

Reduction of Unintentionally Produced Persistent Organic Pollutants (UPOPs) emissions by improving waste management practices at landfills

Practices that impact operational resilience

GEF Project ID: 5558 – Component 2 - Development and Implementation of a Sustainable Management Mechanism for POPs in the Caribbean

06 October 2021



Landfill practices that impact operational resilience

The five (5) POPs categories:

1. Pesticides

- E.g. DDT, Lindane



2. Perfluorooctane sulfonic acid and its salts (PFOS)

- fire fighting foam, Aviation Fluid, Metal Plating, Oil Production, Insecticide for Fire Ants, Textiles and Carpets



3. Brominated Flame Retardants

- foam in vehicles, plastic (CRT TVs and Monitors)



4. Polychlorinated biphenyls (PCBs)

- electrical transformers and capacitor oils (pre 1985)



5. Unintentionally Produced POPs (UPOPs)

- waste incineration / burning (Furans and Dioxins), metal production, heat and power generation, production of mineral products



1

The impact of uncontrolled waste disposal

An Overview

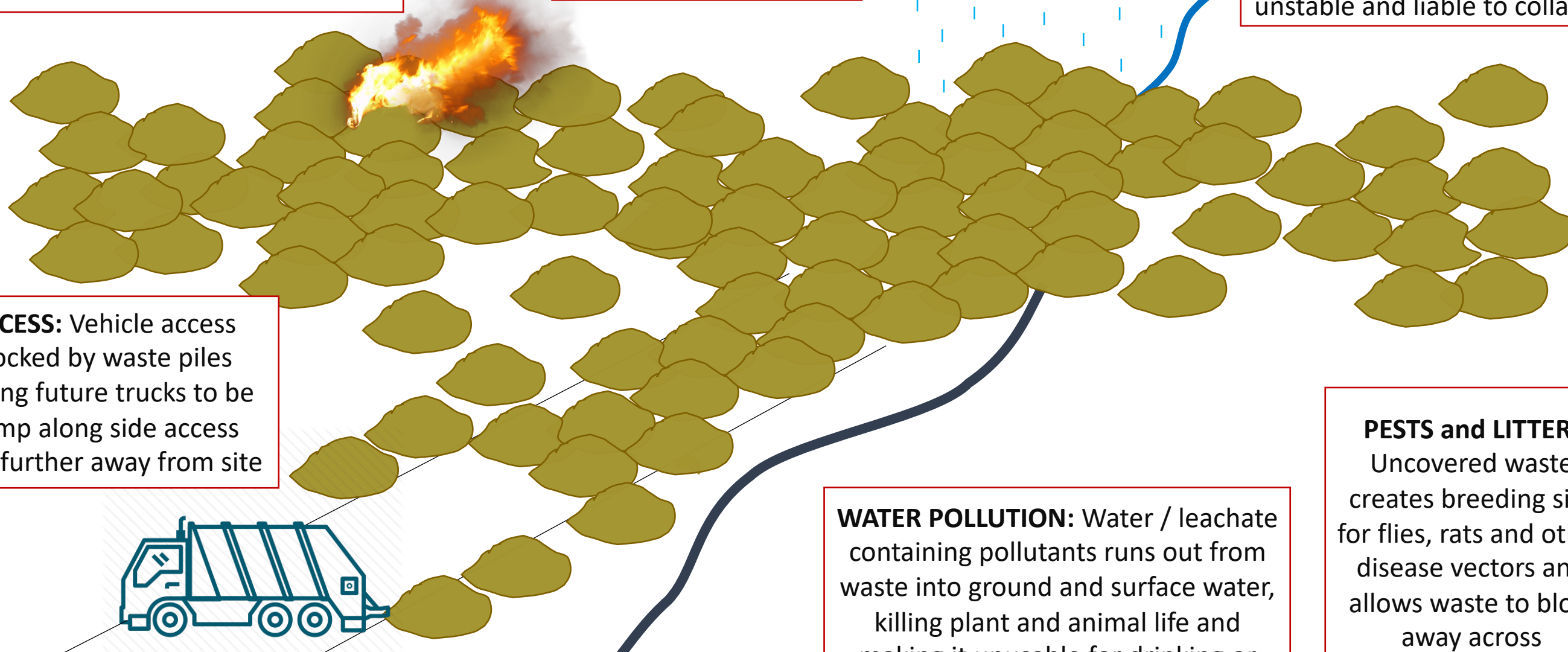


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FIRE: Uncovered waste easily burns either intentionally to reduce volume or recover metals or unintentionally due to spontaneous combustion or reactive waste (e.g. exploding batteries) producing toxic smoke.

LANDUSE: Inefficient use of land as undefined area and no compaction results in waste spread out over large area

SITE STABILITY and EMISSIONS: Rain and surface storm water enter uncovered waste creating leachate and gas. Also erodes waste piles and slopes making waste unstable and liable to collapse



ACCESS: Vehicle access blocked by waste piles forcing future trucks to be dump along side access road further away from site

WATER POLLUTION: Water / leachate containing pollutants runs out from waste into ground and surface water, killing plant and animal life and making it unusable for drinking or farming.

PESTS and LITTER: Uncovered waste creates breeding site for flies, rats and other disease vectors and allows waste to blow away across neighbouring land.

WASTE ACCEPTANCE: Waste loads not inspected, commingled waste including hazardous and problematic materials dumped on site

Impacts of poor waste disposal practices

Water pollution

Rainwater falling on landfill, and surface water flowing into landfill, and mixing / interacting with waste to create leachate, before flowing from landfill into ground and surface waters:

1. Picking up heavy metals, POP chemicals, other toxic compounds in solution and carrying them out of the site
2. Depletion of dissolved oxygen.
3. Bacteriological and virus contaminations.
4. Chemical alteration of groundwater and surface waters.
5. Marine litter / plastics and associated impacts on marine life

Upstream



Downstream





Impacts of poor waste disposal practices

Gas and air pollution

1. Noxious odours.
2. Releases of particulates from fire, UPOPs (Dioxins and Furans) and other short lived climate pollutants,
3. Releases of methane from anaerobic decomposition, ammonia, hydrogen sulphates and other gases.
4. Dust released during operations and carcinogenic smoke caused by fires.



Stop the Burn, Stop the UPOPs!



HUMAN RIGHTS WATCH

**WHERE DID THE TRASH GO?
IT'S IN THE AIR YOU BREATHE.**

YOUR HEALTH, YOUR RIGHT.
Sign the petition
www.hrw.org/StopTheBurning

Billboard poster from Lebanon where waste management collapsed after corruption and poor policy resulted in under investment in waste treatment and disposal capacity

Impacts of poor waste disposal practices

Soil pollution

1. Release of chemical compounds that are taken up and concentrated in plants and animals including POPs and Microplastics.

Aesthetic impact

1. Unsightly or odious aspects of an active landfill.
2. Increased traffic and truck spillage
3. Increased litter and waste particles in the natural environment

2

Sanitary Landfill Sites

An Overview



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What is a Sanitary Landfill Site

A designed, engineered and managed site where waste is isolated from the environment (water, soil and air) until it is safe, and any emissions from it are contained and treated in an environmentally appropriate manner.



Basic conditions for a site to be sanitary

- ****Full or partial hydrogeological isolation:** Isolating waste from the natural water cycle. Leachate collection and treatment must be stressed as a basic requirement. ******
- **Formal engineering preparations:** The site must be designed appropriately for local conditions. A waste disposal plan and a final restoration plan should also be developed.
- **Permanent control:** trained staff should be based at the landfill to supervise site preparation and construction, the depositing of waste and the regular operation and maintenance.
- **Planned waste emplacement and covering:** waste should be spread in layers and compacted then covered to retard rain and oxygen infiltration.

UN Habitat Waste Wise Cities - Landfill Control Ladder

The UN Habitat WASTE WISE CITIES TOOL provides a step-by-step guide to assess a city's Municipal Solid Waste Management performance through Sustainable Development Goals (SDG) indicator 11.6.1 monitoring

Within this tool, a guide is provided to classify the control level of landfills, the Landfill Control Ladder (see image). Basic Control is the minimum level of control required to meet the SDG 11.6.1 and offers a minimum level that any disposal site must meet.

Access the UN Habitat Waste Wise Cities Tool (WaCT) Data Portal at:

<https://unh.rwm.global>

CONTROL LEVEL	Landfill Site
Full Control	<ul style="list-style-type: none"> Waste daily covered Waste compacted Site fenced and full 24-hour control of access Properly sited, designed and functional sanitary landfill Leachate containment and treatment (naturally consolidated clay on the site or constructed liner) Landfill gas collection and flaring and/or utilization Site staffed; Post closure plan Weighing and recording conducted Protection of workers' health and safety
Improved Control	<ul style="list-style-type: none"> Waste periodically covered Waste compacted Site fenced and control of access Leachate containment and treatment Landfill gas collection (depending on landfill technology) Site staffed Weighing and recording conducted Protection of workers' health and safety
Basic Control	<ul style="list-style-type: none"> Some use of cover Waste compacted Sufficient equipment for compaction Site fenced and control of access No fire/smoke existence Site staffed Weighing and recording conducted The slope of the landfill is stable, landslides not possible Protection of workers' health and safety
Limited Control	<ul style="list-style-type: none"> No cover Some compaction Some equipment for compaction Some level of access control/fencing No leachate control Some fire/smoke existence Site staffed Weighing and recording conducted The slope of the landfill is unstable with high possibility of a landslide
No Control	<ul style="list-style-type: none"> No cover No compaction No/ limited equipment No fencing No leachate control Fire/smoke existence No staff The slope of the landfill is unstable with high possibility of a landslide

Sanitary landfills do not safeguard the environment without proper sustained operational management, and even then... the resiliency of operation must continuously be improved
- photo shows a fully engineered sanitary landfill on fire



(Photo/Elkhart County Sheriff's Dept.)



(Photo/Elkhart County Sheriff's Dept.)

Without proper Operation and Maintenance, a Landfill is just a dumpsite

No management, no compaction, no cover



Without proper Operation and Maintenance, a Landfill is just a dumpsite



Management, Compaction, Cover

More than just engineering

CATEGORY	REQUIREMENT
<ul style="list-style-type: none"> • Security 	<ul style="list-style-type: none"> • Physical boundary surrounding the site and supervised access control 24/7
<ul style="list-style-type: none"> • Water and leachate control 	<ul style="list-style-type: none"> • Site engineering preventing surface and groundwater ingress into the landfill • Functioning leachate containment liner, collection and management
<ul style="list-style-type: none"> • Slope stabilization 	<ul style="list-style-type: none"> • Slopes stabilized, including erosion control, to mitigate risk of collapse
<ul style="list-style-type: none"> • Waste handling, compaction and cover 	<ul style="list-style-type: none"> • Waste deposited in clearly defined operational areas with strict management control • Waste layered and compacted promptly • Daily and intermediate cover applied
<ul style="list-style-type: none"> • Fire control 	<ul style="list-style-type: none"> • Zero occurrence of burning of waste within the landfill site
<ul style="list-style-type: none"> • Landfill gas management 	<ul style="list-style-type: none"> • Landfill gas controlled with utilization where practicable
<ul style="list-style-type: none"> • Staffing 	<ul style="list-style-type: none"> • Site staffed full-time with professionally qualified personnel
<ul style="list-style-type: none"> • Recording 	<ul style="list-style-type: none"> • Functional weighbridge in use with recording waste quantities by waste types
<ul style="list-style-type: none"> • Environment Health and Safety (EHS)_ 	<ul style="list-style-type: none"> • EHS measures implemented in accordance with professional risk assessment and operating plan • Showering and sanitary facilities • Environmental monitoring system in place with annual reporting capability
<ul style="list-style-type: none"> • Site planning 	<ul style="list-style-type: none"> • Site development and operational filling plan in place • Post closure plan in place

FIRE: Cover material on compacted waste reduces waste exposure to air and dramatically reduces the chance of fire, both intentional and accidental limiting risk of toxic smoke.

LANDUSE: Efficient use of land as site is **planned** and waste is **layered and compacted** to a workable depth within a **defined boundary**

SITE STABILITY and EMISSIONS: Compacted and covered waste reduces rainwater entry and **perimeter ditches** divert surface water away from waste helping to reduce leachate and gas generation as well as prevent site erosion. **Appropriately sloped and compacted waste** improves site stability, minimising risk of collapse

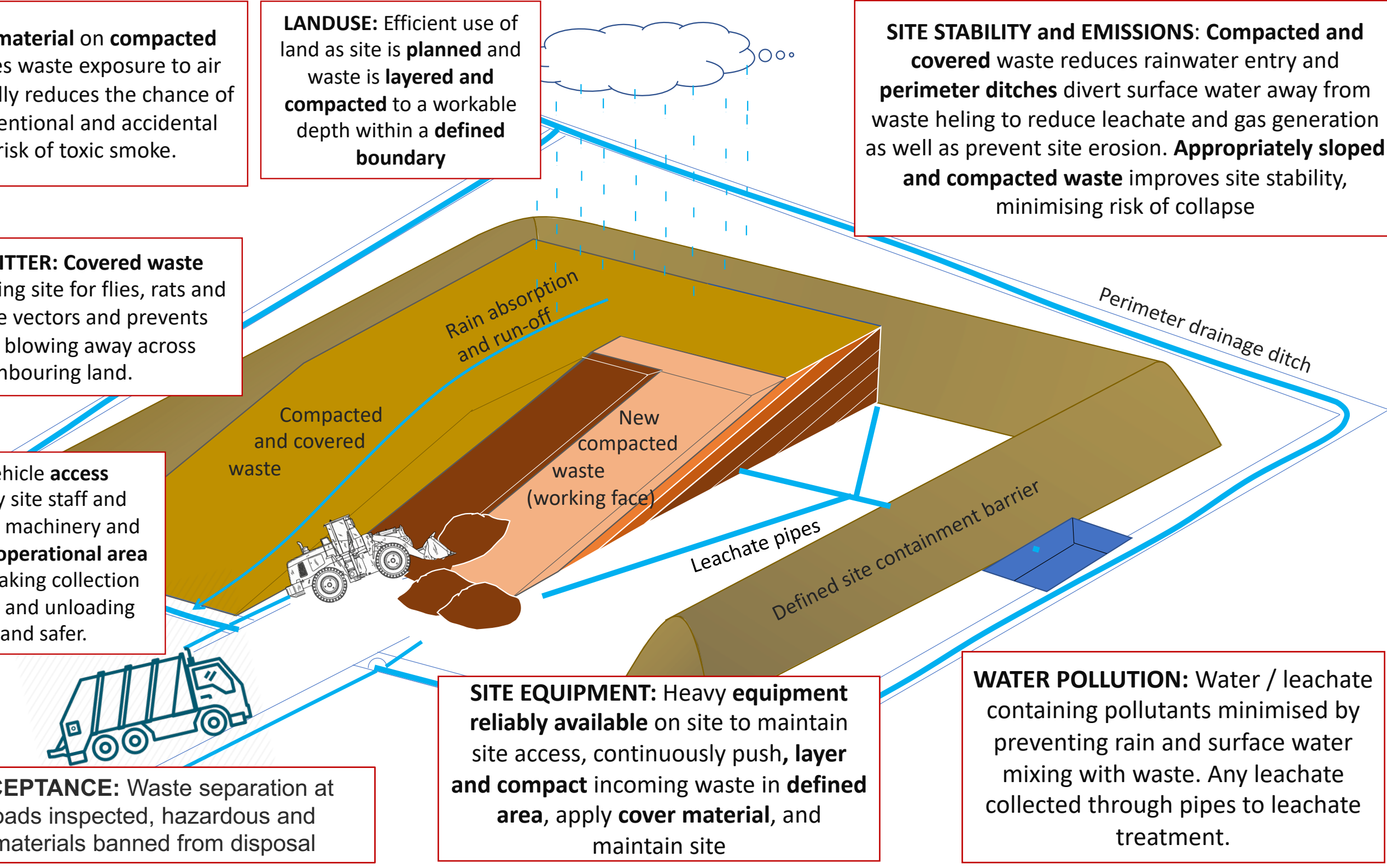
PESTS and LITTER: Covered waste reduces breeding site for flies, rats and other disease vectors and prevents waste from blowing away across neighbouring land.

ACCESS: Vehicle access monitored by site staff and maintained by machinery and with a **specific operational area for disposal** making collection vehicle access and unloading efficient and safer.

WASTE ACCEPTANCE: Waste separation at source and loads inspected, hazardous and problematic materials banned from disposal

SITE EQUIPMENT: Heavy equipment reliably available on site to maintain site access, continuously push, **layer and compact** incoming waste in **defined area**, apply **cover material**, and maintain site

WATER POLLUTION: Water / leachate containing pollutants minimised by preventing rain and surface water mixing with waste. Any leachate collected through pipes to leachate treatment.



3

Operational Resilience



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Operational Resilience

The ability to prevent, adapt, respond to, recover and learn from operational disruptions.

Part of **Organisational Resilience**: The ability of an organization to anticipate, prepare for, respond and adapt to incremental change and sudden disruptions in order to survive and prosper.”

ISO 22316:2020 – Security and resilience – Organisational resilience – principles and attributes.

Highly recommended framework to adopt.

Business Continuity management systems

Plan, establish, implement, operate, monitor, review, maintain and continually improve your **management system** to

protect against, reduce the likelihood of occurrence, prepare for, respond to, and recover from **disruptive incidents** when they arise.

ISO 22301:2019, *Security and resilience – Business continuity management systems – Requirements*

Highly recommended framework to adopt.

Operational Resilience

Key components to developing Operational Resilience:

1. **Identify important business services** that if disrupted could cause harm to your customers or your reputation, threaten the viability of the service or cause instability in the local economy and environment;
2. **Identify and document** the people, processes, technology, facilities and information that support your important business services; and
3. **Take actions to be able to ensure business continuity** through a range of severe but plausible disruption scenarios by incrementally addressing vulnerabilities.



Operational Resilience – Stage 1

Stage one to enhancing Operational Resilience

Identify important business services that if disrupted could:

- Cause intolerable harm to the end users (i.e. waste producers, waste collectors),
- Harm your reputation and that of the corporation or government (i.e. waste management body's board of directors, staff, or government representatives);
- Threaten health, environment and safety (i.e. society / general population);
- Threaten your financial stability (to continue to provide services).

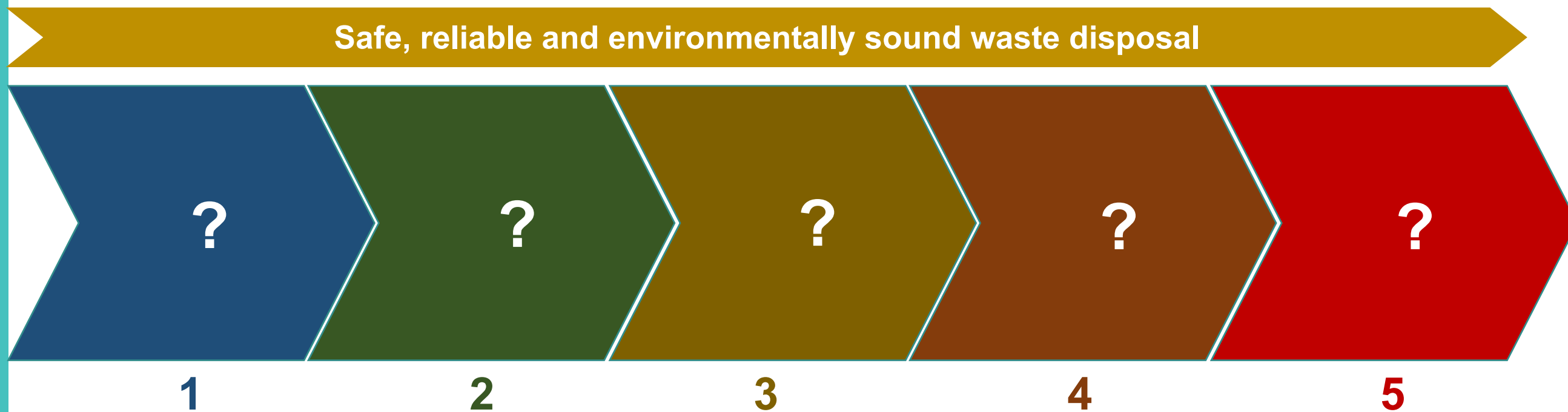
Exercise: What are the important business services of CWSA?



Identify important business services

Stage one to enhancing Operational Resilience

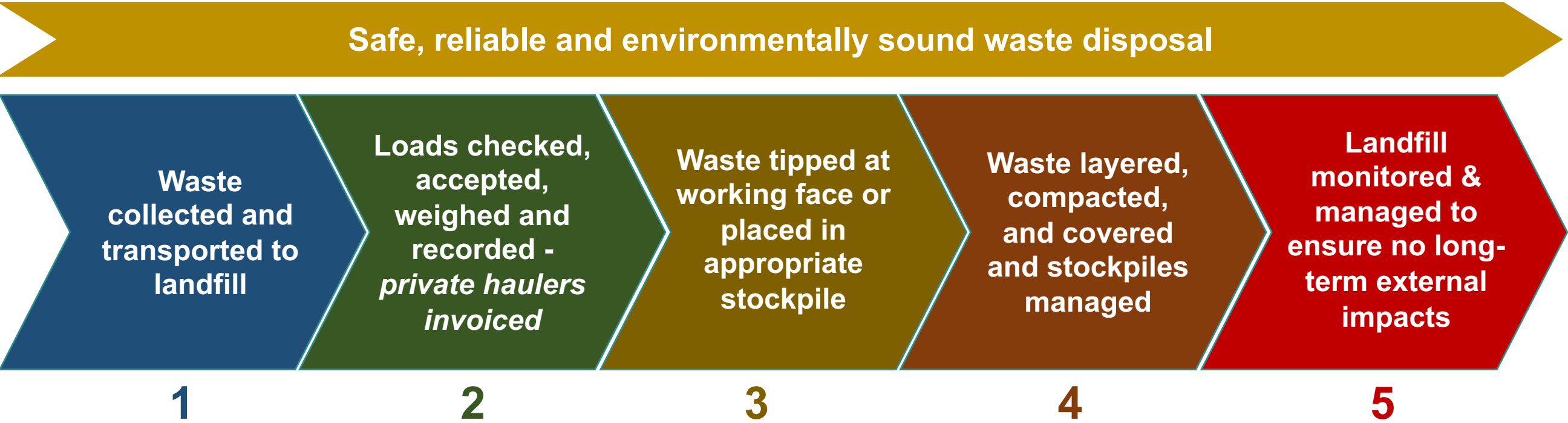
Understand how the business service is delivered by mapping the key process steps – the focus here being on the safe, reliable and environmentally sound disposal / landfilling of waste – rather than integrated sustainable management



(later we will define what resources enable these steps to be delivered)

Identify important business services

Stage one to enhancing Operational Resilience



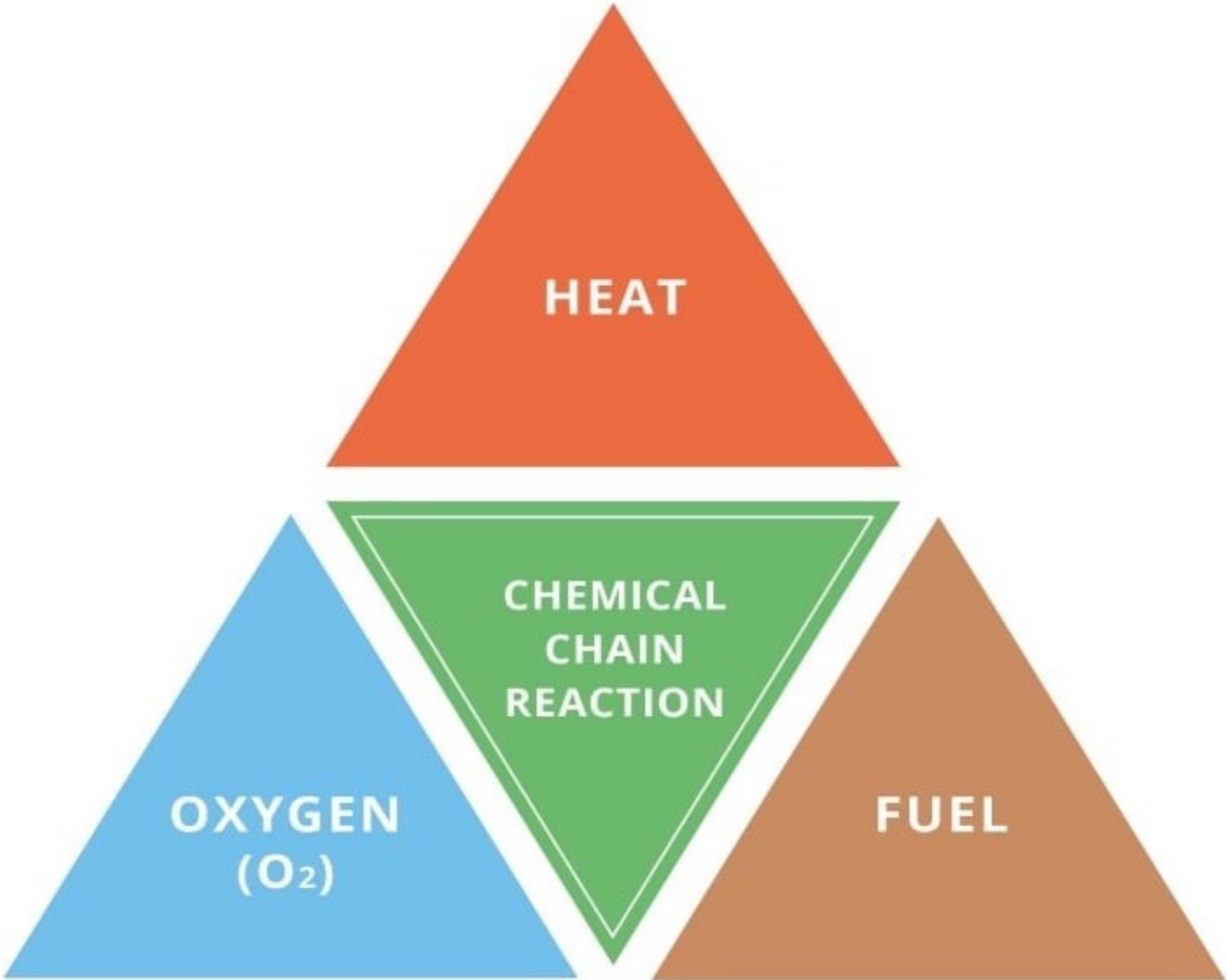
Incidents that can disrupt operation of service

A great number of adverse circumstances of varying nature, severity and duration may cause disruption to the important business service operation. These might include:

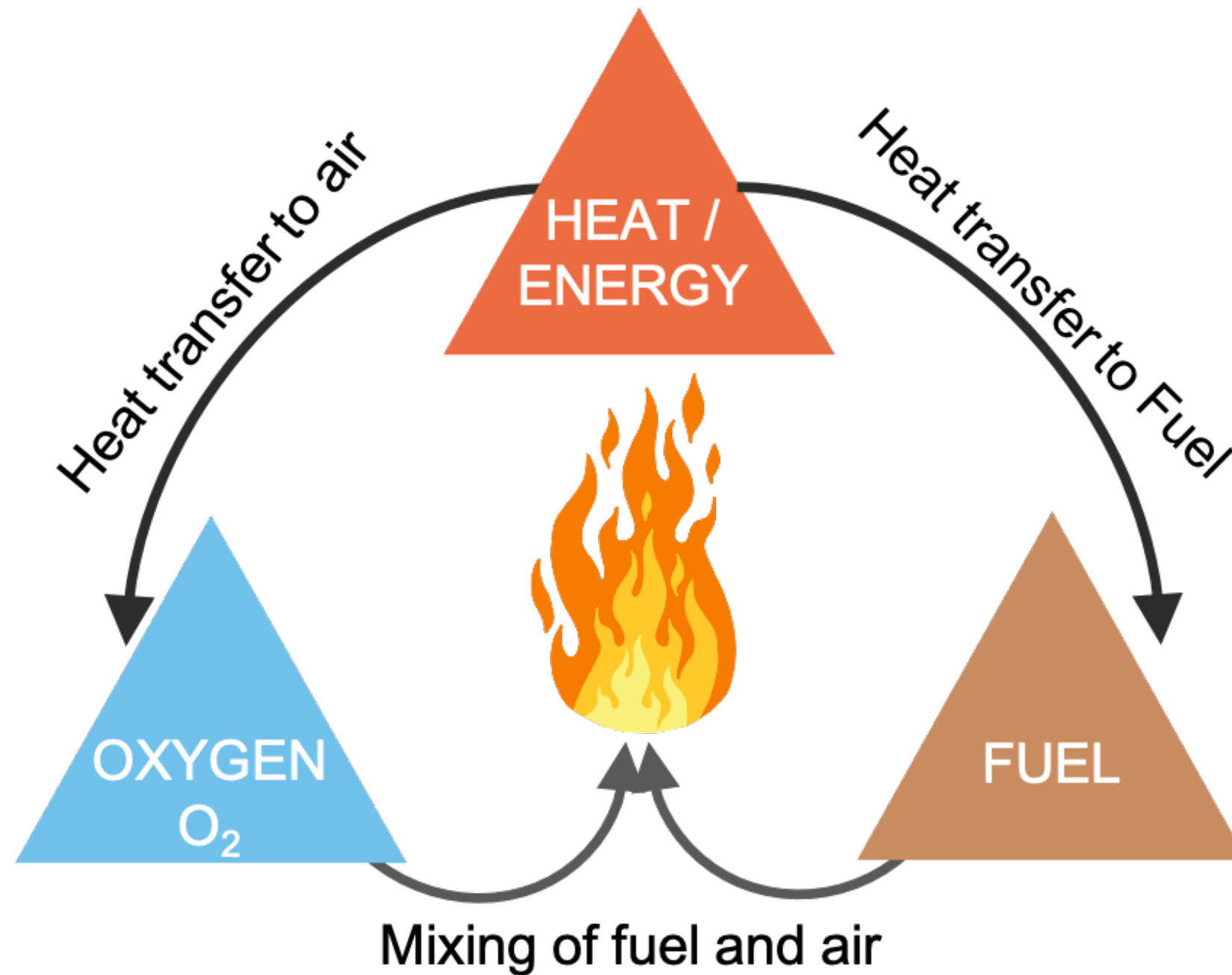
- **Hurricane** (direct (damage to landfill facility / equipment) or indirect (debris generation))
- **Pandemic / epidemic**
- **Fire**
- **Pollutant emissions to air, ground / surface water**
- **Political unrest**
- **Fuel crisis**
- **Equipment / spare part supply chain disruption**
- **Financial crisis**
- **Etc.**

Direct UPOPS and POPs release, but any of the other events may create conditions for these two events to occur

Fire Triangle – The needs of a fire



Fire Triangle – The needs of a fire



4

Landfill practices that impact operational resilience



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Case study - Fire on Landfill in Grenada

Grenada Solid Waste Management Authority – Perseverance landfill

Fire at the Perseverance Landfill facility (now old dumpsite, new landfill since constructed)

<https://youtu.be/3eIUP4kHu64>

Look at some of the aspect of the old perseverance disposal site (before fire)

<https://youtu.be/QERe4qrekUw>

Step 1 Landfill Practices - Collection

IF IT DOESN'T GO IN, IT CAN'T COME OUT!

- Must have basic segregated collection


Ban and enforce ban on hazardous, POPs containing, bulky wastes, organic wastes etc. collection (we will see the issues with these later).

- Ensure collection fleet is properly maintained

**Waste
collected and
transported to
landfill**



Step 2 Landfill Practices – Waste Acceptance



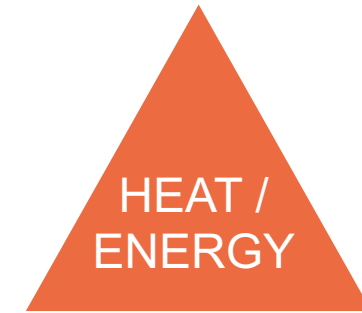
Loads checked,
accepted,
weighed and
recorded -
private haulers
invoiced

Green waste - compost

Bulky waste – dismantle and recycle

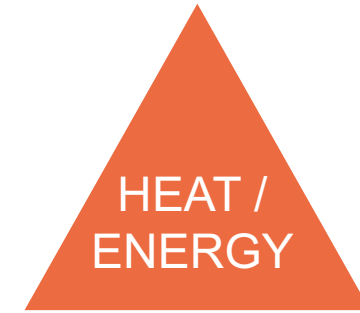
- **Publicise and enforce** waste acceptance criteria (physically inspect trucks from time to time)
- **Ensure alternative options** exist and are published for non-acceptable waste. Develop strategy for alternatives for acceptable but problematic wastes
- **Keep and use records** and statistics on quantity of different waste types - this enables alternate management options planning – No weigh bridges (you can't manage what you can't measure!)
- **Establish financing mechanisms** with correct pricing / cost recovery
- **Producer pays principle** / enforce punishment for dumping / illegitimate haulers that avoid payment

Potential sources of heat / energy (sparks) on the landfill



- Batteries,
- Hot waste loads from collection vehicles
- Heat generated by waste decomposition can reach 90°C.
- Oxidising chemicals,
- Boating flares,
- Sparks from vehicles delivering and compacting waste,
- Informal waste pickers burning off wires,
- Smoking.
- Grass / bush fires on adjacent sites

Lithium Ion / Polymer batteries



Lithium Ion battery fire at ecomaine's Recycling Facility - <https://youtu.be/WsUjSE-ibKo>

Dangerous vs. Safe batteries, Explosion and fire test! - <https://youtu.be/Qzt9RZ0FQyM>

Are you prepared for a lithium-ion battery fire? - <https://youtu.be/DCNyTm55sR4>

Step 3 Landfill Practices – Waste placement



Waste tipped at
working face or
placed in
appropriate
stockpile

- Lack of **fire extinguishers** and training on rapidly extinguishing fires.
- Not moving fire extinguisher system with working face
- Not updating or following Landfill Operation and Maintenance Plan and **insufficient allocation of resources (including human capacity and financial) to implement it**
- No management plan for stockpiling of bulky waste, tyres, end of life vehicles.

Step 4 Landfill Practices - Containment

Keep small working face and cover rest of site with sufficient material.

No cover material / insufficient cover material =

Rainwater getting in, leachate being generated.

Oxygen getting in, increasing fire risk



Waste layered,
compacted,
and covered
and stockpiles
managed

Too much or inappropriate management of cover material reduces landfill space and site lifespan



FUEL

Unlined landfills with no leachate treatment have great potential to result in UPOPs in landfilled waste materials being leached out into surrounding soil and water systems.

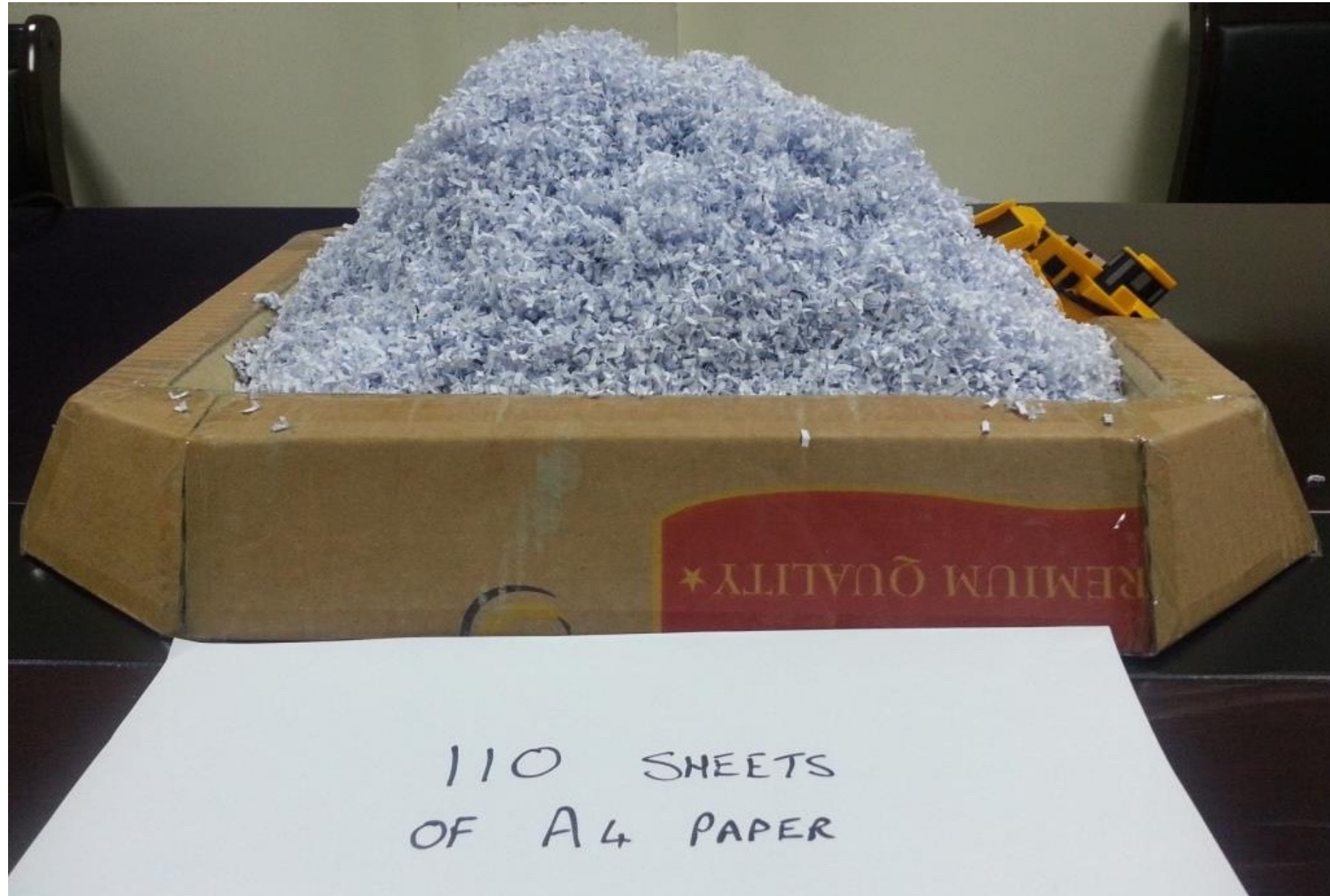
Benefits of layering and compaction

Maximise free void space, minimize fire risk



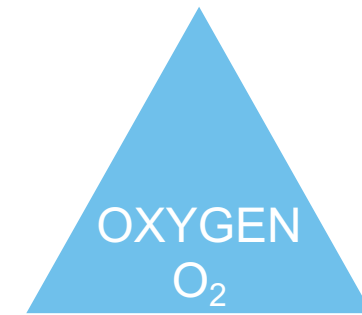
Impact of sporadic activity and non-compaction

Minimise free void space, maximise fire risk



Low density / non-compactible bulky waste

Bulky Green waste, white goods, tyres, mattresses

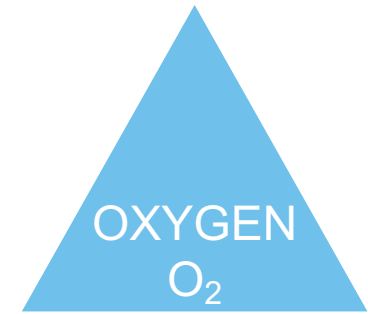


Bulky Green waste, white goods, tyres, mattresses are thick, difficult to drive over and compact and so hold air in the landfill.

Green waste and mattresses have tendency to rebound (spring back) after compaction, opening air spaces and pathways within waste mass that hold air / oxygen.

Small bulldozers have good traction, but poor compaction, and do not compact the waste enough to squeeze out air.

**Appropriate machine, inappropriate maintenance!
Establish robust fleet management system
Ensure finance and procurement systems**

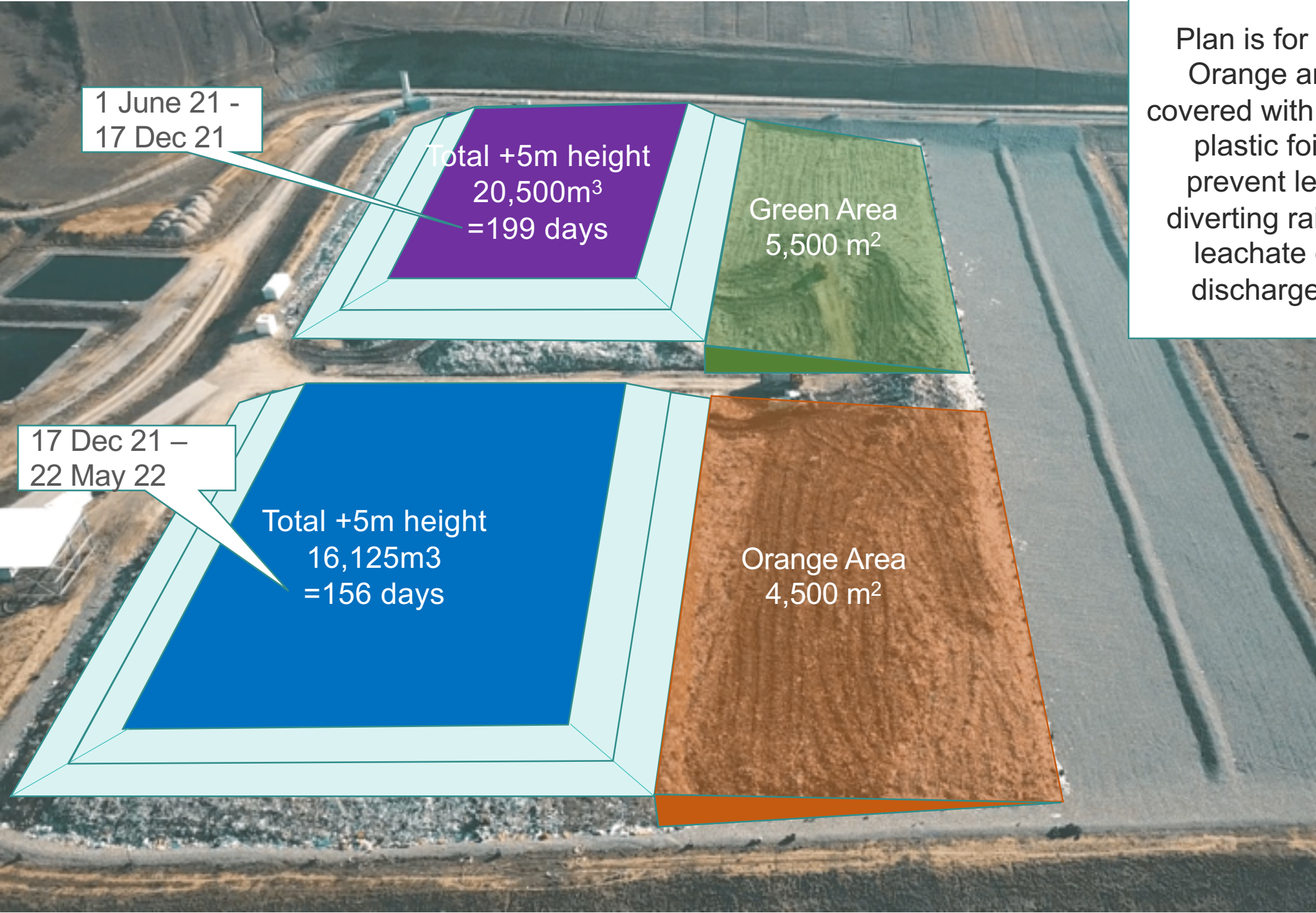




Due to breakdown of compactor, waste could not be consolidated in layers and site had to be expanded horizontally before planned, resulting in additional leachate generation, overwhelming leachate treatment plant.



With compactor back in action, extra effort and resources required to apply sufficient cover over expanded site, focus now placed on filling one area vertically as planned.



1 June 21 -
17 Dec 21

Total +5m height
20,500m³
=199 days

Green Area
5,500 m²

17 Dec 21 –
22 May 22

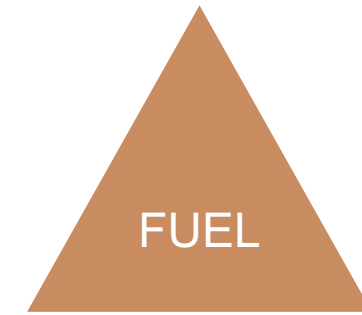
Total +5m height
16,125m³
=156 days

Orange Area
4,500 m²

Plan is for Green and Orange areas to be covered with intermediate plastic foil cover to prevent leachate by diverting rainwater into leachate drain that discharges to river.

Waste used tyres

Waste used tyres



- Waste used vehicles tyres are a significant fuel and produce highly toxic, uPOPs laden smoke and residues when openly burnt;
- Must have robust and enforceable management plan for stockpiling and treating tyres that prevents burning.

Step 5 Landfill Practices – Monitoring and Aftercare



Landfill
monitored &
managed to
ensure no long-
term external
impacts

- Must ensure **environmental monitoring** to provide early warning of issues and **inform planning / investment** decisions.
- Must maintain **cover material** and conduct **de-bushing** to prevent wildfires entering site
- Establish security **preventing waste pickers** on site
- Have **robust and resourced management strategy** for all systems and processes including stockpiled wastes
- Plan for **progressive engineered site closure** (proper closure and cover of unlined landfill will dramatically reduce leachate from rain infiltration).

Avoid single points of failure



Reverse Osmosis leachate treatment plant

Broke down due to computer crashing as result of power surge and no UPC,

local operator and national maintenance company have no back up computer

Now waiting on computer repair for 2 weeks, rainy season and leachate pond fast filling to overflow

Single failure point with no back up.

5

Exercise on triggering disruptive events and consequences

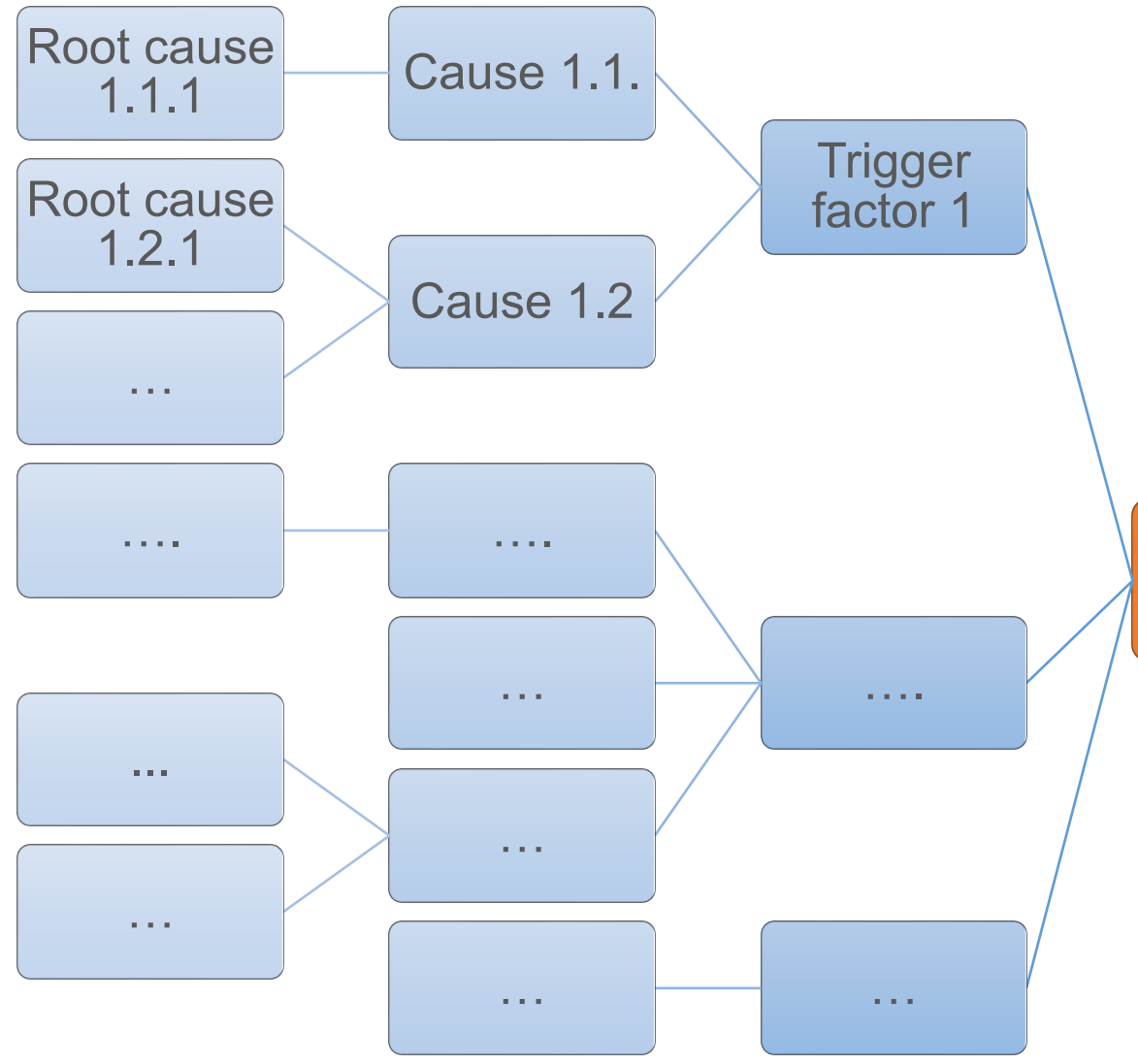


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15 minutes
or less

Trigger factors, causes/root causes

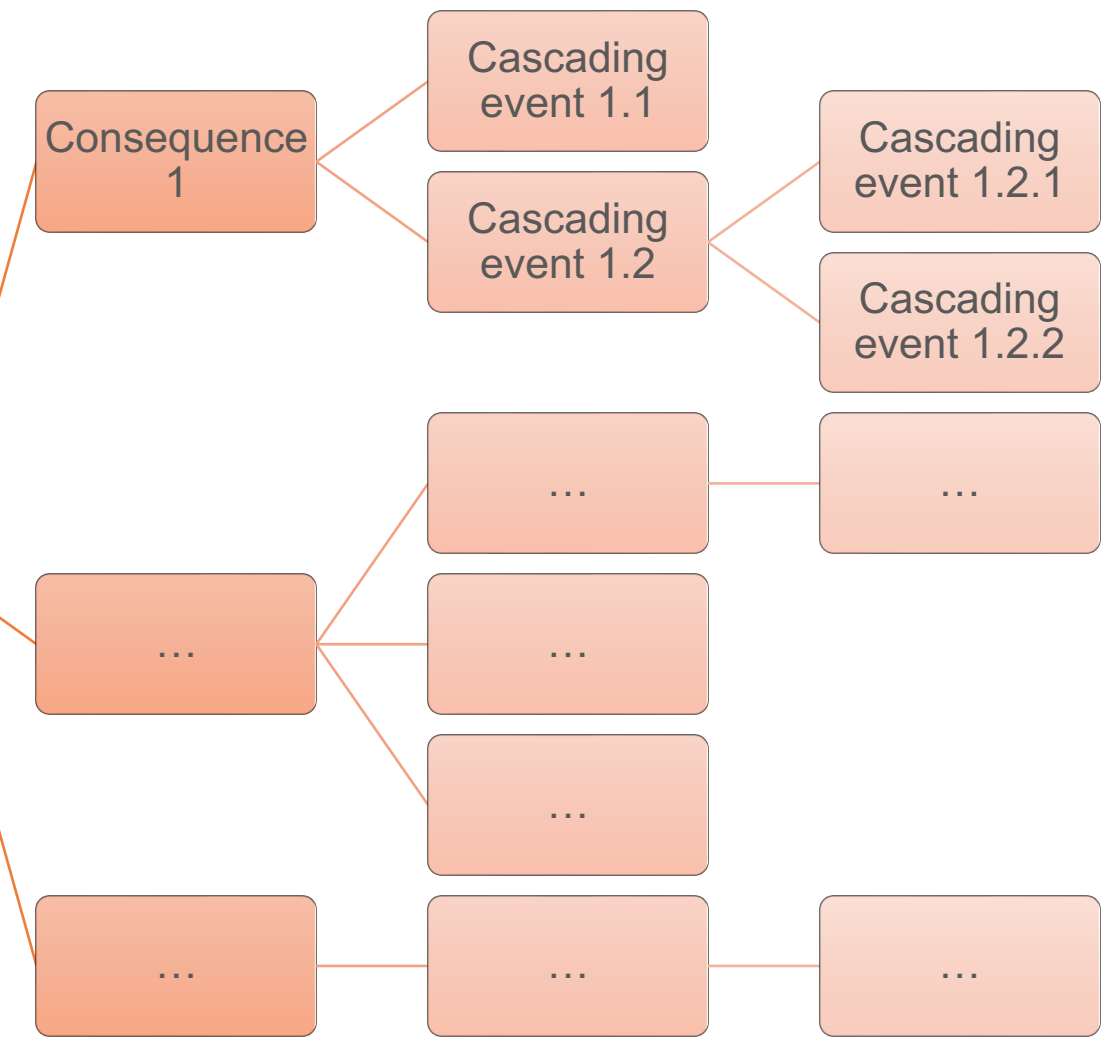


Disruptive Event

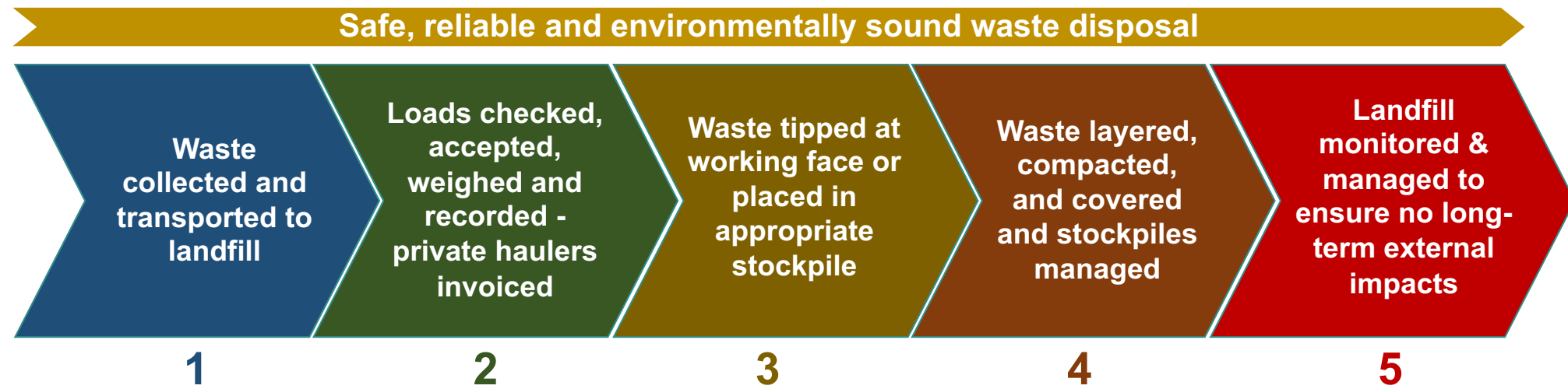


Fire on landfill

Consequence chains of events / cascading effects



Resources required for each process step



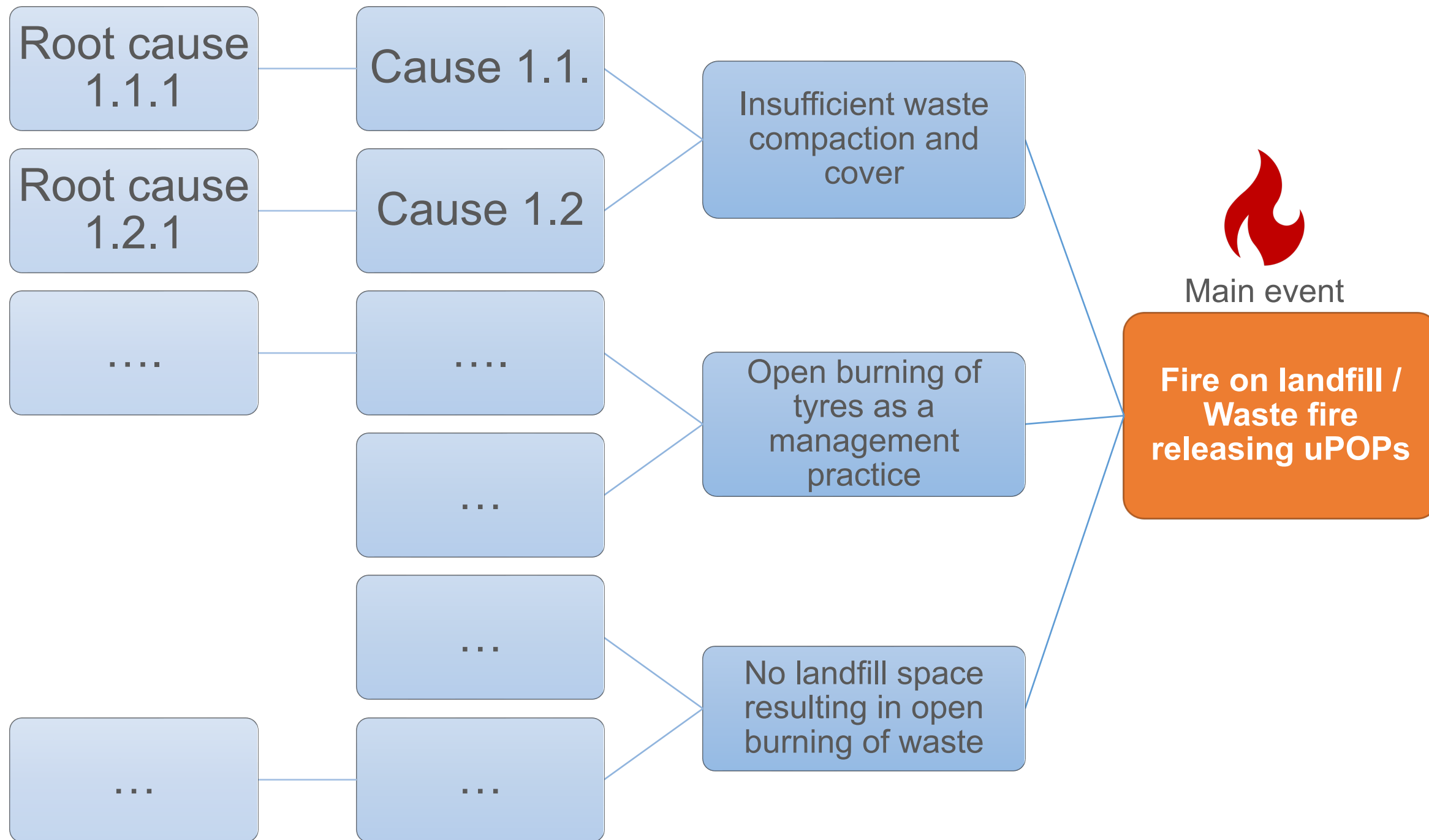
Macro system influences

- Political
- Economic
- Social
- Technological
- Environmental
- Legal

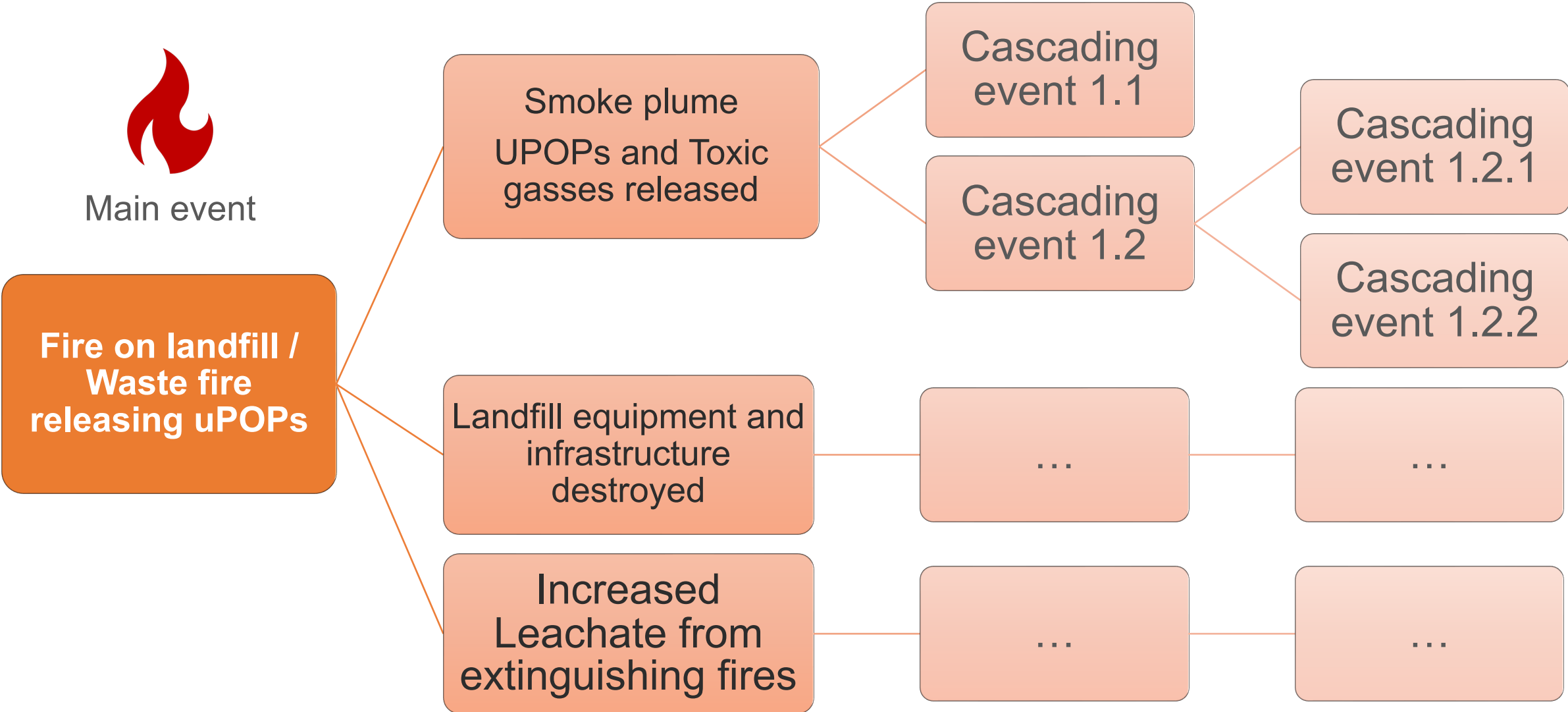
Operational resources

- Technology
- Materials
- People
- Facilities
- Information
- Third parties

Group 1 - Trigger factors, causes / root causes



Group 2 - Consequence chains of events / cascading effects (include cost of inaction)



Group 1 - Trigger factors, causes / root causes

Tyre levy finance not ringfenced for tyre recycling	No resources allocated to tyre recycling	Tyres set on fire releasing uPOPs
No management strategy for tyres		
Increasing number of vehicles and associated waste tyres	No proper management of tyres – Open burning as a disposal method	
Insufficient budget allocated to machinery	Lack of / inappropriate machinery	Insufficient waste compaction and cover
Unqualified award of equipment contracts	Operators insufficiently trained	
Poor enabling environment to attract investment in alternate waste treatment tech	Insufficient alternatives to landfill	
Waste not segregated at source	Lithium batteries in waste crushed by compactor and ignite waste mass	
No site security	Waste pickers active on site	Open burning to recover metals
No enforced ban on purchasing burnt wire	Recyclers pay more for wire without plastic	
Fire on neighbouring plot	De-bushing not conducted around landfill site	No fire breaks maintained fire enters landfill/stockpiles
Green waste and cardboard bulky and consuming void space	No alternate option for treating green waste and card	Open burning on site as a management practice

Fire on landfill



Fire on landfill



Smoke plume UPOPs and Toxic gasses released	Air pollution	Respiratory illnesses in citizens
		Loss of workdays and income
		Increased medical expenses
	Airport traffic grounded	Loss of revenue
	Negative social media and press reports	Tourism affected – loss of national reputation and income
		Reputation loss – citizens unwilling to pay for services
Politician reputations damaged –political instability		
Increased Leachate from extinguishing fires	Water pollution	Extra technology and expense to treat water for drinking / agriculture
		Increased health impacts – health care costs
	Clean-up costs	Finances and staff capacity diverted from future investment or operational priorities
Landfill equipment and infrastructure destroyed	Inability to continue accepting waste	Increase in waste dumping, increased risk of another fire event, waste left on streets and impacting tourism and public health.
	Replacement costs	Finances and staff capacity diverted from future investment or operational priorities
Resources taken to fight fire	Fire authority prevented from tackling other fires	Other properties and emergencies at risk
	Human and financial cost to corporation / authority to fight fire	Finances and staff capacity diverted from future investment or operational priorities