Modern mining impacts & mitigation

An overview of principles and criteria for environmental protection in Arctic mining with a focus on the marine environment.

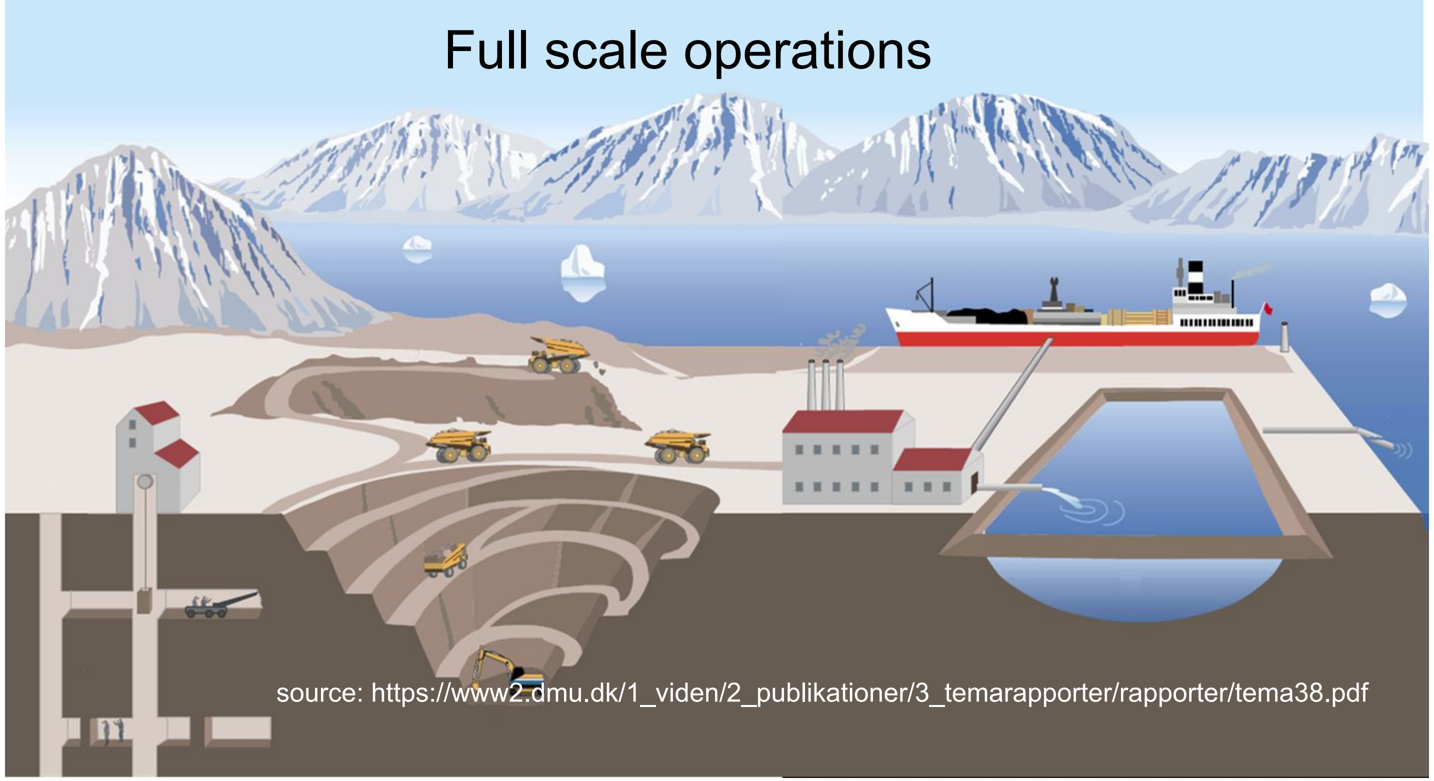
Session 1A: Opening keynote, Christian Juncher Jørgensen, PhD

AARHUS UNIVERSITY
DEPARTMENT OF ECOSCIENCE

Outline of themes and topics

1. General principles and requirements for the protection of the environment
2. Impacts and acceptance
3. Operational freedom vs. regulatory constraints
4. Principles of environmental monitoring
5. Rehabilitation and restoration
6. “Let’s build a mine” and other examples
7. Mine closure and post-closure considerations
8. Mining impacts on marine ecosystems

Environmental impacts often correlate with scale of operations



Different requirements:

- Waste water
- Fuel storage
- Handling of drilling additives
- other

Overall principles for environmental protection remains the same.

General principles for the protection of the environment

Overarching principles which mining companies are obligated to use

- **The Best Available Technique (BAT): "***the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste*"

- **Best Environmental Practice (BEP)**: "*the application of the most appropriate combination of environmental control measures and strategies*"

- **Best Practicable Control Technology (BPT):** "*the best technology available for the control of pollutants that is available at a realistic cost and that can be operated under normal operating conditions*"

General requirements for the protection of the environment

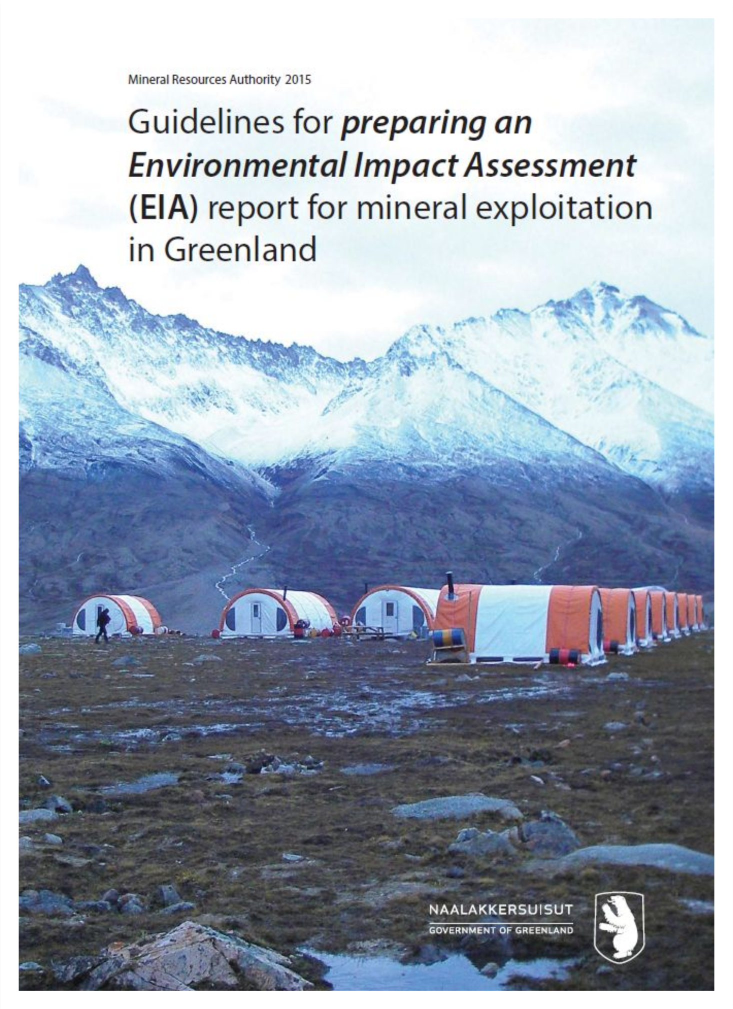
Full scale operations require an in-depth Environmental Impact Assessment (EIA):

- EIA-report for public hearing and political approval

Scope of EIA-assessment for full scale operations

- identify, predict, describe, assess and communicate potential environmental impacts of a proposed mining project from all sources and in all phases
  - Construction
  - Operation
  - Closure
  - Postclosure
- cover the entire area that is affected by the project.
- present mitigation measures to the identified impacts
- include all aspects in relation to nature, wildlife and public health regarding exposure to hazardous substances
- based on environment baseline studies typically covering 2-3 years before onset of construction

Greenland guidelines for describing environmental impacts



For Greenland, specific guidelines exist which are based on international best practice and international standards.

Example from EIA-guidelines (2015)

Discharges/emissions from power plants, fuel combustion plants, incineration plants, process plants and others shall as a main rule comply with EU standards (EU Directive on Industrial Emissions – IE Directive). US or DK standards shall be used if EU standards are not available. Other standards may be used, if they according to BAT, BET and BPT represent a better solution

International guidelines & environmental impacts


11.4.2006 EN Official Journal of the European Union L 102/15

DIRECTIVE 2006/21/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 15 March 2006

on the management of waste from extractive industries and amending Directive 2004/35/EC

European Commission

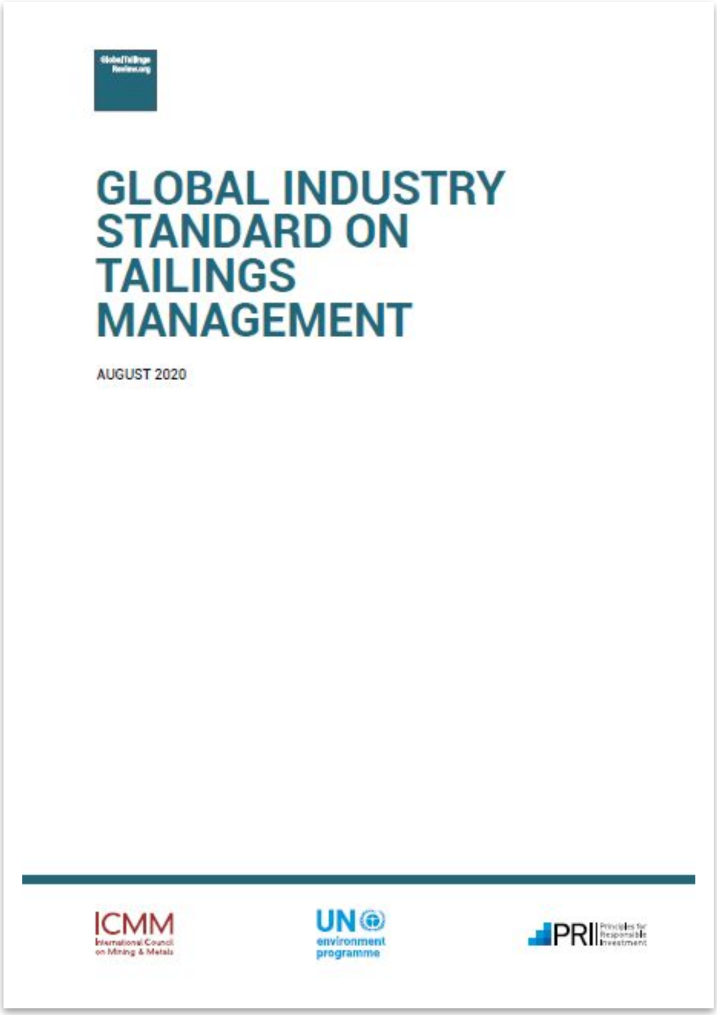
JRC SCIENCE FOR POLICY REPORT

Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries

in accordance with Directive 2006/21/EC

Elena Garbarino, Glenn Orveillon, Hans G. M. Saveyn, Pascal Barthe, Peter Eder

2018


GLOBAL INDUSTRY STANDARD ON TAILINGS MANAGEMENT

AUGUST 2020

ICMM International Council on Mining & Metals

UN environment programme

PRI Principles for Responsible Investment

link

Other leading practice handbooks for sustainable mining

RISK MANAGEMENT

Leading Practice Sustainable Development Program for the Mining Industry

HAZARDOUS MATERIALS MANAGEMENT

Leading Practice Sustainable Development Program for the Mining Industry

BIODIVERSITY MANAGEMENT

Leading Practice Sustainable Development Program for the Mining Industry

EVALUATING PERFORMANCE: MONITORING AND AUDITING

Leading Practice Sustainable Development Program for the Mining Industry

PREVENTING ACID AND METALLIFEROUS DRAINAGE

Leading Practice Sustainable Development Program for the Mining Industry

http

TAILINGS MANAGEMENT

Leading Practice Sustainable Development Program for the Mining Industry

ding-

MINE CLOSURE

Leading Practice Sustainable Development Program for the Mining Industry

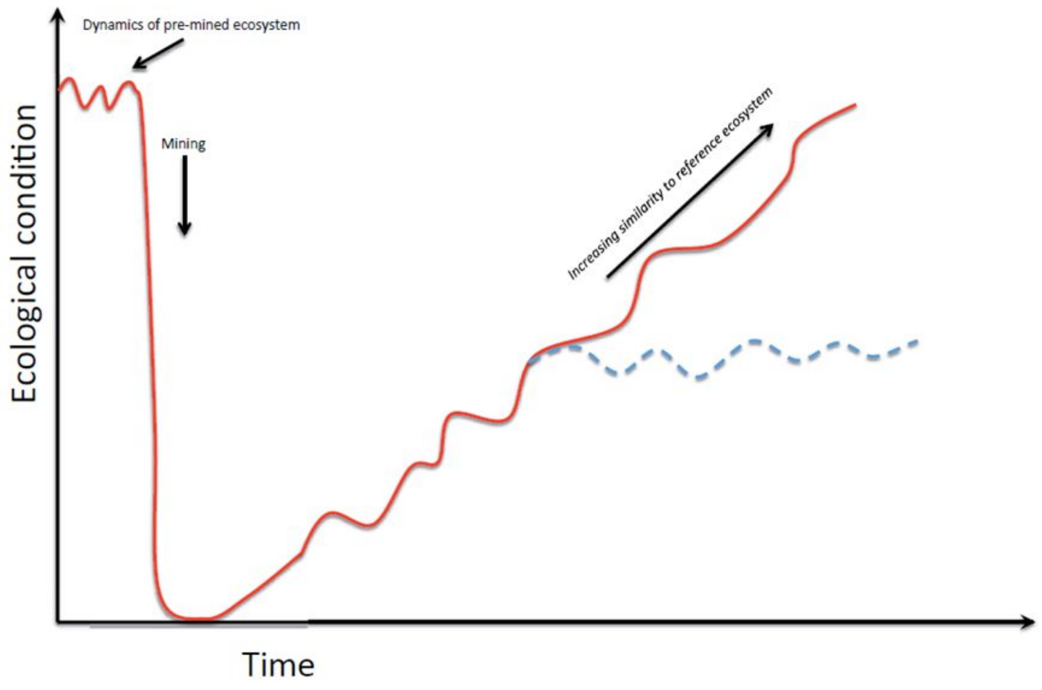
MINE REHABILITATION

Leading Practice Sustainable Development Program for the Mining Industry

Impacts & acceptance

Main decision for society and policy makers

- What impacts can be accepted?
- Which risk can be tolerated?



How large a deviation from baseline conditions can be accepted:

Spatial dimension: How large an area can be affected?

Temporal dimension: How long can it last?

Quantitative dimension: How much can be emitted/discharged?

Ecological dimension: Special protection needs (wildlife, fauna, red listed species, breeding grounds, sensitive habitats etc.

Project specific aspects: Site specific (geo)chemical profiles associated with ore processing (physical/chemical), waste disposal, etc.

Post-mining aspects: Need for restoration or full rehabilitation?

Operational freedom vs. regulatory constraints

Fact 1: Mining has unavoidable impacts to the local environment of the mine

Fact 2: Mining companies need operational freedom within permitted limits to be able to work

Fact 3: Objective control measures are needed to show compliance with permits

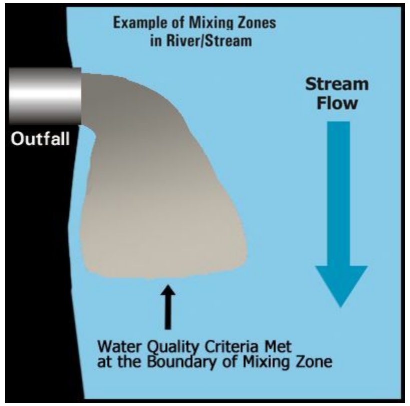
Basis for “Where, when and for how long” is not necessarily an exact science and are often a matter for (some) discussion before an agreement can be made between communities, authorities and mining companies.

International Council on Mining and Metals (ICMM):
“Industry has a responsibility to be proactive *in contributing practical solutions to the significant environmental challenges facing society. …**adopt practices and approaches that support continuous improvement in environmental performance**…”*

Operational freedom vs. regulatory constraints

Common regulatory tools for footprint control are:

- Contaminant reduction techniques at discrete sources (chemical suppression, dust control, flue gas treatment, water filtration etc.)
- Discharge limits values “at the end of the pipe”
- Buffer zones around point sources
- Mixing zones between point sources and control points
- Water and air quality criteria at defined control points
- On-going environmental monitoring both inside and outside industrial perimeter



Case example – Network of regulatory monitoring points

Example from Giant Mine remediation site, Yellowknife, Canada. Former gold mine (1948-2004).

Gold ore containing arsenopyrite (FeAsS) was roasted to liberate gold forming arsenodioxide gas arsenotrioxide dust

"greatest challenge associated with the remediation of Giant Mine is the safe long-term storage 237,000 t of the arsenic trioxide dust"

Giant Mine Air Program Components

- **Community Program**: Completed at three community monitoring stations (in N'dilo, downtown Yellowknife and at the Yellowknife Cruising Club) to measure and assess air quality in the community and help to ensure the effectiveness of the fence-line air quality program.
- **Fenceline Program** is done using six monitors that are placed in six locations around the perimeter of an active work area and along the southeast shore of the site, at the townsite, the cruising club, and the southeast beach.
- **Activity Specific Program** is established to monitor potential impacts to air quality in the vicinity of workers. Both fixed and mobile monitors are placed near work such as roaster deconstruction or drilling.

https://www.rcaanc-cirnac.gc.ca/eng/1100100027413/1617999134934

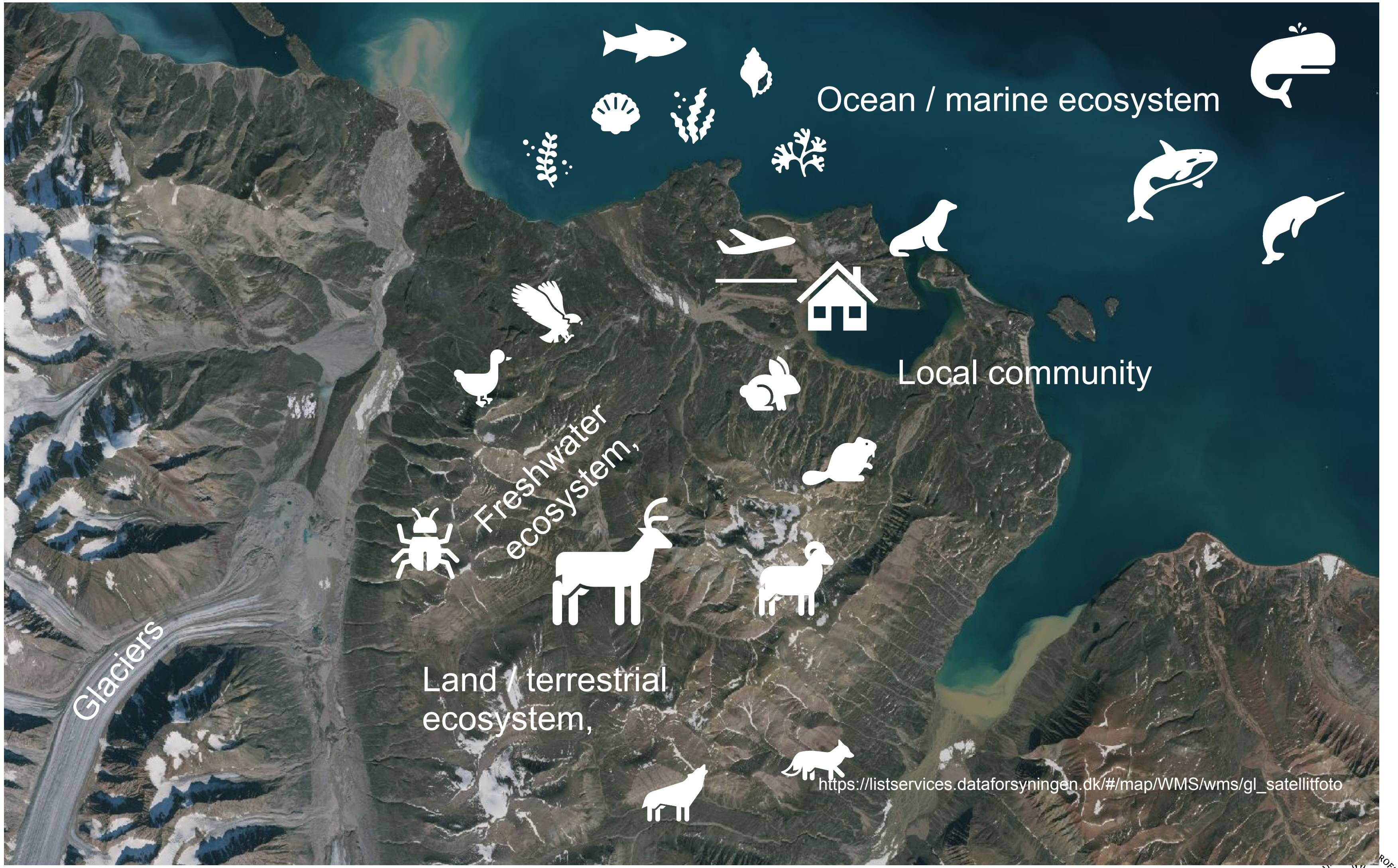
Special case – Industrial perimeter Gr~~een~~land

Private ownership of land does not exist in Greenland.

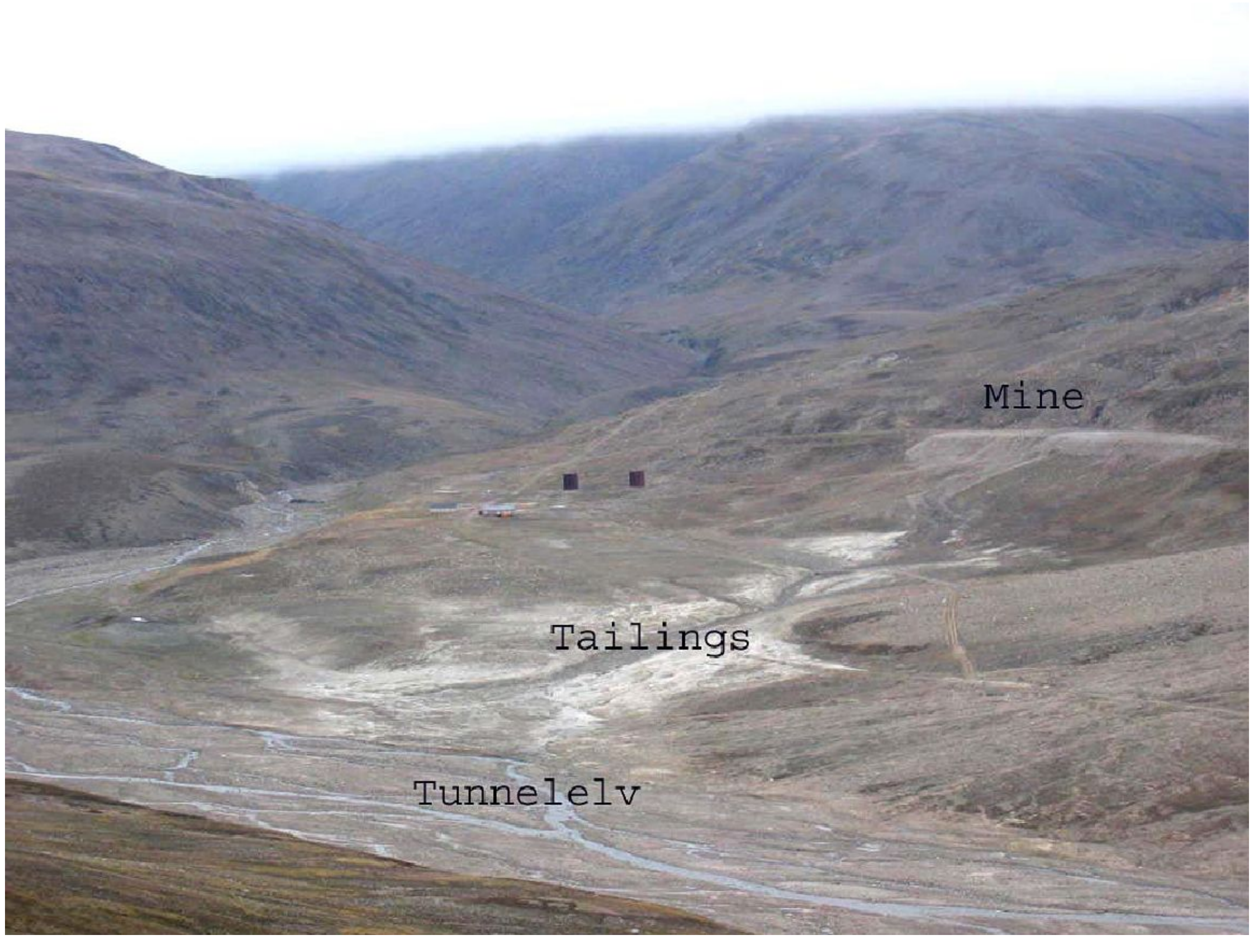
Industrial perimeter of mines in Greenland is defined by factors other that “fence-line”

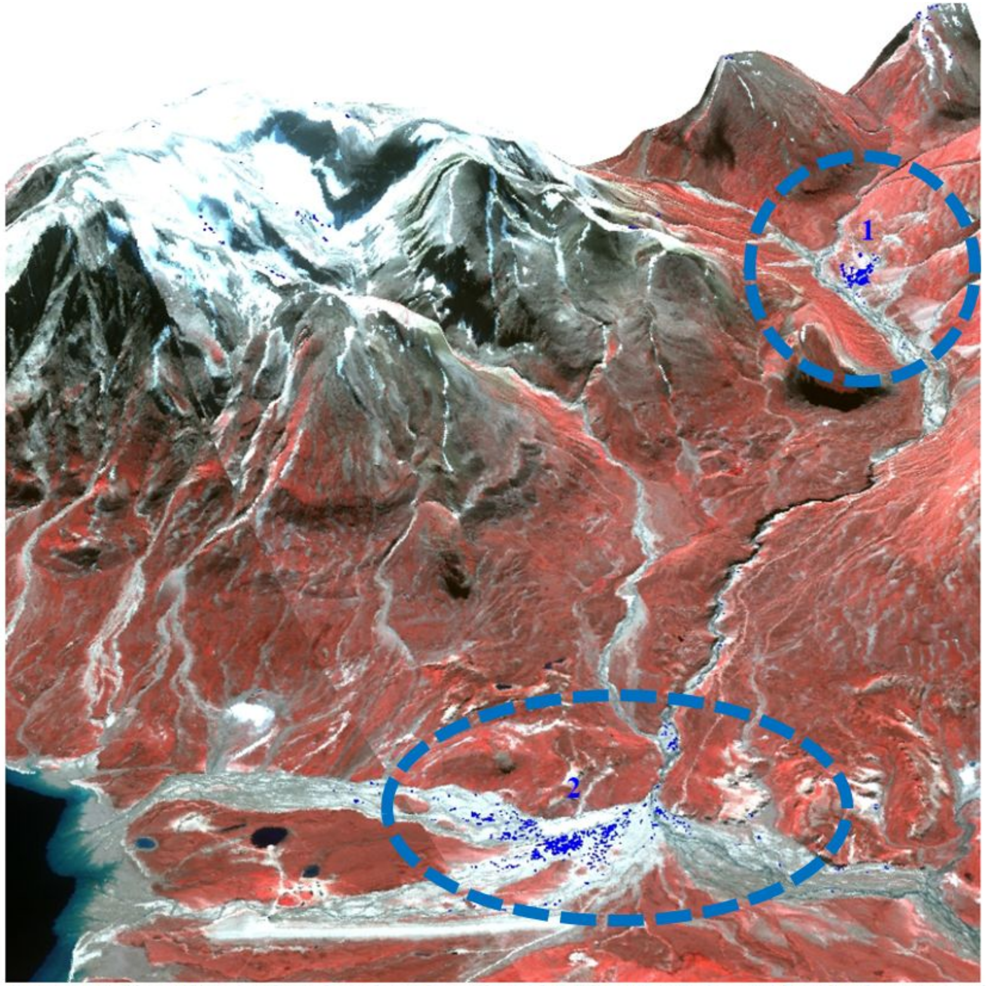
Overall **industrial footprint**, including bufferzones, mixing zones and location of control points are often government by physical **properties of the landscape** the mine is located in.

Hypothetical example based on legacy mine “Blyklippen”



“Blyklippen” – legacy Pb/Zn mine (1957-1963)



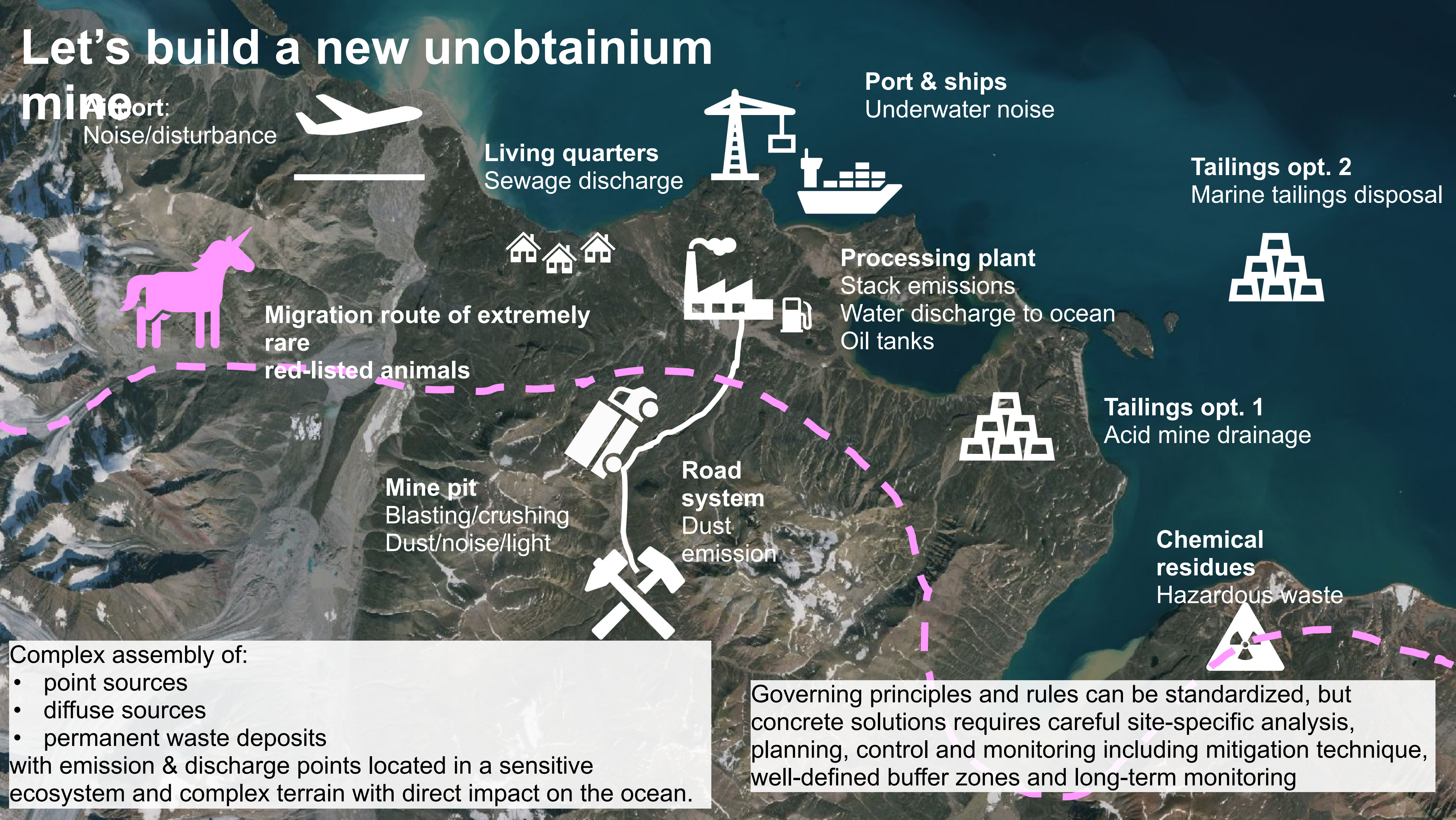


Mine & tailings

Por
t

Figure 27: The tailings and washout have been draped on the 3D map to visualise the deposition of material in the lower parts of the river bed. Tailings are here shown in blue with the deposit numbered 1 and the deposition in the lower riverbed as 2.

Let’s build a new unobtainium mine



Complex assembly of:

- point sources
- diffuse sources
- permanent waste deposits

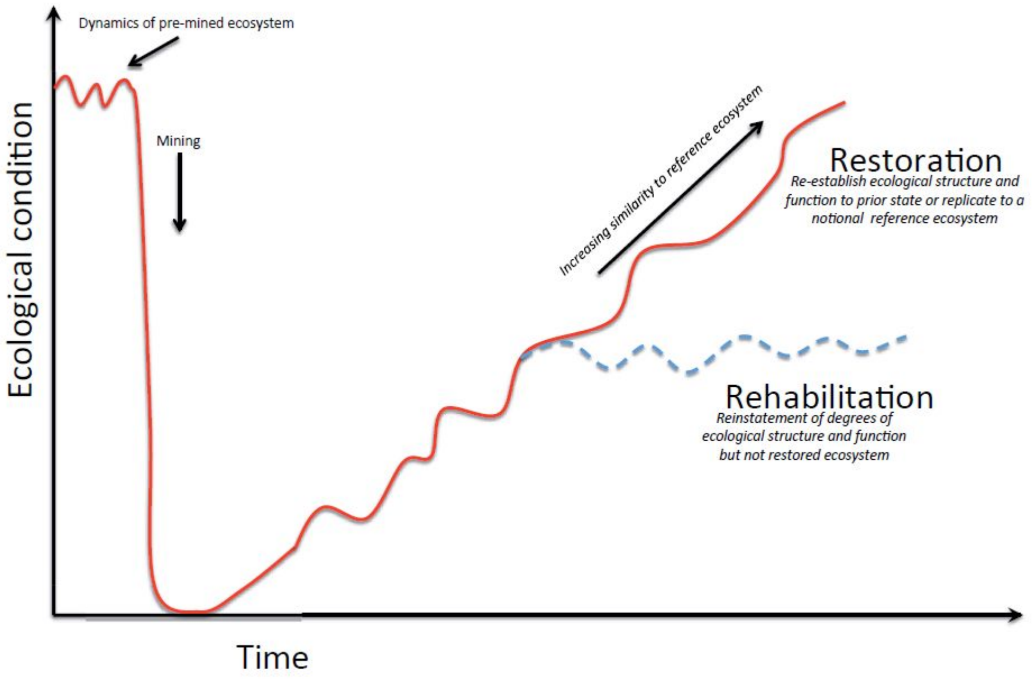
with emission & discharge points located in a sensitive ecosystem and complex terrain with direct impact on the ocean.

Governing principles and rules can be standardized, but concrete solutions requires careful site-specific analysis, planning, control and monitoring including mitigation technique, well-defined buffer zones and long-term monitoring

Mine closure and post-closure conditions

Mine site rehabilitation should be designed to meet three key objectives:

1. the long-term stability and sustainability of the landforms, soils and hydrology of the site
2. the partial or full repair of ecosystem capacity to provide habitats for biota and services for people (WA EPA 2006)
3. the prevention of pollution of the surrounding environment.



With adequate attention and planning successful rehabilitation and/or restoration is achievable for mines, tailings storage facilities and waste rock dumps on land.

Restoration of the marine environment are more complex as most – if not all – impacts are practically irreversible.

Re-mining: Special considerations for future ~~oppo~~rtunities

Reprocessing – turning 'waste to value'

Reprocessing of tailings following technological advances and/or improving world market value of certain minerals/metals.

Not an option for *deep marine tailings disposal*, so additional careful long-term analysis is needed in this type of scenario.

Summary and concluding remarks

Modern mining relies on responsible stewardship of environmental resources, balancing the needs of global society, local community and conservation interests.

Failure to effectively manage the potential adverse impacts of mining on these shared resources can result in the deterioration of environmental resources and have adverse consequences for human health.

Mining in contact with marine ecosystems require particular attention as impacts are often irreversible.

Marine tailings disposal and seafloor mining has the potential to take a significant toll on the life in the sea which may be difficult – if at all possible – to remedy.

Strengthened dialogue between mining companies, authorities, local stakeholders, consultants, technicians and scientist will lead the way to a more sustainable future mining industry.

AARHUS U