CREATING READINESS FOR CHANGE IN LARGE INFRASTRUCTURE PROJECTS BASED ON EXPERIENCE FEEDBACK FROM ACCIDENT INVESTIGATIONS

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CONTENTS

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Statkraft International Hydropower Construction Projects (2006 -)

- Note 1: > 50% ownership
- Note 2: Figures in parenthesis represent year of completion

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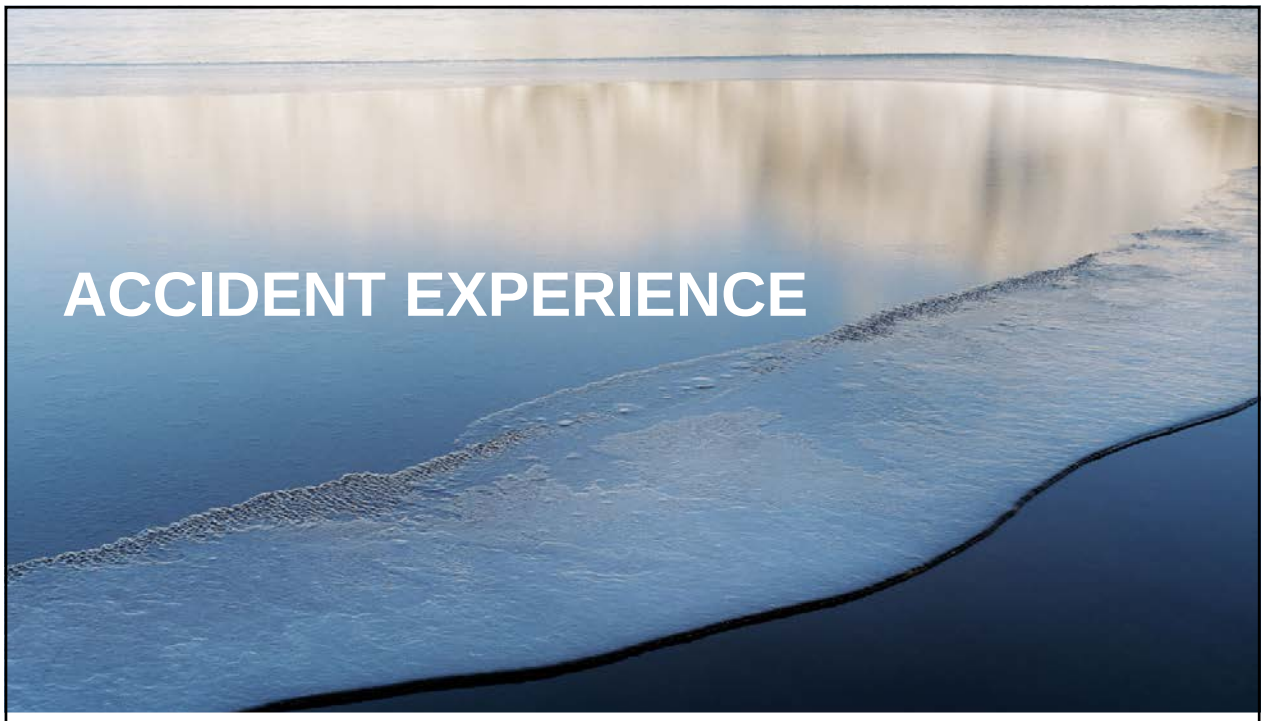

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HSE results in construction projects

Performance indicator	Statkraft IH Jan – Aug '15	Building and construction Norway 2013[2)]	Veidekke Norway 2012[3)]	Skanska International 2012[3)]	Int. Oil & Gas Industry general 2014[4)]	Selected projects in developing countries[5)]
TRI rate Projects	4,0	11			1,5	
LTI rate Projects	2,2		7,4	2,9	0,4	
FAR Construction	17[1)]	2,5			1,0	> 100

Note 1: Accumulated 2013 – Aug 2015
Note 2: Arbeidstilsynet, 2014
Note 3: www.veidekke.no; www.skanska.com
Note 4: www.ogp.org.uk
Note 5: «Guesstimate» based on private communication

TRI rate = Total recordable injury frequency rate
LTI rate = Lost time injury frequency rate
FAR = Fatal accident rate (no. of fatalities / 100 mill. hrs of work)

Comments:

- **TRI rate is adequate but not meeting the results of the O&G industry. Conditions are more demanding in hydropower projects (stretched out projects, underground work)**
- **Statkraft IH's FAR is high compared to a Norwegian standard, but other projects in countries where Statkraft operates are performing significantly worse.**
- **Note: The statistics in developing countries is poor.**

5

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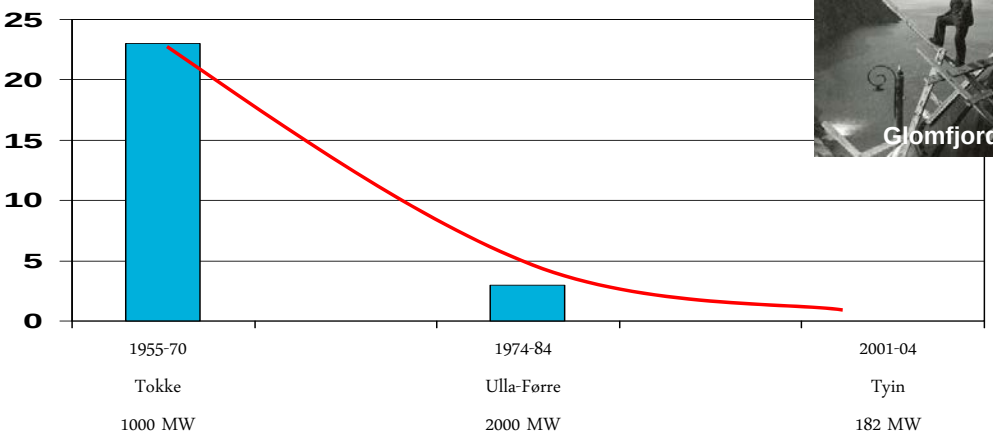
It took the Nowegian Power and Construction industry "50 years" to reach today's HSE performance



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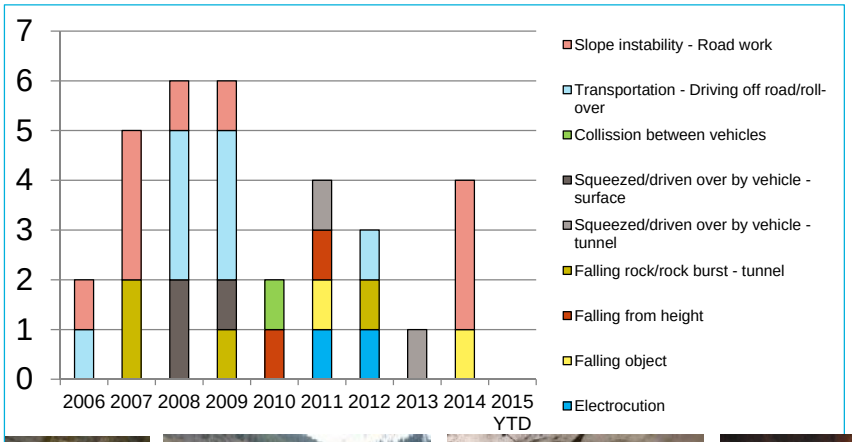
Fatalities in construction projects (2006 – 2015 YTD)



Comments:

- **Transportation and slope instability hazards dominated the risk picture during 2006 - 2009.**
- **The picture is more mixed from 2011. Some of the accidents require expert knowledge to prevent not typically available within HSE (rock burst, electrocution, rock slide).**

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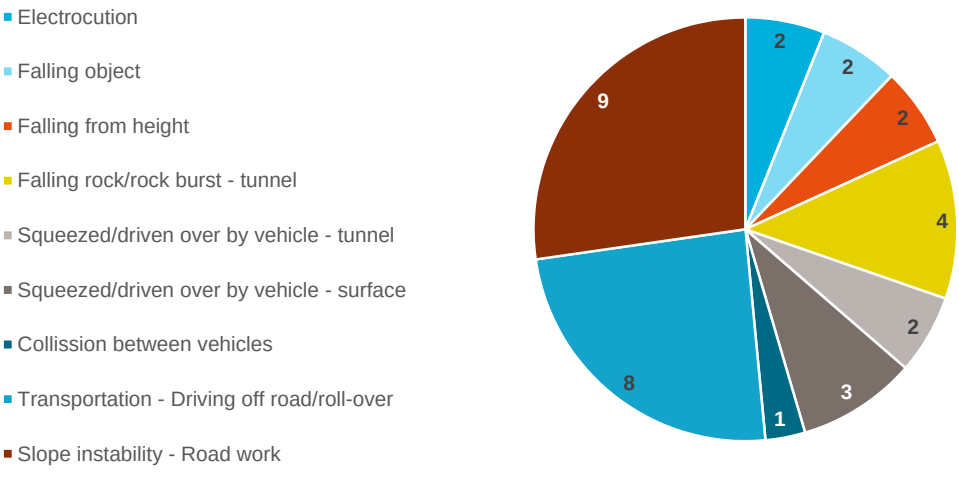
Fatalities in construction projects 2006 – 2015 YTD (N=31)



8

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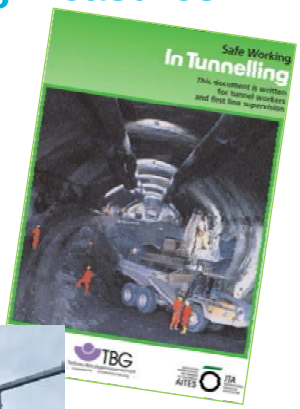
Accidents occur when contractors fail to prevent well known accident risks with defined mitigating measures…


Turkey, Jan 2014 (HIPO)


Crushed between vehicle and wall, Peru, Aug 2013




Falling rock, Peru, Jan 2012 (HIPO)


Fall from height, Peru, Nov. 2014 (HIPO)


Hit by falling barrel, Panama, Nov. 2014

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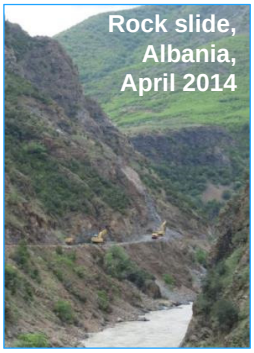
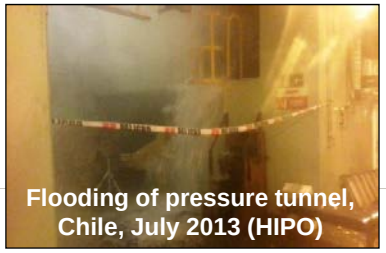
….but also when we fail to identify the risks.


Rock-burst accident, Peru, July 2012


Rock slide, Albania, April 2014


Electrocution, Peru, Oct 2012


Flooding of pressure tunnel, Chile, July 2013 (HIPO)

Common for all incidents:

- Risk with (potentially) high consequence not included in risk assessment.
- Technical competence is required to identify the risks.

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APPROACH TO IN-DEPTH INVESTIGATIONS AND SECURING LESSONS LEARNED
11
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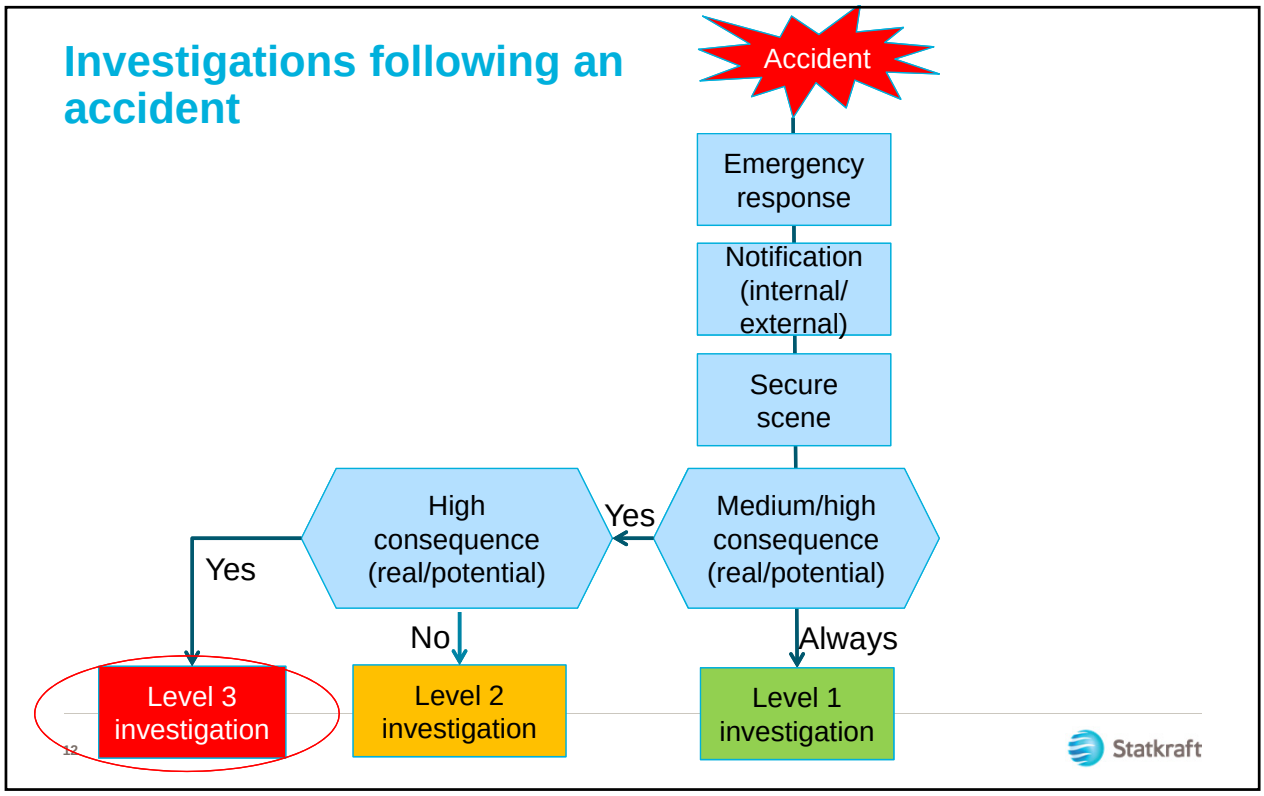
Investigations following an accident
Accident
Emergency response
Notification (internal/ external)
Secure scene
Medium/high consequence (real/potential)
Yes
High consequence (real/potential)
Yes
No
Always
Level 3 investigation
Level 2 investigation
Level 1 investigation
12
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Level 3 investigation

A systematic and independent examination to determine whether accident prevention activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

- Based on definition of “audit” in ISO 9000:2005, Para. 3.9.1

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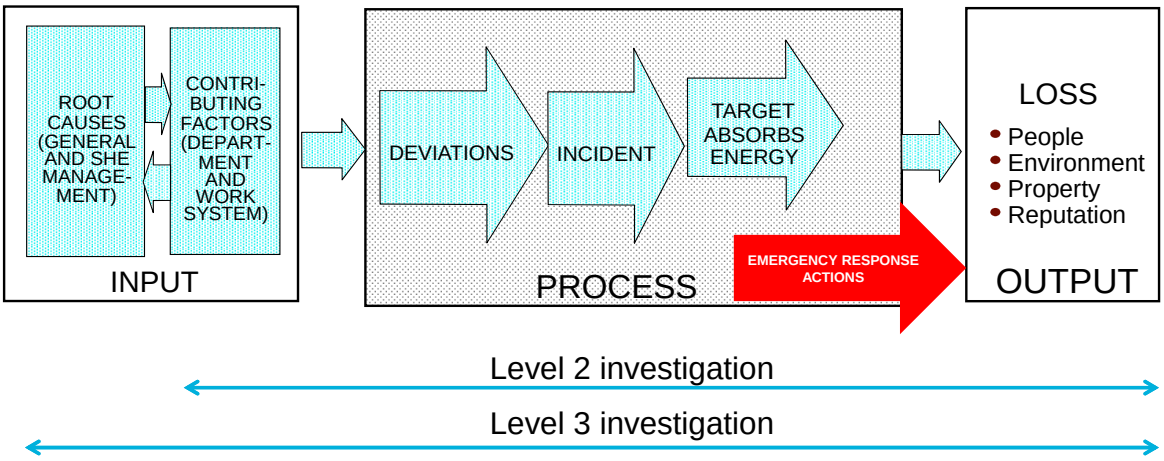
Accident Analysis Framework – Typical questions in a Level 3 investigation



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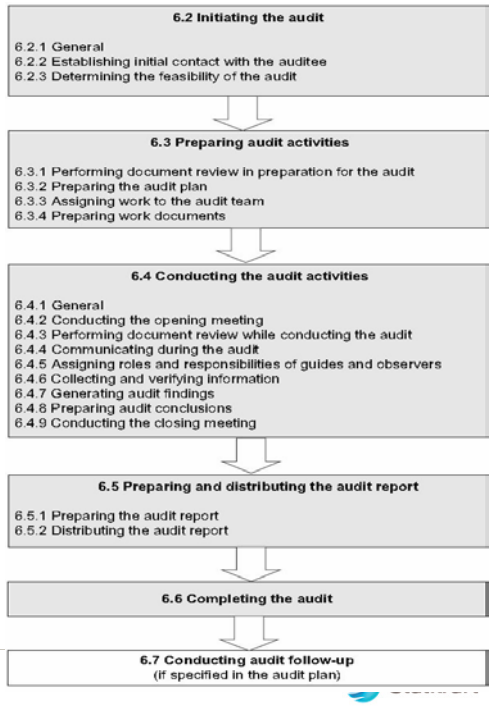
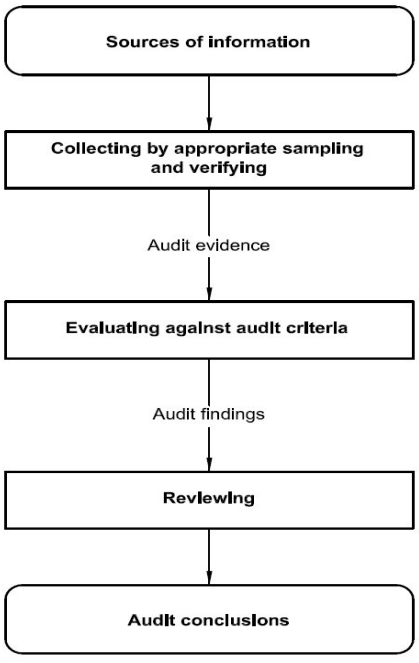
The steps in a Level 3 investigation

1. Secure the scene
2. Appoint an investigation commission
3. Pre-meeting, planning the commission's work
4. Collection of information
5. Evaluations and organization of information
6. Preparing the commission's report
7. Post-meeting
8. Follow-up

Audit flow chart (ref. ISO 19011):



Process to arrive at conclusions (ISO 19011)



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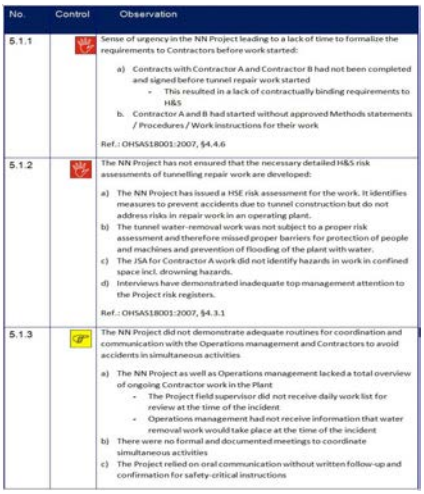
Use of symbols

Critical - Serious weaknesses exist which need Immediate action

Not satisfactory - does not meet minimum acceptable standards

Improvements needed - meets minimum standards over-all, but could be improved.

Satisfactory – meets acceptable standards



No.	Control	Observation
5.1.1		Sense of urgency in the NN Project leading to a lack of time to formalize the requirements to Contractors before work started: a) Contracts with Contractor A and Contractor B had not been completed and signed before tunnel repair work started - This resulted in a lack of contractually binding requirements to H&S b. Contractor A and B had started without approved Methods statements / Procedures / Work instructions for their work Ref.: OHSAS18001:2007, §4.4.6
5.1.2		The NN Project has not ensured that the necessary detailed H&S risk assessments of tunnelling repair work are developed: a) The NN Project has issued a HSE risk assessment for the work. It identifies measures to prevent accidents due to tunnel construction but do not address risks in repair work in an operating plant. b) The tunnel water-removal work was not subject to a proper risk assessment and therefore missed proper barriers for protection of people and machines and prevention of flooding of the plant with water. c) The JSA for Contractor A work did not identify hazards in work in confined space incl. drowning hazards. d) Interviews have demonstrated inadequate top management attention to the Project risk registers. Ref.: OHSAS18001:2007, §4.3.1
5.1.3		The NN Project did not demonstrate adequate routines for coordination and communication with the Operations management and Contractors to avoid accidents in simultaneous activities a) The NN Project as well as Operations management lacked a total overview of ongoing Contractor work in the Plant - The Project field supervisor did not receive daily work list for review at the time of the incident - Operations management had not receive information that water removal work would take place at the time of the incident b) There were no formal and documented meetings to coordinate simultaneous activities c) The Project relied on oral communication without written follow-up and confirmation for safety-critical instructions

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Investigation team

- Leader, trained in Level 3 investigations, management, technical or HSE background
- Technical expert in a discipline of relevance to the accident (activity or energy involved)
- Senior manager from a similar organisation
- Criteria in selecting team members
  - Competence
  - Credibility, ability to influence
  - Time away from competing duties

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THREE CASES

A. Transportation accidents
B. Slope instability
C. Electrocution

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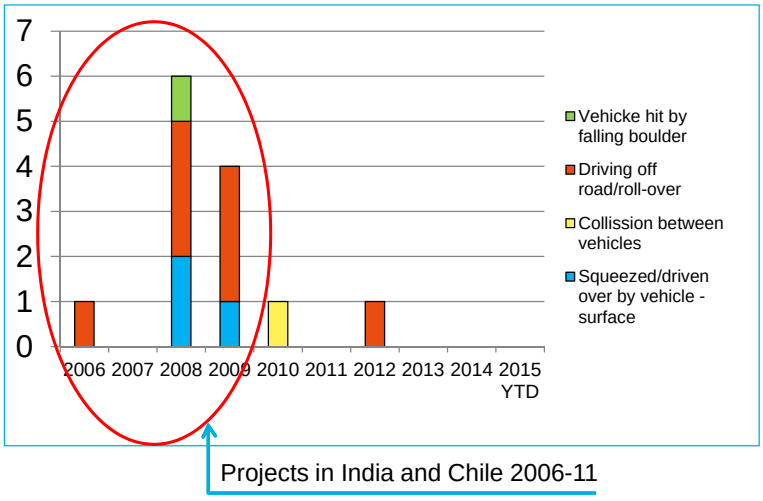
Fatalities in surface transportation



Projects in India and Chile 2006-11

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The accident investigation process 2006 - 2009

- Mainly made by a JV partner as operator
- Typically Level 1 and 2
- SN Power (50% Statkraft ownership at that time) initiated measures based on information in the reports on fatal accidents
  - Transportation dominated the fatal accident statistics and the transportation volume remained high throughout the project period
  - Driving off the road and roll over were dominant accidental events

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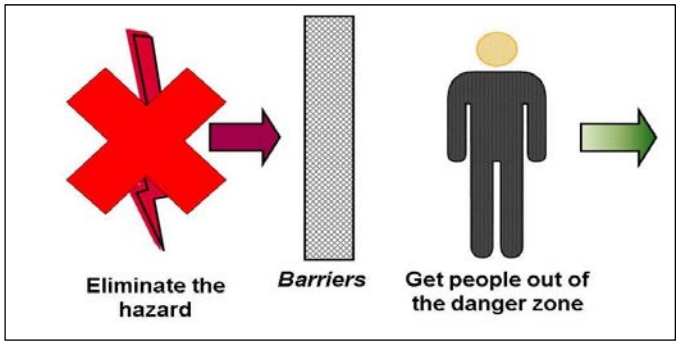
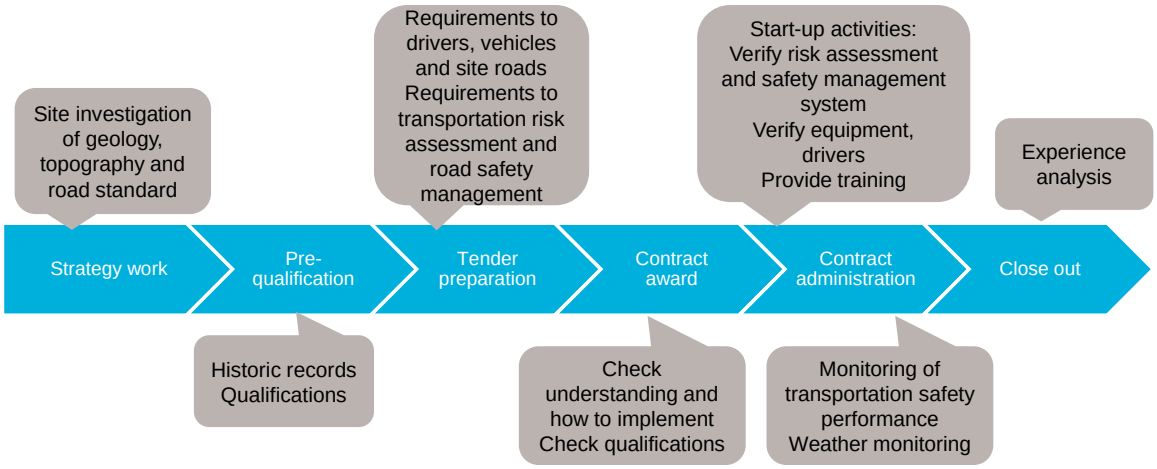
Points for intervention in preventing road accidents (based on Haddon)



Implementation of lessons learned in the management of transportation safety in the contracting process - examples



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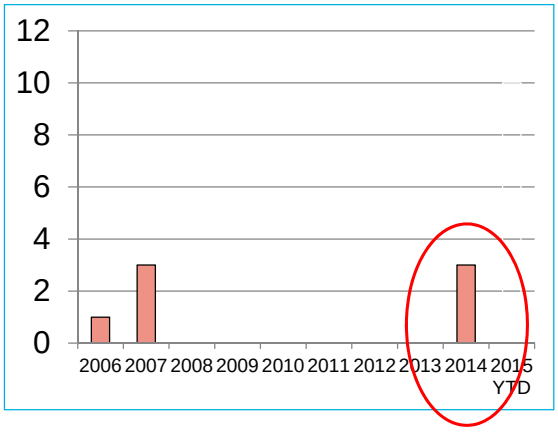
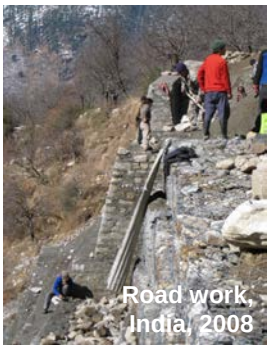
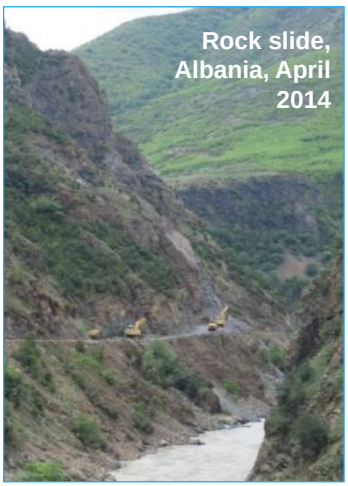
Fatalities due to slope instability in road work







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Fatal accident in Albania during road work in April 2014

- A team of three persons were scaling for loose stones and were about to finish the work
- A section of rock (1000 m^3) started to slide when the crew was located in the danger zone of the rock slide
- Two scalers were dragged with the rock-slide to the river bed; the supervisor was still hanging in his rope after the slide

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The investigation in 2014

- Team members
  - Team leader, Head of HSE, SN Power
  - Geologist, HQ
  - Civil engineer / Construction manager, HQ
  - Norwegian scaling specialist (Vesta)
- Performed as a Level 3 investigation
- Owner's project organisation, Owner's Engineer, Road contractor and Subcontractor for scaling were subject to investigation

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Establish a new standard in the planning and execution of scaling and rock support work

- Overall strategy for moving forward on the road
  - Controlled progress section by section
  - Permit-to-work procedure to ensure compliance
  - Monitoring of precipitation and stop of work in heavy rain
  - Geologist present for detailed planning and supervision of work
- Requirements to crew member qualifications
- Step-by-step procedure to ensure controlled execution of work

Detailed geological mapping and design → Risk assessment → Methods statement → Detailed job planning & Job Safety Analysis → Permit to Work → Toolbox meeting → Execution and close out

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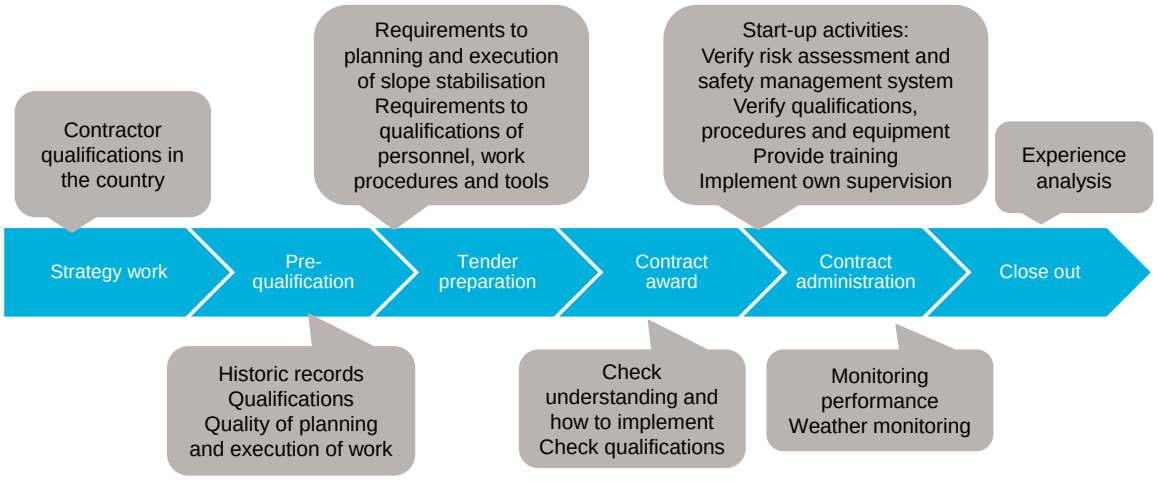
Management of high-risk slope stabilisation work through the contracting process - examples



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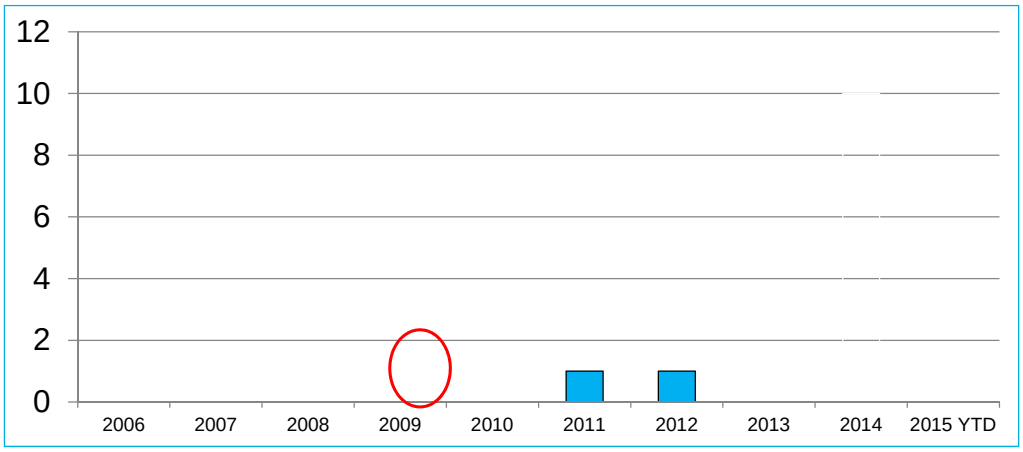
Fatalities due to electrocution



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Electrocution accident in tunnel in 2012

- A tunnel worker was involved in removing stones and clods coming with the cement from a mixer truck while it was transferred to an Alpha 20 shotcrete robot
- Electric current went from the Alpha robot to the worker's left hand, torso and right hand and to the chute and mixer and finally to ground, see photo
- The immediate cause of the accident was an earth fault in a 240V halogen lamp mounted on the alpha robot by Contractor to improve illumination at the tunnel face

30

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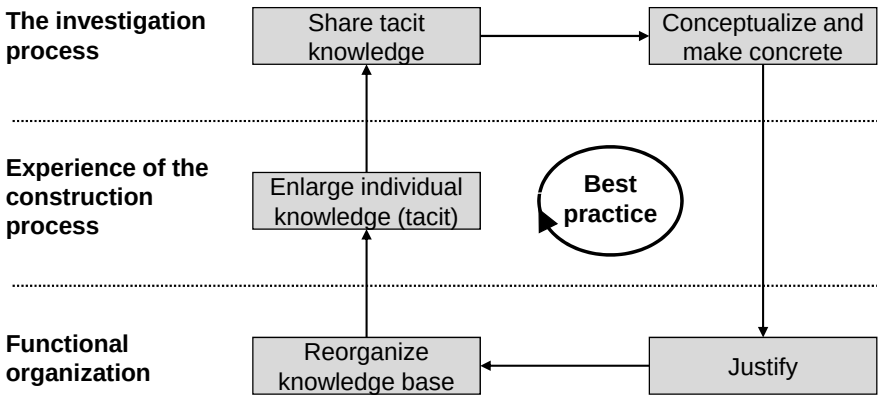
Accident investigations play an important role in the knowledge creation process



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The Owner's knowledge base to capture lessons learned - examples

- Specifications
  - HSE in Design of hydro-power plants
  - Contractor's management of HSE in construction
- Internal procedures
  - Management of HSE in the value chain (from Business Development to Hand-over to Operations)
- Audit and review checklists
  - Construction and commissioning readiness reviews
  - HSE audits during construction
- HSE culture workshops

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Concluding remarks

- Statistics from Level 1 and 2 investigations have proved valuable to prevent accidents through design and implementation of well-defined barriers
- Results from Level 3 investigation may under the right circumstances provide a basis for fundamental changes in how projects are managed
- Enabling factors
  - Multidisciplinary composition of the investigation team, including a combination of management, technical and HSE competence
  - A systematic approach to establish root causes from facts and interpretations, ref. process to arrive at conclusions according to ISO 19011
- Utilize learning potential in HIPO incidents

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