) Protocols for sample transfer and evidence presentation*	*a) DOE records* *b) Appointment letters and listing of accredited designated laboratories* *c) SOP on sample transfer and evidence presentation*	*Good collaboration and official arrangements exist between DOE and other relevant departments/ agencies/ public.*

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
	6. Establish formal arrangement with relevant institutions to complete the range of activities and competencies required to provide comprehensive environmental forensic applications	*a) Formal or legislative arrangements to establish the linkage between DOE and relevant institutions*	*a) Letters of appointment/ MOAs of formal arrangements with relevant institutions*	
	7. Develop a specific information reference portal for forensic work under purview of Enviro Knowledge Management Centre (EKMC)	*a) List of information and databases in the specific website*	*a) Web-access information portal with databases*	
	7.1 Develop long-term plan for databases generation such as database of fingerprints of scheduled waste of licensed waste generators, emission profiles include isotope fingerprints from approved stacks, signature chemicals of waste generators, ambient air samples, combustion fuels and others	*b) Implementation of long-term plan on databases development*	*b) Annual budgetary request for development of datasets for the databases*	

GANTT CHART – PLANNING ON THE ESTABLISHMENT OF ENVIRONMENTAL FORENSIC IN DOE (2016 – 2020)

Activities	Year				
	2016	2017	2018	2019	2020
1. Expansion of Act 127 to include environmental forensic consideration					
2. Establish Environmental Forensic Section and linkage with State Office					
2.1 Formal establishment of Environmental Forensic Section and linkage with State Offices					
2.2.Develop job specification					
2.3 Full operation (ready to receive cases)					
3. Human capacity development programme					
3.1 Develop module for environmental forensic course					
3.2 Ten-year manpower planning programme					
4. Establish Evidence Collection Facilities					
3.1 Form project team for physical development					
3.2 Develop equipment specification and procurement					
3.3 Develop quality management system					
3.4 Develop tracking/ traceability system					
3.5 Strengthen spatial identification and representation system					
3.6 Develop routine hands-on “refresher courses”					
3.7 Achieve accreditation status					
5. Establish designated testing laboratories					
5.1 Develop protocols and procedures					
5.2 Develop directory of test methods and applications					
5.3 Develop transfer protocols					
6. Establish formal arrangement with relevant institutions					
7. Develop a specific information reference portal for forensic work under Enviro Knowledge Management Centre (EKMC)					
7.1 Develop long-term plan for databases generation and implement annual plan					

Budgetary Requirement for Site Sampling, Site Measurement and Instrumental Analysis

Item	**Year (RM)**				
	2016	**2017**	**2018**	**2019**	**2020**
1. Procurement of sampling apparatus for air, water, sediments, soil and biological materials (~RM2.5 million) • Handheld X-ray Fluorescent (XRF) Analyser for metal analysis and identification • Handheld Spectrometers for identification or verification of organic chemicals in the environmental compartments of air, water, soil/sediments and industrial wastes • Portable GC-MSD for organic analysis of gaseous, liquids, solids or vapours in diverse types of samples • Portable TOC analyser for low level total organic carbon in water samples • Portable FTIR analysers for identifying components in organic and inorganic gases/ Portable ambient air analyser • Portable mercury analyser • Sampling apparatus and gadgets e.g. Ekman bottom grab samplers, water samplers, flow meters, soil TPH kit, soil augers and detector tubes.	Preparation of specification and procurement	Commissioning & training Development of SOPs, WIs, and procedures for accreditation	ISO17025 compliant onsite measurement and sampling laboratories	Maintain accreditation status	Maintain accreditation status
2. Procurement of forensic mobile laboratory consisting of a mobile truck and settings of a working laboratory such as work benches, fume hoods, sinks, IT facility etc. (~RM0.5 million)	Preparation of specification, procurement and commissioning	Intensive training of identified group of field technicians	Full operation of mobile laboratory	Full operation of mobile laboratory	Full operation of mobile laboratory
3. Construction and renovation of Laboratory units (for screening and continual investigation purpose) (~RM2 million)	Renovation work	Completion of renovation work	Achieve and maintain accreditation	Achieve and maintain accreditation	Achieve and maintain accreditation

4. Consumables and components for equipment and apparatus listed in items 1 and 3.(~RM1 million)	Procurement and use	Procurement and use	Procurement and use	Procurement and use	Procurement and use
Activities	**Year**				
	2016	**2017**	**2018**	**2019**	**2020**
5. Analytical equipment include: (~RM5 million) • Gas chromatography with various detectors • High performance liquid chromatography with various detectors • X-Ray fluorescence spectrometer • Infra-red spectrometer • Inductively coupled plasma spectrometer (ICP-OE) • Light and polarized light microscope • Sample preparation equipment	Preparation of specification	Procurement, commissioning & training	Achieve and maintain accreditation status for selected scope	Achieve and maintain accreditation status for selected scope	Achieve and maintain accreditation status for selected scope
6. Conduct testing and information sourcing to develop databases	Develop datasets	Develop datasets	Develop datasets	Develop datasets	Develop datasets

APPENDIX-B: BRIEF DESCRIPTION OF THE MALAYSIAN LAWS THAT HAVE IMPLICATIONS ON THE LITIGATION OF ENVIRONMENTAL CRIMES

- Fisheries Act 1985

The Fisheries Act is for administration and management of fisheries, including the conservation and development of maritime and estuarine fishing and fisheries in Malaysia waters, protection to aquatic mammals and turtles and riverine fishing in Malaysia and to matters connected to establishment of marine parks and marine reserves

- Merchant Shipping (Oil Pollution) Act, 1994

Clause on "Restriction of liability for oil pollution damage"

5. (1) Where an incident occurs and pollution damage results from the incident, whether or not the owner of the ship incurs a liability, the owner of the ship shall not be liable for such pollution damage otherwise than under that section.

(2) The liability for pollution damage shall not apply to—

(a) any servant or agent of the owner of the ship or any member of the crew;

(b) the pilot or any other person who, not being a member of the crew, performs services for the ship;

(c) any charterer (howsoever described, including a bareboat charterer), manager or operator of the ship;

(d) any person performing salvage operations with the consent of the owner of the ship or on the instructions of a competent public authority;

(e) any person taking preventive measures;

(f) all servants or agents of the persons mentioned in paragraphs *(c)*, *(d)* and *(e)*, unless the pollution damage resulted from their own act or omission, committed with the intent to cause such damage, or recklessly and with the knowledge that such damage would probably result.

Restriction on enforcement of claims after establishment of limitation fund

8. Where the Court has found that a person who has incurred a liability under section 3 is entitled to limit that liability under section 6 and he has paid a sum or deposited a bank guarantee or **s**ecurity into the Court for a sum not less than that amount—

(a) the Court shall order the release of any ship or other property arrested in connection with the claim in respect of that liability or any bail or other security given toavoid such arrest; and

(b) no judgement or order in respect of any such claim shallbe enforced, except so far as it is for costs,if the claimant has access to the Court and if the payment or the bank guarantee or security or such part thereof as corresponds to

the claim will be actually available to the claimant.

Extinguishment of claims

10. No action to enforce a claim in respect of a liability incurred under section 3 shall be considered by any Court in Malaysia unless the action is commenced within three years from the date the pollution damage occurred or within six years from the date of the incident which caused the pollution damage, and where the incident consists of a series of occurrences, the six years' period shall run from the date of the first such occurrence.

The Director of Marine is responsible to carry out powers and duties under this Act and regulations.

- Atomic Energy Licensing Act 1984, Act 304

Licensing of nuclear installation and of activities

Section 26 (1) :No person shall dispose of or cause to be disposed any radioactive waste without the prior authorization in writing of the appropriate authority.

Section 27 (1) : No person shall accumulate or cause to be accumulated any radioactive waste on any premises without the prior authorization in writing of the appropriate authority.

(i) Governments to claim compensation for nuclear damage to environment

Where there is any nuclear damage to the environment, a claim for compensation shall be made by the Government of Malaysia,the Government of a State in Malaysia or by both, as the case may be, according to whether the segment of the environment that isdamaged is within the jurisdiction of the Government of Malaysia, of a State in Malaysia or of both.

1. Notwithstanding any law to the contrary, the liability of an installation operator for nuclear damage under this Act shall be limited to an amount equivalent at the commencement of this Act to fifty million ringgit for any one nuclear incident.
2. The Board may, taking into account the size and nature of the nuclear installation, the extent of the damage involved or any other circumstances, prescribe a different limit of liability from that provided under subsection (1) but such different limit of liability shall in no event be less than an amount equivalent at the commencement of this Act to twelve million ringgit for any one nuclear incident.
3. The amounts referred to in subsections (1) and (2) shall not include any interest or costs awarded by the court in actions for compensation for nuclear damage.

- **Pesticides Act 1974**

Control of manufacture, sale and storage of pesticides by licensing (IV);Control of presence of pesticides in food (V); Death and injury occasioned by pesticides (VI); Enforcement (VII); Analysis (VIII); Proceedings (IX)

The manufacture, sale and storage of pesticides are subject to the issue of a licence by the Board, upon receipt of an application duly made according to the provisions of Part IV. The Act regulates the control of pesticides in food, the enforcement of the provisions of this Act by authorized officers, the analysis of pesticides by analysts appointed by the Minister, the proceedings before the court, offences and penalties. According to the provisions of Part V, the Minister may, after consulting the Pesticides Board and the Minister responsible for Health Services, make regulations to control the presence of pesticides in food. Part VI establishes the measures to be taken in case of death and injury caused by pesticides. In particular, it concerns (a) reporting of accident or death, (b) inquiry and investigation, (c) legal proceedings.

APPENDIX C- SAMPLE OF JOB DESCRIPTION OF AN ENVIRONMENTAL FORENSIC INVESTIGATOR

1. PRINCIPAL ACCOUNTABILITIES

Under supervision, able to conduct investigations of alleged violations of environmental laws, and inspects facilities for compliance with environmental regulations and performs related duties as required. She/He is responsible for the following accountabilities:

i) Conducts covert surveillance to gather evidence and to catch violators in the act of committing illegal activities such as dumping, open burning and improper disposal of toxic waste.
ii) Communicate and inform offenders of activities are in violation of environmental laws and instruct them to cease activities.
iii) Investigates complaints of environmental pollution by inspecting sites and documenting conditions.
iv) Collecting samples as evidence and identifying illegal activities with other enforcement agencies
v) Uses site sampling equipment and photographic equipment in the performance of investigation activities
vi) Evaluate of site conditions and nature of contaminants. Based on the information obtained, a relevant forensic sampling and analysis plan should be proposed.
vii) Interviews witnesses and complainants to obtain information concerning alleged sources of environmental pollution,
viii) Conducts environmental testing on location to detect sources of possible toxic pollutants
ix) Document all the collected evidence properly
x) Testifies in court on citations issued for violations of environmental ordinances.

2. MAIN SPECIFICATION

a. QUALIFICATION

Minimum Masters degree in Science/Environmental with specialization in Forensic Science. Candidates with postgraduate or professional qualifications in the above disciplines will have an added advantage or with minimum 12 years of hands-on enforcement experience including ability to conduct legal proceedings

b. EXPERIENCE

Minimum 5 years working experience in the field of Environmental management or responsible in conducting environmental inspections.

c. KNOWLEDGE, SKILLS/COMPETENCIES

i) Good interpersonal skills
ii) Demonstrates ability in analytical thinking and problem solving
iii) Demonstrates excellent written and oral communication skills.
iv) Able to interpret aerial and other photographs photographs.
v) Skill in investigation and surveillance, and in persuading witnesses to cooperate with investigations.
vi) Able to conduct site sampling and measurement for environmental forensic application.
vii) Knowledge on various available analytical techniques and the limitations associated such as lowest detection limits and potential interferences for chemical fingerprinting.
viii) Understand test methods related to laboratory analysis.
ix) Ability to interpret fingerprinting results from the laboratory.
x) Knowledge of data collection sources and methods
xi) Knowledge of investigative techniques and method of evidence collection skills.
xii) Ability to conduct inspections of abandoned sites, industrial facilities, limited access and multi-level facilities.
xiii) Ability to conduct covert surveillance activities.
xiv) Ability to interview witnesses and prepare investigative reports.
xv) Ability to obtain and prepare evidence
xvi) Ability to interpret environmental regulations.

APPENDIX D -INSTITUTIONS THAT OFFER ENVIRONMENTAL SCIENCE COURSES WITH ENVIRONMENTAL FORENSIC CONTENT

LOCAL institutions FOR Environmental forensic programmes

There are 17 institutions in Malaysia that offer Environmental Science course; tabulated as follows:

NO.	NAME OF INSTITUTIONS	COURSES OFFERED
1.	Monash University Malaysia	a. M.Sc. in Environmental Science b. PhD – Doctor of Philosophy in Environmental Science
2.	Sunway University	a. American Degree Transfer Programme (Science) majoring in Environmental Science
3.	University Tunku Abdul Rahman (UTAR)	a. Master of Engineering Science – Environmental Science & Technology b. Master of Science – Environmental Science & Technology c. PhD – Doctor of Philosophy (Science) in Environmental Science & Technology d. PhD – Doctor of Philosophy (Engineering) in Environmental Science & Technology
4.	University of Malaya (UM)	a. Bachelor in Applied Science with Islamic studies (Environment) b. B.Sc. in Environmental Science & Management
5.	Malaysia University of Science and Technology (MUST)	a. B.Sc. in Environmental Science
6.	Universiti Teknologi Mara (UiTM)	a. Master of Science (Built Environment) specializing in Building & Environmental Science b. PhD – Doctor of Philosophy (Built Environment) specializing in Building & Environmental Science c. Master of Science – Environmental Science & Technology

		d. PhD – Doctor of Philosophy specializing in Ecology & Environmental Science/ Management
7.	Universiti Kebangsaan Malaysia (UKM)	a. B.Sc.(Hons) Environmental Science b. M.Sc. Environmental Science c. PhD – Doctor of Philosophy in Environmental Science
8.	The University of Nottingham Malaysia Campus	a. B.Sc.(Hons) Environmental Science
9.	Universiti Sains Malaysia (USM)	a. M.Sc. Environmental Science b. PhD – Doctor of Philosophy in Environmental Science
10.	Universiti Malaysia Sabah (UMS)	a. B.Sc.(Hons) Environmental Science b. PhD – Doctor of Philosophy in Science & Natural Resources - Environmental Science c. Master of Philosophy (MPhil) in Science & Natural Resources - Environmental Science d. M.Sc. Environmental Science
11.	International Medical University (IMU)	a. M.Sc.in Environmental Health
12.	SEGi University	a. PhD – Doctor of Philosophy in Environmental Science
13.	Universiti Putra Malaysia (UPM)	a. Bachelor of Environmental Science & Technology b. Master of Environment (M.Env) c. Master of Environmental Engineering

		d. M.Sc. in Biodiversity and Conservation of Natural Resources e. M.Sc. in Environmental Ethics f. M.Sc. in Environmental Hydrology & Hydrogeology g. M.Sc. in Environmental Systems & Processes h. PhD – Doctor of Philosophy in Environmental Ethics i. PhD – Doctor of Philosophy in Hydrology & Hydrogeology j. PhD – Doctor of Philosophy in Environmental Systems & Processes
14.	Universiti Malaysia Sarawak (UNIMAS)	a. M.Sc. Environmental Science b. PhD – Doctor of Philosophy in Environmental Science
15.	Universiti Tun Hussein Onn Malaysia (UTHM)	a. PhD – Doctor of Philosophy in Science – Biology & Chemistry b. M.Sc. Biology & Chemistry
16.	Universiti Pendidikan Sultan Idris (UPSI)	a. M.Sc. in Environmental Biotechnology
17.	Universiti Selangor (UNISEL)	a. Bachelor (Hons) of Environmental Science (Biodiversity & Conservation)

Global institutions FOR Environmental forensic programmes

These are the global institutions that offer Environmental Forensic programme; tabulated as follows:

NO.	NAME OF INSTITUTIONS	COURSES OFFERED
1.	King's College London, United Kingdom	The Analytical and Environmental Sciences Division offers a range of postgraduate taught programmes: a. MSc in Analytical Science for Industry b. MSc in Analytical Toxicology c. MSc in Forensic Science d. MSc/MRes in Biomedical & Molecular Sciences Research King's College London has had an active, dedicated forensic science research programme since 1978. Throughout this period, they have worked closely with forensic science practitioners to ensure that their research is focused on addressing their fundamental questions and most important needs.
2.	Montclair State University, New Jersey, United States	Graduate Certificate Program in Environmental Forensics (EF): The Graduate Certificate Program in Environmental Forensics (EF) provides graduate students and working professionals with the analytical, interpretive, and communication skills needed to enter or advance within the EF profession, including the use of scientific techniques to investigate violations of environmental regulations and to apportion responsibility for environmental damages. The program examines the characterization of contaminants and determination of their origins, even if the discharge occurred decades ago. The methods employed include those of analytical (geo) chemistry, field geology and biology, and remote sensing, among other disciplines. Practitioners must also understand the legal framework and have considerable computational and statistical expertise. This program emphasizes both theory and hands-on

		experience in the geochemical fingerprinting of environmental matrices using polycyclic aromatic hydrocarbons (PAHs), petroleum biomarkers, and trace metals, as well as in applying electron and optical microscopy of Earth materials to forensic problems. Complete the following 5 courses for 15 semester hours with a minimum GPA of 2.50:. EAES 525 X-ray Microanalysis (3 hours lecture) EAES 527 Organic Geoghemistry (3 hours lecture) EAES 528 Environmental Forensics (3 hours lecture) EAES 529 Instrumental Environmental Analysis (3 hours lecture) LAWS 590 Environmental Law and Policy (3 hours lecture)
3.	British Columbia Institute of Technology (BCIT), Canada BRITISH COLUMBIA INSTITUTE OF TECHNOLOGY	Bachelor of Technology in Forensic Investigation (BTech): The goal of the forensic science program is to provide a strong scientific approach to an applied discipline by exploring both the theoretical and practical aspects involved with forensics. The curriculum covers key areas required by forensic investigators, including, but not limited to: Canadian legal aspects, evidence and expert witness training, crime scene processing, case management, death investigation, biological aspects (DNA, anthropology, entomology, odontology, etc.), chemical aspects (fingerprinting, firearms/toolmarks, photography/video/imaging, etc.), physical aspects, and a variety of elective topics.
4.	Victoria University of Wellington, Australia - Twinning programme with University of Singapore (NUS)	Forensic Science is offered as a minor only at Victoria University, and is taken as part of a Bachelor of Science (BSc).

	TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI VICTORIA UNIVERSITY OF WELLINGTON NUS National University of Singapore	It is available to students specialising in Chemistry, Biomedical Science or Cell and Molecular Bioscience during a semester of exchange study at the National University of Singapore (NUS). NUS is one of the world's top universities, ranked number 22 in the world and number 1 in Asia in 2014.
5.	St. Edward's University, Austin, Texas ST. EDWARD'S UNIVERSITY	The Bachelor of Science in Forensic Science: Students majoring in Forensic Science at St. Edward's University take a combination of: a. Forensic science requirements b. Core requirements in criminal justice, bioinformatics, biology, chemistry, physics and math c. Supporting courses chosen from criminal justice, criminology, additional forensic science courses and psychology (field track) or biology, chemistry, math and forensic science courses (lab track) Students can choose between two tracks: Laboratory Emphasis: This track is for students who prefer to focus on laboratory-based jobs such as DNA analysis, drug analysis and toxicology. This emphasis also has coursework designed to prepare students for medical school, which is important for those interested in a role in pathology or as a medical examiner. Field Emphasis: This track is geared toward students who intend to pursue careers with an emphasis in crime scene, latent prints, or firearms, or who want to work as investigators or detectives.
6.	Carson-Newman University,	Master of Science in Environmental Forensics:

	Jefferson City, United States CARSON-NEWMAN UNIVERSITY	Carson-Newman officials announced the beginning of an explorative study of an Environmental Forensics Program and, as part of it, an Environmental Decomposition Site to measure the residual effects both animal and human decay have on air quality, water supply and surrounding soil.
7.	University of Florida, United States UF UNIVERSITY of FLORIDA	Master's Degree in Forensic Studies (online course): The University of Florida offers the world's Largest Forensic Science Program. This award winning program offers an opportunity to learn from faculty with an international reputation. The program director Dr. Ian Tebbett, Ph.D., was recently awarded the 2010 Outstanding Leadership Award by the U.S. Distance Learning Association. Now in its 11th year, UF's Forensic Science programs are designed for today's working professionals, the program is offered entirely online, so you can work comfortably at home.
8.	University of Canberra, Australia UNIVERSITY OF CANBERRA AUSTRALIA'S CAPITAL UNIVERSITY	Master's Degree in Forensic Studies (online course): The course is part of a collaborative education partnership with the University of Florida and the University of Edinburgh. The University of Canberra (UC) is known for its expertise in Environmental Forensics, Forensic Chemistry and Forensic Biology, as well as practical application exemplified by their participation in the National Centre for Forensic Studies, a collaboration between the forensic sections of UC, the Canberra Institute of Technology and the Australian Federal Police. This partnership is unique in Australia, providing unmatched access to expertise and resources in the forensic science arena.

9.	University of Edinburgh, United Kingdom	Master's Degree in Forensic Studies (online course): The course is part of a collaborative education partnership with the University of Florida and the University of Edinburgh. The University of Edinburgh Forensic Medicine section is dedicated to the education, training and research of all aspects of forensic medicine. The section maintains close links with the pathologists who are employed by NHS Lothian - University Hospitals Division to carry out postmortem examinations on the instructions of the Procurators Fiscal. Research interests include brain trauma, road traffic collisions, suicide, drug use, forensic entomology, forensic odontology, psychology, head injury, rail track deaths, DNA and the role of the autopsy in the investigation of death.
10.	University of Strathclyde, Glasgow, United Kingdom	MSc in Environmental Forensics: This unique MSc in Environmental Forensics, the first of its kind in the UK, harnesses Strathclyde's world-leading expertise in environmental forensics. The course is the result of a close collaboration between the Department of Civil Engineering and the Centre for Forensic Science (from the Department of Pure and Applied Chemistry) - the UK's most respected Forensic Science Research and Education Centre - with input from the Strathclyde Law School.

BEST GLOBAL UNIVERSITIES FOR Environmental Science Courses
Top 10 institutions

These are the top 10 institutions of the world's best universities that offer Environmental Science courses; ranked by the U.S. News & World Report; tabulated as follows:

NO.	NAME OF INSTITUTIONS	COURSES OFFERED
1.	University of California – Berkeley, United States	Undergraduate Programme: c. Conservation and Resource Studies d. Environmental Sciences e. Forestry and Natural Resources f. Molecular Environmental Biology g. Society and Environment Graduate Programme: a. Master of Science in Range Management b. Master of Forestry c. PhD with the area of specialization on Microbial Community Ecology, Ecosystem Function, American Environmental History & Policy, International Forest Management, Biogeochemistry, Mediterranean Grassland Ecosystems, Remote Sensing, and Forest Management
2.	Harvard University – Massachusetts, United States	Undergraduate Programme: a. Earth and Planetary Sciences (EPS) b. Environmental Sciences and Engineering (ESE) c. Environmental Science and Public Policy (ESPP) d. Organismic and Evolutionary Biology (OEB) Graduate Programme: a. Master of Science (SM) Environmental Health b. Master of Public Health (MPH);concentrations in Occupational and Environmental Health and in Quantitative Methods c. Master of Occupational Health (MOH) d. Doctor of Science (SD); e. Doctor of Public Health (DPH)

3.	Stanford University – California, United States Stanford University	Undergraduate Programme: a. Geological Sciences (GS) Graduate Programme: a. Master of Science in Geological Sciences (GS) b. PhD in Geological Sciences (GS)
4.	University of California – Davis, United States UC DAVIS UNIVERSITY OF CALIFORNIA	Undergraduate Programme: Bachelor Degree courses in the following majors: <u>Major: Environmental Science and Management (ESM)</u> Courses in biology, chemistry, physics, economics and calculus form the lower-division foundation of the ESM major curriculum. The upper-division core consists of courses in physical, biological and social sciences, as well as applied courses in environmental monitoring, GIS, impact reporting and statistical analysis. <u>Major: Environmental Policy Analysis and Planning (EPAP)</u> The courses in this major focus on the relationship between humans and the environment. Interdisciplinary coursework includes economics, agricultural economics, political science and sociology. Internships are highly encouraged in this major, as real-world research work is a focus of the program. <u>Major: Environmental Toxicology</u> Preparatory courses in biology, chemistry, mathematics and physics provide the fundamental principles which underlie toxicology. Students in the major will learn the environmental fates and biological activities of different classes of toxic substances, and the legislative issues which arise from chemical use. Graduate Programme: Master's degree and PhD's in the following majors: <u>Major: Environmental Science and Management (ESM)</u> a. Climate Change & Air Quality b. Ecology, Biodiversity, & Conservation c. Geospatial Information Science

		d. Natural Resource Management e. Soils & Biogeochemistry f. Watershed Science <u>Major: Environmental Policy Analysis and Planning (EPAP)</u> a. City & Regional Planning b. Climate Change Policy c. Conservation Management d. Energy & Transportation Policy e. Environmental Policy & Politics f. Water Management g. Integrative Policy <u>Major: Environmental Toxicology</u> **a. Ecotoxicology and Environmental Chemistry** Aquatic Toxicology; Ecology; Chemical Fate **b. Forensic Science and Regulatory Toxicology** Environmental Policy and Management; Forensic Science; Public Health **c. Molecular and Biomedical Toxicology** Biotechnology; Food Toxicology; Medicine; Pharmacology; Veterinary Medicine
5.	Duke University – North Carolina, United States	Undergraduate Programme: a. A.B. in Environmental Sciences & Policy (New for 2015 - A.B. In Environmental Sciences & Policy with Marine Science & Conservation Leadership concentration) b. B.S. in Environmental Sciences (New for 2015 - B.S. In Environmental Sciences with Marine Science & Conservation Leadership concentration) c. A.B. in Earth & Ocean Sciences d. B.S. in Earth & Ocean Sciences Graduate Programme: a. Master Of Environmental Management (MEM) Seven specialized concentrations as a focal point for

		this major i. Coastal Environmental Management (CEM) ii. Energy and Environment (EE) iii. Ecotoxicology and Environmental Health (EEH) iv. Environmental Economics and Policy (EEP) v. Ecosystem Science and Conservation (ESC) vi. Global Environmental Change (GEC) vii. Water Resources Management (WRM) b. Master of Forestry Five core competencies for this major: i. Forest ecology and biology ii. Measurement of forest resources iii. Forest management iv. Forest policy and administration v. Professional ethics c. PhD i. Integrated Toxicology & Environmental Health
6.	Swiss Federal Institute of Technology Zurich – Switzerland ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich	Undergraduate Programme: a. Bachelor of Science course Special subject for system-oriented studies, choosing between i. Atmosphere and Climate ii. Biogeochemistry iii. Environmental Biology iv. Human-Environment Systems v. Forest and Landscape Graduate Programme: a. M.Sc. Environmental Sciences The master programme offers various in-depth subjects (Majors), such as i. Atmosphere und Climate

		ii. Biogeochemistry and Pollutant Dynamics Ecology and Evolution iii. Environmental Systems and Policy iv. Forest Landscape Management v. Human Health, Nutrition and Environment b. PhD Each Ph.D. program offers their Ph.D. students a specialised set of introductory and advanced courses: i. Biomedical Ethics and Law - Medical Track ii. Biomolecular Structure and Mechanism iii. Cancer Biology iv. Ecology v. Evolutionary Biology vi. Integrative Molecular Medicine vii. Microbiology & Immunology viii. Molecular Life Sciences ix. Molecular and Transitional Biomedicine x. Neuroscience xi. Plant Science xii. Science and Policy xiii. Systems Biology
7.	University of British Columbia – Vancouver, Canada THE UNIVERSITY OF BRITISH COLUMBIA	Undergraduate Programme: a. Earth and Environmental Sciences (BSc) Graduate Programme: a. Master of Science in Resource Management and Environmental Studies (MSc) b. Doctor of Philosophy in Resource Management and Environmental Studies (PhD)
8.	University of Queensland Australia – Brisbane, Australia	Undergraduate Programme: a. Bachelor of Environmental Science (Honours) Graduate Programme: a. Masters by coursework - Environmental Science

	THE UNIVERSITY OF QUEENSLAND AUSTRALIA	b. MPhil - Environmental Science c. PhD - Environmental Science
9.	Wageningen University and Research Center – Wageningen, Netherlands WAGENINGEN UR For quality of life	Undergraduate Programme: a. Bachelor of Science (B.Sc) 20 BSc programmes (2014-2015). The language of instruction is partly Dutch, partly English. i. Agro technology ii. Animal sciences iii. Biology iv. Biotechnology v. Business and consumer studies vi. Communication Science vii. Economics and policy viii. Environmental sciences ix. Food technology x. Forest and nature conservation xi. Health and society xii. International development studies xiii. International land and water management xiv. Landscape architecture and spatial planning xv. Molecular life sciences xvi. Nutrition and health xvii. Plant sciences xviii. Soil, water and atmosphere Graduate Programme: a. Master Environmental Sciences of the following majors: i. Aquatic ecology and water quality management ii. Soil biology and biological soil quality iii. Soil chemistry and chemical soil quality iv. Air Quality and Atmospheric Chemistry

		v. Environmental toxicology vi. Environmental systems analysis vii. Environmental policy viii. Environmental economics ix. Integrated water management x. Environmental technology b. PhD i. Plant sciences ii. Production ecology and resource conservation
10.	University of Oxford – United Kingdom	Undergraduate Programme: a. Bachelor of Science (B.Sc) Areas of Environmental Science are covered in: i. Biological Sciences ii. Earth Sciences (Geology) iii. Human Sciences iv. Geography Graduate Programme: a. Master of Philosophy (MPhil) in Geography and the Environment b. MSc in Biodiversity, Conservation and Management c. MSc in Environmental Change and Management d. MSc in Nature, Society and Environmental Governance e. MSc in Water Science, Policy and Management f. Doctor of Philosophy (DPhil) in Geography and the Environment

APPENDIX E - SAMPLING AND SITE MEASUREMENT FOR ENVIRONMENTAL FORENSIC INVESTIGATION

The INTERPOL ENVIRONMENTAL SECURITY SUB-DIRECTORATE-Pollution Crime Forensic Investigation Manual Vol. I of II, 2014 provide concise and comprehensive information on the legal sampling strategy and site selection including the necessary Quality Assurance (QA) and documentation for the different contamination scenarios such as:

SCENARIOS:

- Improper disposal of sewage through runoff to water body
- Spill of chemical/waste oil to surface water and/or surface soil
- Spill of chemical/waste oil to storm drain and to surface water
- Discharge of contaminated process effluent from an established outfall
- Discharge of process effluent containing high BOD5 or high COD
- Discharge of blood and slaughter waste from abattoir to surface water
- Spill of chemical into soils which enters groundwater
- Hazardous wastes/products illegally dumped on the surface at a landfill
- Hazardous tannery waste illegally buried in a landfill
- Hazardous waste attempted to be exported illegally
- Contaminated with crude oil, processed or waste oil, diesel or gasoline
- Contaminated with agricultural pesticides
- Contaminated with blood and slaughter waste from an abattoir
- Open burning of non-hazardous waste
- Hazardous waste illegally disposed of and incinerated
- Hazardous waste illegally disposed or incinerated (medical)

The QA practices should be strengthened through getting the entire sampling and site measurement activities accredited, such as the activities of sample planning and documentation listed herewith:

SAMPLE PLANNING AND DOCUMENTATION

- Information Sources
- Consultation – legal, technical and laboratory experts
- Preliminary site assessment
- Legal sampling strategy and sample site selection
- Quality Assurance – quality control of samples
- Health and safety planning
- Site and sample documentation
- Field and expert reports
- Tables of information
- Acronyms
- Conversion factors
- Units of measure abbreviations
- Checklist of equipment for field sampling
- Calculations and formulas

APPENDIX E1 - HANDHELD EQUIPMENT FOR SITE MEASUREMENT DURING ENVIRONEMTAL FORENSICS INVESTIGATION

NO	EQUIPMENTS	APPLICATION
1	**Handheld X-ray fluorescent (XRF) analyser** - a robust analytical tool that provides elemental composition information for a variety of samples 	• Metal analysis and metal identification • On-site geochemical analysis of mine face, drill core or prepared samples • Soils analysis when characterizing, remediating and monitoring contaminated soil sites
2	**Handheld Spectrometers** -does not require sample pre-treatment or direct contact with the sample, and has the unique capability of being able to test a sample directly through a transparent packing material like glass or plastic. 	• To identify or verify the components of a sample • For rapid, nondestructive analysis of chemical and pharmaceutical samples, be they liquid or solid
3	**Portable GC MSD Systems** - feature miniaturized ion traps or quadrupole technology and can identify volatile and semivolatile organic compounds in complex mixtures, including gases, liquids, solids, and vapors. 	• Use in extreme environments or hot zones and are well suited for environmental, petrochemical, forensics, and food applications
4	**Handheld Refractometers** - Is important in the food and beverage industry, clinical laboratories for analysing serum	• Measures the refractive index of aqueous solutions and is based on the relationship between refractive index and density

		
5	**Portable TOC Analyser** 	• Measuring low level total organic carbon (TOC). It can be used on-line for continuous monitoring or hand-carried to any point in a water system for rapid diagnostic sampling
6	**Portable FTIR Analyser** Portable FTIR gas analyser is a battery operated system	• Capable of measuring multiple gases (both organic & inorganic) at low concentrations simultaneously in real-time. • Other application including chemical spill, security, forensic investigation, occupational health, anaesthetic gases, greenhouse gases, refrigerants, leak detection, VOCs.

APPENDIX F-LABORATORY FACILITIES TO SUPPORT DOE ENVIRONMENTAL FORENSIC INVESTIGATION

1. Jabatan Kimia

The Forensic Division of Jabatan Kimia provides services in the areas of Narcotics, DNA Forensic, Crimnalistics, Toxicology and Questioned Document Examination. The Forensic Division only covers criminal and police cases and has been accredited to the ASCLD/LAB (Americal Society of Crime Laboratory Directors/ Laboratory Accreditation Board) since October 2005.

Analyses needed for environmental forensics can be carried out at the Environmental Section in Environmental Health Division.

1.1 Environmental Health Division

The Environmental Health Division provides scientific services for the safeguarding of public health in terms of food and drinking water safety as well as for the protection and conservation of the environment. The division consists of four sections, namely:

- Environment
- Food
- Water
- Biotechnology

Environment Section consists

- Surface Water and Effluent Unit
- Scheduled Waste and Oil Spill Unit
- Air Unit
- Trace Metal Unit
- Dioxins and Furans Unit

a. Surface Water and Effluent Unit

Surface Water and Effluent Unit provide a comprehensive scientific analysis services, consultation and advisory services to the relevant government agencies for the monitoring and enforcement of the act/regulations regarding environmental issues.Types of samples received are surface water, ground water, sewage water and liquid effluent. The routine parameters analysed were

- TOC, BOD, COD
- Ca, Mg, Na, K, Hardness, Chloride, Sulphate, Phosphate
- Ammonical Nitrogen, Total Kjedahl Nitrogen
- Solids: Total Solids, Suspended Solids, Dissolved Solids
- Trace Metals,

- Pesticide Residue
- Physical Test (pH, conductivity, Colour and Turbidity)
- Silica, VOC, Phenol
- Sulphide
- Cyanide
- Chromium hexavalent.

b. Schedule Waste and Oil Spill Unit

Schedule waste and oil spill give analysis service on exile samples dangerous and spill oil for the enforcement of the act. Other than that this unit is also conducting an investigation and advice service to certain parties with regard to exile issues dangerous and spill oil. The unit analysis the following samples:

- Paint sludge
- Solvent
- Aluminium dross
- Oil Spillage
- Battery and
- Electronic Waste

c. Air Unit

The Air Unit provides analytical services and consultancy in air quality monitoring. The samples analysed consist of wet deposition and dry deposition samples which are received from the Malaysian Meteorological Department. The unit also provides analytical support services for the international air quality monitoring.

d. Trace Metal Unit

Trace Metal Unit is a centralized laboratory for the analysis of trace elements. The unit is equipped with sophisticated instruments for the analysis, such as Inductively Coupled Plasma- Mass Spectrometry (ICPMS), Inductively Coupled Plasma-Optical Emission Spectrometry (ICPOES) and Flow Injection Mercury System (FIMS).

e. Dioxin and Furans Unit

The Dioxin and Furan Unit offers scientific services for the analysis of dioxins and furans for the purpose of monitoring and enforcement of Environmental Quality Regulations (Dioxins & Furans) 2004. The Unit is well equipped with instrumentations for sample preparations and determinations of dioxin and furan compounds at low levels. The type of samples receive are gas samples from incinerators, solvent rinses of samplers, particulate collected on the filters and field blanks. The methods used are EPA Method 23 and EPA Method 8290.

2. Malaysia Nuclear Agency

The Malaysia Nuclear Agency has two laboratories that will be able to provide direct support to the environmental forensic activities of DOE, namely **The Radiochemistry and Environment Laboratory (RAS)** and **The Isotope Ratio Mass Spectrometer (IRMS) Laboratory**

The Radiochemistry and Environment Laboratory (RAS) provides radio analytical services for government and commercial needs. RAS performs radiochemical analyses for alpha, beta and gamma emitting radionuclides in a wide range of matrices such as soil, sediment, sludge, water, food, smear test, fauna and flora.

RAS Laboratory has been accredited to MS ISO/IEC 17025since December 2005 for the analysis of gamma emitting radionuclides. For alpha and beta emitting radionuclides, the laboratory participates in inter-comparison analysis and proficiency tests organised by International Atomic Energy Agency (IAEA) and other competent international bodies.

List of Services for Environmental Samples offered by RAS

No	Type of Analysis	Analysis Technique
1	Measurement of Ra-226, Ra-228 (or Ac-228), K-40 etc., in environmental sample (sediment, soil, water, etc.)	Direct measurement using Gamma Spectrometry System
2	Measurement of gross alpha/beta in environmental samples (sediment, soil, water, fauna, flora, etc.)	Direct measurement using Low Background Gross Alpha/Beta Counting System
3	Measurement of gross alpha/beta in air borne/particulate, filter and “smear test”	Direct measurement using Low Background Gross Alpha/Beta Counting System
4	Measurement of Po-210 in various samples	Radiochemical separation and direct measurement using Alpha Spectrometry System
5	Measurement of U-235, U-234 and U-238 in various samples	
6	Measurement of Th-232, Th-230 and Th-228 in various samples	
7	Measurement of tritium (H-3) in urine/water/ice	Distillation technique and direct measurement using Liquid Scintillation Counter
8	Measurement of Pu-239+240 in various samples	Radiochemical separation and direct measurement using Alpha Spectrometry System
9	Measurement of Am-241 in various samples	
10	Measuring of Sr-90 in various samples	Radiochemical separation and direct measurement using Low Background Gross Alpha/Beta Counting System

The Isotope Ratio Mass Spectrometer (IRMS) Laboratory provides isotope analyses services of light stable isotopes of hydrogen ($^{2}H/^{1}H$), carbon ($^{13}C/^{12}C$), nitrogen ($^{15}N/^{14}N$), oxygen ($^{18O}/^{16}O$) and sulphur ($^{34}S/^{32}S$). The laboratory provides the analyses for a variety of sample matrices such as water, liquid and solid materials on both inorganic and organic compounds.