Annex 8. Visual examples of incompliances to TMF safety operation and protective measures

Visual inspection is the important part of TMF safety evaluation. It allows briefly identifying inconsistencies in the design and incompliances to normal operation mode of the facility. The quantity and significance of such incompliances will increase in time, which will lead to the appearance of pre-incident safety deficiencies. These signs are not always noticeable and may be interpreted in a different way; at the same time they could lead to serious problems in the future if not prevented after visual inspection.

The photos below collected by Prof. D. Pikarenia and Prof. O. Orlinskaya demonstrated safety deficiencies at different parts of the TMF including

- Drainage and spillway (Fig. A8.1-A8.5), covered by questions 4-8 of Subgroup B1;
- Seepage and leakages through the dam (Fig. A8.6-A8.12), covered by questions 14-18 of Subgroup B1;
- Waterproof of the tailings pond (Fig. A8.13-A8.15), covered by question 19 of Subgroup B1;
- Erosion of tailings dams (Fig. A8.16-A8.22), covered by questions 12, 15, 20 of Subgroup B1
- Landslides and subsidence in the dam body (Fig. A8.23– A8.26), covered by questions 15, 18 of Subgroup B1.

Explicit visual signs of incompliances to TMF safe operation indicate an active stage of the development of unfavorable processes, which can lead to an incident or emergency. Prevention should include a set of short-term or urgent measures.

Implicit visual signs of incompliances to TMF safe operation evidence the initial stages of development of unfavorable processes. The recommended measures to be applied refer to medium-term, in some cases to short-term measures aimed to prevent the active development of an incident.

When selecting the measures, priority should be given to those that will prevent from the most dangerous (critical) scenario and accident. Regarding to the significance these accidents to TMFs they can be classified as follows:

- The hazard of tailings dam failure and release of tailings materials on the ground (Fig. A8.27-A8.31).
- The hazard of instantaneous release of tailings materials from the tailings pond and pipelines into the ground (Fig. A8.32-A8.34).
- The hazard of blowing out of dry tailings materials by wind (Fig. A8.35-A8.38).

All other safety deficiencies at the TMF can be improved together or after elimination of the mentioned hazards. If there is at least one of these critical hazards, short-term and/or urgent measures should be applied.

Figure A8.1: Spillway of tunnel type. Protective spillway grid is destroyed as a result of vandalism

Figure A8.2: Spillway of mine type. Clogged shaft causes overflow through the dam

Figure A8.3: Spillway of mine type. Protective grid was destroyed by corrosion; as a result the spillway does not function.

Figure A8.4: Emergency tailings spillway with the inlets blocked by sediments.

Figure A8.5: The clogged channel of the tailing pond prevents full water evacuation

Figure A8.6: The third upper ledge of the tailings dam. Excessive waterlogging of the dam, atmospheric precipitation is not absorbed (View from the second ledge)

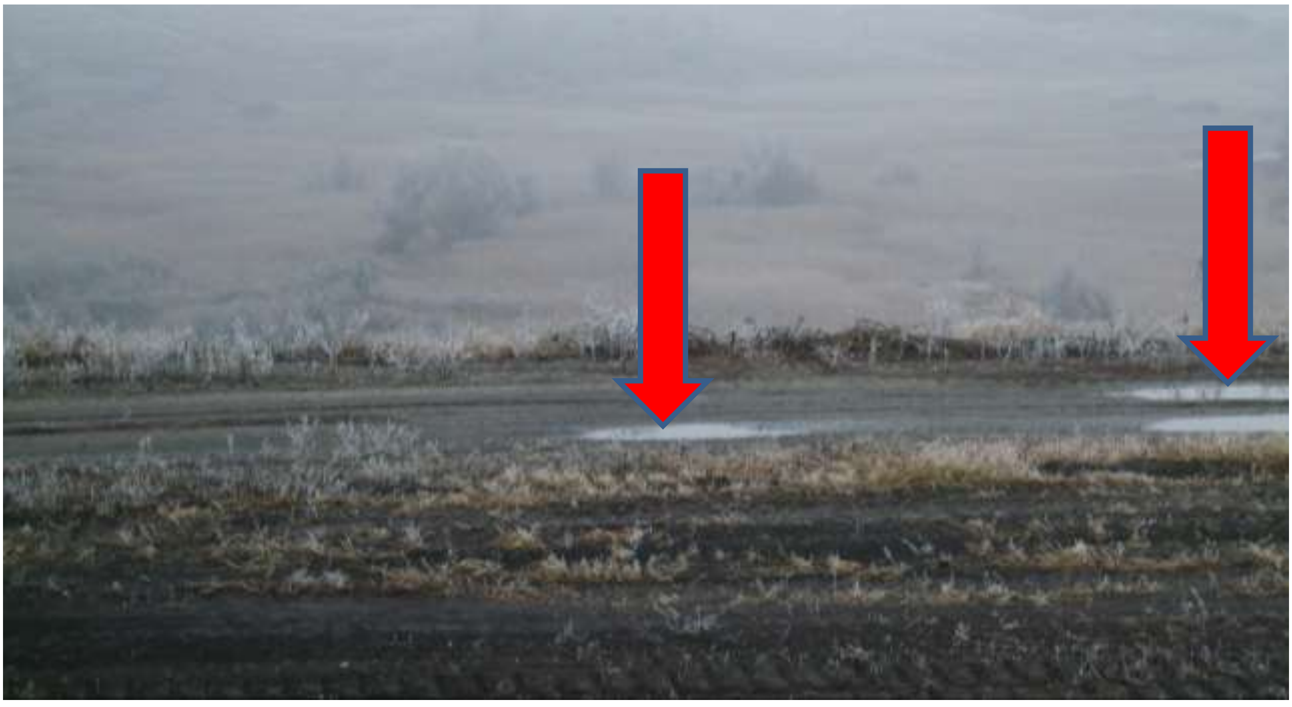

Figure A8.7: The second upper ledge of the tailings dam. Growth of water-resistant plants can be interpreted as the implicit sign of seepage

Figure A8.8: External slope of the dam. Water leaks and flows aside the spillway

Figure A8.9: Bottom-line of the tailings dam. Seepage through the dam and outlet is identified as a spring (View from the dam)

Figure A8.10: Concrete tailings dam. Seepage through the pores in the monolith is visible as "tears".

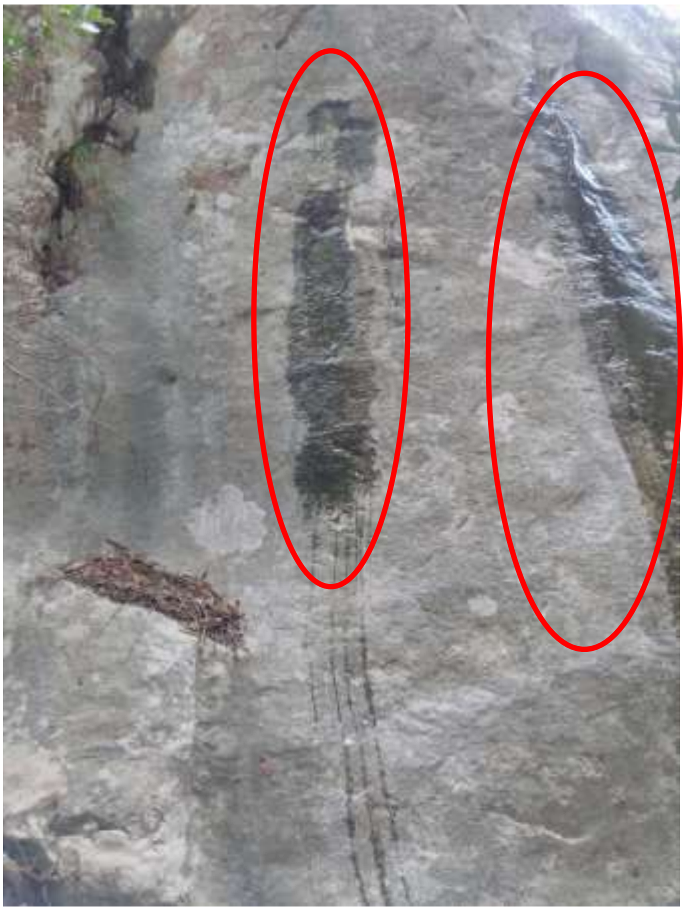

Figure A8.11: Central part of the external slope of the tailings dam. Seepage is identified in the form of spots of soil moisturizing

Figure A8.12: External slopes of the tailings dam. Salt is deposited on the slopes as a result of seepage of mineralized tailings water through the dam body (Photo taken at the TMF near Kalush, Ukraine)

Figure A8.13: Internal part of the tailings dam. Slipping of concrete slabs, exposure and damage of the waterproofing film

Figure A8.14: Bottom inner part of the tailings dam. Breakthrough of a waterproofing due to destruction of lining.

Figure A8.15: Tailings pond.The spillway remains above the water level, which can be interpreted as the implicit sign of leakages from the tailings pond due to permeable waterproofing.

Figure A8.16: External slope of the tailings dam. The promontory arose as a result of uncontrollable surface run-off

Figure A8.17: External slope of the tailings dam. The promontory appeared as a result of uncontrollable flow of precipitation water

Figure A8.18: External slope of the tailings dam. Small gullies that may become ravines.

Figure A8.19: The crest and slope of the dam composed of loose materials. The holes of large size in the dam body allow direct inspection.

Figure A8.20: The crest of the tailings dam. Salt water accumulation in a poodle on tailings material may lead to suffusion in the dam body

Figure A8.21: A protective screen on the tailing pond with hazardous waste. Linear erosion is caused by atmospheric precipitation. Furrows are formed as a result of incorrect installation of a protective screen by a bulldozer. Precipitation water destroys the screen and accumulates from the inside of the dam, which may lead to its erosion and transport of contaminants to the surface. This is an implicit indication of the poor condition of the tailings pond with serious problems developing in time.

Figure A8.22: Upland drainage ditches and trays. Improper drainage of the tailings causes floor erosion of the talweg of a gully/ravine. The drainage system may be destroyed with further development of erosion

Figure A8.23: External slope of the dam. Moving landslide (mudflow) evidences strong watering of the dam (View from the dam)

Figure A8.24: The external slope of the dam of an abandoned TMF. The wooden pile series indicate implicitly at a landslide occurred

Figure A8.25: The outer side of the tailings dam (left) and the crest of the tailings dam with the break-away gap is an implicit sign of an emerging landslide (right)

Figure A8.26: External slope of the tailings dam. A rickety road bump and a breakaway in this place implicitly evidence the emerging landslide

Figure A8.27: Measure 19B – Increase the height of separating earthen walls. The dams separate the parts (sections) of the fly ash TMF of a thermal power plant

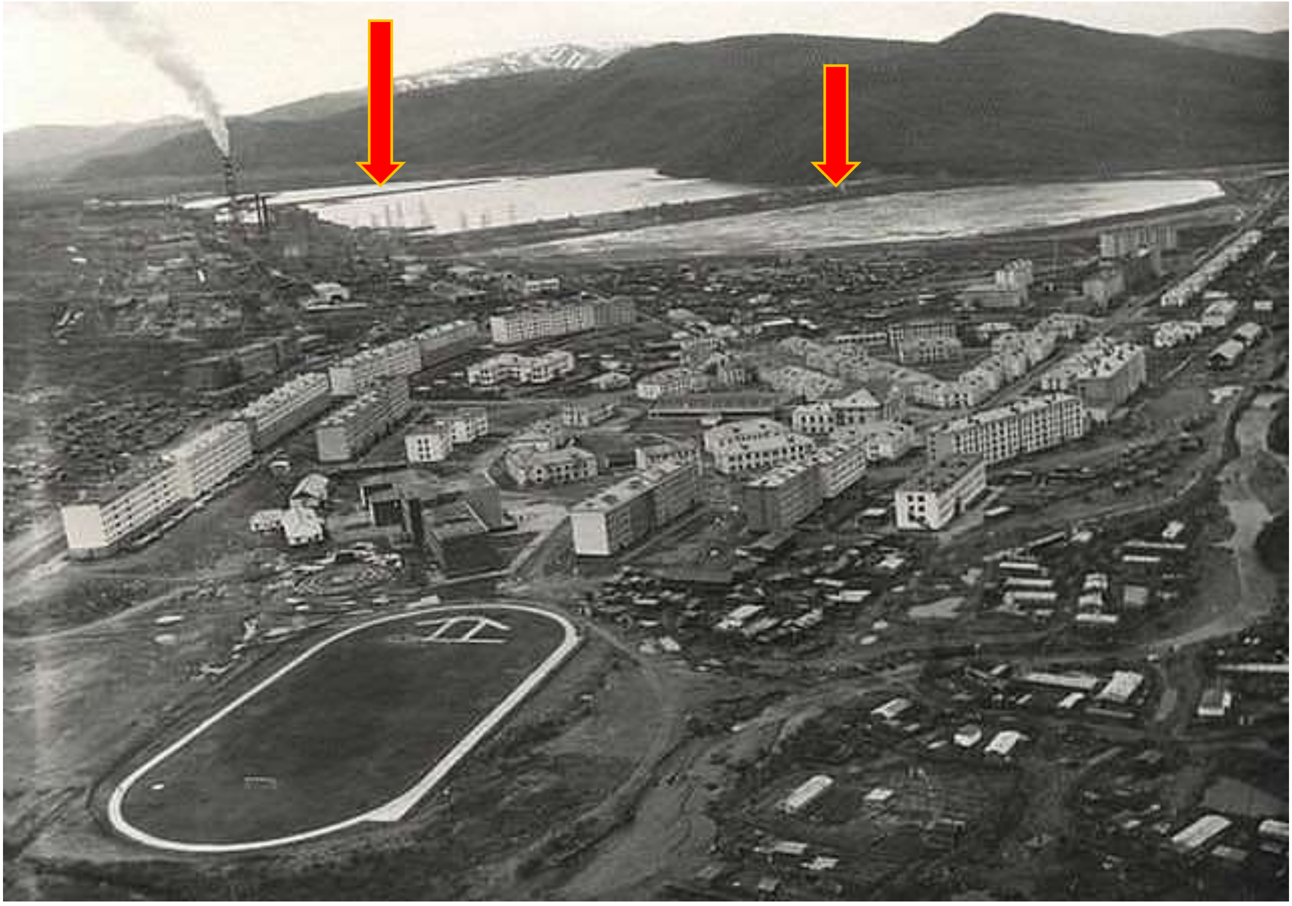

Figure A8.28: Measure 19C – Strengthen the dam using grouting and/or drainage curtains. The slope of the tailings dam has been cemented.

Figure A8.29: Concrete retaining wall prevents from slipping the dam

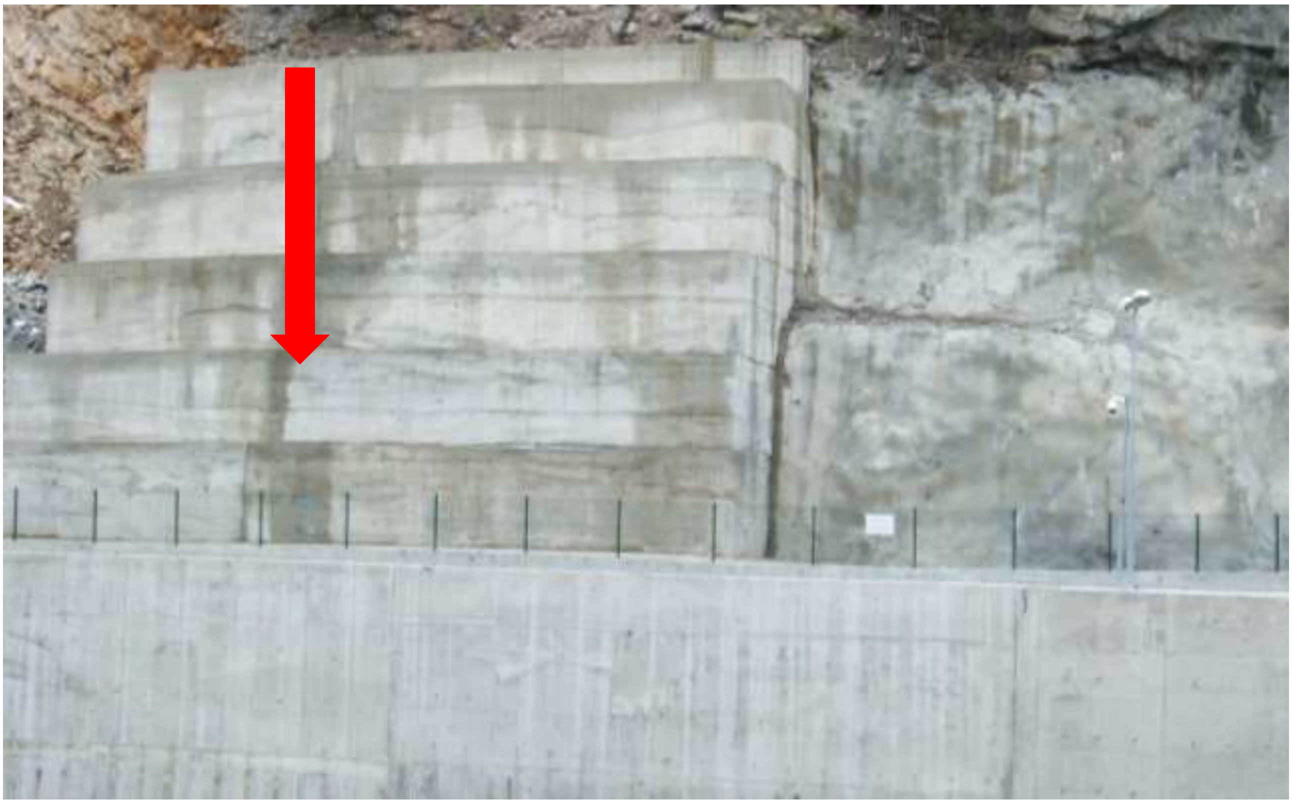

Figure A8.30: Supporting the slopes prevents from dam failure

Figure A8.31: The dam slope has been fastened with anchors and lining mesh

Figure A8.32: Measure 21C – Install additional drainage facilities. Drainage spillway of cascade type is installed at the tailings dam

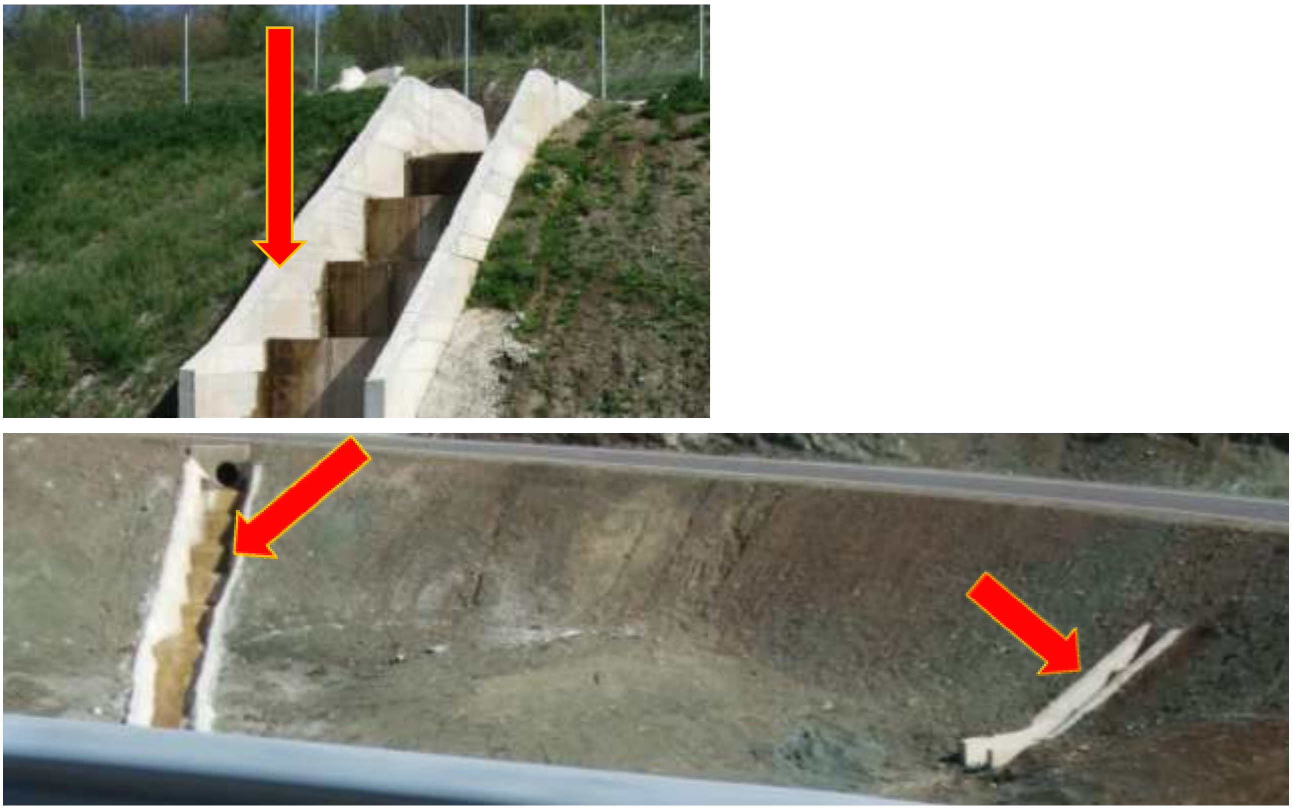

Figure A8.33: Measure 21F – Increase throughput of TMF drainage facilities. Advanced drainage concrete spillway is installed

Figure A8.34: Measure 21G – Create or repair the upper ditch to reduce surface water run-off into the tailings pond. Drainage concrete gutters are installed to catch water from the dam

Figure A8.35: Measure 18I – Create barriers and protection against hits (concrete walls, steel beams, earthen dams). Bulk dam supports the pipeline for delivery of tailings materials (sludge)

Figure A8.36: Measure 14C – Construct, if justified, the top cover. Hazardous waste is covered with a layer of water.

Figure A8.37: Measure 14D – Construct, if justified, the bottom protective screen. Protective screen is installed in the form of concrete slabs with an underlying film

Figure A8.38: Measure 34C. Elaborate technical measures for phyto-rehabilitation of the TMF site. Biological plateau is installed for drainage water treatment (View from the tailings dam)