



Bujagali Dam – Dam Break Emergency Preparedness and Response Plan

PART 1 OF 2

Quick Reference Guide



Bujagali Dam looking downstream (https://www.bujagali-energy.com/)

Quick reference guide

This section of the EPRP (Part 1) is intended for use during events and exercises by trained persons familiar with the content of this EPRP (Parts 1 and 2). The following tables and figures summarise the process for responding to potential failure of the Bujagali Hydroelectric Power Plant Dam (Bujagali Dam). These are:

FIGURE A: Threat Classifications and Action Summary

TABLE A: Threat Classification Guidance (Response Levels)

TABLE B: Roles and Responsibilities

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TABLE C: Contact List

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TABLE E: Dam breach flood hazard plan index

TABLE F: Predicted peak water levels, arrival times and time to peak of dam breach floods

PLANS: Dam breach flood hazard plans

LIST: Evacuation Areas

FIGURE A: THREAT CLASSIFICATIONS AND ACTION SUMMARY

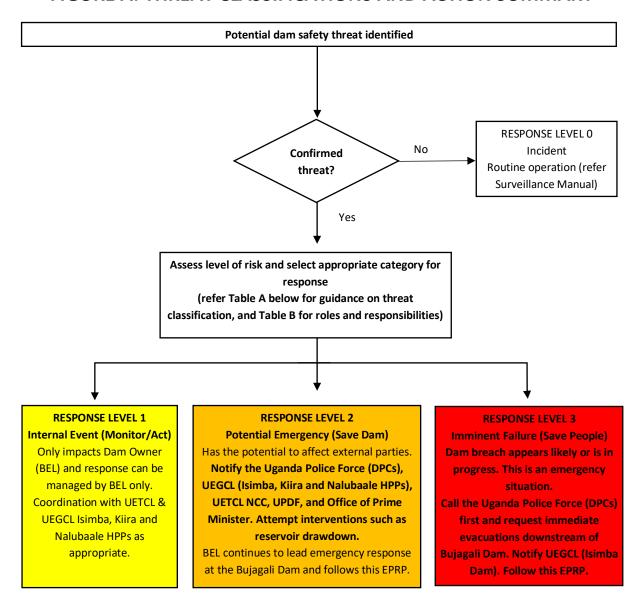


 Table A
 Threat classification guidance

Potential safety threat (WHAT IS HAPPENING)	Potential failure mode (refer Section 3 for further details)	Example dam safety threat classification (Guidance and descriptions provided for context only. BEL Power station Asset Manager to consider specifics of event when setting response level) (HOW SERIOUS IS THE EVENT AND WHAT ACTION SHOULD BE TAKEN)					
	(HOW CAN THIS LEAD TO DAM FAILURE)	Response Level 1 - Internal event (Monitor/Act)	Response Level 2 - Potential Emergency (Save Dam)	Response Level 3 - Imminent Failure (Save People)			
Embankment dams (Left, c	entral and right embankment dam sections) – Zoi	ned earthcore rockfill dams					
Deterioration of embankment dam sections during normal reservoir operation (i.e. ≤ 1111.5 m RL) and/or floods (up to MFL 1112 m RL).	Interface seepage/concentrated leak failure - Internal erosion of the dam due to high seepage along the spillway and gravity dam block interfaces that leads to concentrated leakage, ongoing erosion of the dam, and development of a pipe/ hole/ void/ crack that enlarges over time and leads to breach.	Seepage at concrete/earthfill dam interface that appears stable and can be controlled with preventative measures/ intervention (such as dumping rockfill, grouting and/or emergency drawdown of the Bujagali Dam reservoir).	Seepage at concrete/earthfill dam interface that is increasing but not discoloured and intervention measures (such as emergency drawdown and placement of rockfill) may or may not be successful but are currently underway.	Seepage at concrete/earthfill dam interface that is increasing and is discoloured, with evidence of enlargement / slope instability / slumping / scour. Whirlpools or other signs of reservoir draining rapidly through the dam or foundation at or near the interface. AND intervention measures (such as emergency drawdown and placement of rockfill) are not expected to be successful such that dam failure can be expected.			
	Internal erosion in the dam leading to piping failure (e.g. a hole in the dam) - Internal erosion of the dam due to material properties or a weaker/more permeable layer that leads to concentrated leakage, ongoing erosion of the dam, and development of a pipe/ hole/ void/ crack that leads to breach.	Seepage above alert level(s) that is steady and not discoloured: a. in drain outlets, and/or b. from localised area on downstream face and/or toe, AND can be controlled with preventative measures/intervention (such as dumping rockfill and/or emergency drawdown of the Bujagali Dam reservoir).	Seepage above alert level(s) that is increasing but not discoloured: a. in drain outlets, and/or b. from localised area on downstream face and/or toe, and intervention measures (such as emergency drawdown and placement of rockfill) may not be successful.	Seepage above alert level(s) that is increasing and evidence of erosion/discolouration: a. in drain outlets, and/or b. on downstream face and/or toe, Whirlpools or other signs of reservoir draining rapidly through the dam or foundation. AND intervention measures (such as emergency drawdown and placement of rockfill) are not successful.			
	Internal erosion in the dam leading to sinkholes and overtopping failure - Internal erosion of the dam due to material properties that leads to development of sinkhole(s) at the crest, and loss of dam level/ freeboard/ flood capacity that leads to overtopping and breach.	Small scale sinkhole(s) observed on crest with declining reservoir level and can be controlled with preventative measures/ intervention to prevent overtopping failure.	Sinkhole(s) observed with steady/increasing reservoir level and can be controlled with preventative measures/ intervention to reduce potential for overtopping failure.	Large scale sinkhole(s) observed with steady/increasing reservoir level and preventative measures/interventions unsuccessful/unable to be implemented in time, and overtopping failure is occurring or likely.			
Deterioration of embankment dam section foundations during normal reservoir operation (i.e. ≤ 1111.5 m RL) and/or floods (up to MFL 1112 m RL).	Internal erosion in the foundations leading to piping failure (e.g. a hole in the foundations) - Internal erosion of the foundation material under the dam due to material properties that leads to concentrated leakage, ongoing erosion, development and enlargement of a pipe/ void /crack that leads to breach (may include pipe collapse and loss of a dam section) (e.g. right embankment contact erosion with foundation rock if foundation treatment and/or grouting were ineffective).	Evidence of small scale foundation seepage and erosion (e.g. new seepage zones and/or sand boils at downstream toe) and Bujagali Dam reservoir can be drawn down for repairs to be implemented.	Evidence of foundation seepage and erosion that is increasing (e.g. new seepage zones and/or sand boils at downstream toe) with steady/increasing reservoir levels. Significant visual changes on embankment crest and slopes such as development of settlement, cracking depressions, bulges and slides. Bujagali Dam reservoir can be drawn down for repairs to be implemented but extent of erosion requires significant repairs with associated long timeframes.	Evidence of large scale foundation seepage and significant erosion leading to pipe(s) developing and enlarging at dam downstream toe. Whirlpools or other signs of reservoir draining rapidly through the dam or foundation. Bujagali Dam reservoir cannot be drawn down in time to halt continuation of erosion and dam failure is expected.			
Earthquakes (any earthquake that is felt at the site)	Seismic instability - Slope failure, settlement, cracking and/or movement due to a large earthquake that results in concentrated seepage and erosion, and/or overtopping, scour and downward cutting leading to dam breach at one or more locations.	Evidence of very small scale movement/ deformation/ settlement at the dam crest/shoulders that requires repair work but unlikely to result in dam failure, and drawdown can be undertaken to reduce the Bujagali Dam reservoir level.	Evidence of larger scale movement/ deformation/ settlement/ bulging at the dam crest and shoulders that could result in dam failure at high reservoir levels unless repaired, and significant flood/inflows are forecast/starting that may exceed the gated spillway capacity. May progress to Response Level 3 unless reservoir level can be drawn down and/or kept at a lower level and/or inflows reduced.	Evidence of larger scale movement/ deformation/ settlement/ bulging at the dam crest and shoulders that has reduced the dam freeboard and will likely result in dam failure and intervention measures are not successful (e.g. emergency drawdown unsuccessful due to gate inoperability and/or large inflows released from Owen Falls).			
	Concentrated seepage along transverse crack due to earthquake damage in dam embankment section – Concentrated leak, scour and gross enlargement leading to piping failure.	Seepage above alert level(s) that is steady and not discoloured: a. in drain outlets, and/or b. localised seepage from downstream face near crest, AND can be controlled with preventative measures/ intervention (such as dumping rockfill and/or emergency drawdown of the Bujagali Dam reservoir).	Seepage above alert level(s) that is increasing but not discoloured: a. in drain outlets, and/or b. from localised area on downstream face and/or toe, AND intervention measures (such as emergency drawdown and placement of rockfill) may or may not be successful but are being implemented.	Seepage above alert level(s) that is increasing and evidence of erosion/discolouration: a. in drain outlets, and/or b. downstream face and/or toe, Whirlpools or other signs of reservoir draining rapidly through the dam or foundation. AND intervention measures (such as emergency drawdown and placement of rockfill) are not successful.			

Potential safety threat (WHAT IS HAPPENING)	Potential failure mode (refer Section 3 for further details)	Example dam safety threat classification (Guidance and descriptions provided for context only. BEL Power station Asset Manager to consider specifics of event when setting response level) (HOW SERIOUS IS THE EVENT AND WHAT ACTION SHOULD BE TAKEN)					
	(HOW CAN THIS LEAD TO DAM FAILURE)	Response Level 1 - Internal event (Monitor/Act)	Response Level 2 - Potential Emergency (Save Dam)	Response Level 3 - Imminent Failure (Save People)			
to flood flows (i.e. reservoir levels ≥1112 m RL) OR High reservoir levels due to inadvertent/ unintentional/ malicious flow releases from Kiira and/or Nalubaale HPP upstream that exceed spillway capacity (e.g. due to operational issues or sabotage/terrorist act) that result in reservoir levels above MFL (> 1112 m RL).	Overtopping of a section(s) of embankment dam (crest)- During a flood leading to scour and erosion at the crest and downstream face, downwards cutting and breach of the dam. This may be aggravated by flood debris accumulation blocking the spillways, and/or inability/failure to operate the spillways and/or high winds causing wave runup (noting reservoir fetch and limited wind wave impacts expected) .	Water level exceeds 1112 m RL but is less than 1112.5 m RL, AND partial blockage to the siphon or gated spillway is identified, and/or high winds are causing wave splashing over the crest (1114.5 m RL), but the damage is limited and can be safely repaired prior to drawdown of the reservoir. NOTE: this would require the combined flow released from Kiira and Nalubaale HPPs to be ≥ 1200 m³/s (nominal siphon spillway capacity) and the gated spillway to be inoperable/partially inoperable (e.g. one radial gate unable to open). NOTE: Spillway Gate Technical Instruction outlines inflow notifications for Owen Falls AND automated high water/ inflow alarms that include Very High alarm for upstream level of 1111.85 m RL. This means the Operator Lead would be aware of high reservoir levels prior to Response Level 1 being triggered.	 Water level exceeds 1112.5 m RL and: partial blockage to one or more spillway sections has occurred and can not be readily cleared, and/or, one or more radial gates can not be opened, and/or high winds are causing wave splashing over the crest (1114.5 m RL) which is showing evidence of erosion, AND Bujagali Dam reservoir cannot be immediately drawn down. NOTE: this would require the combined flow released from Kiira and Nalubaale HPPs to be >> 1200 m³/s (nominal siphon spillway capacity) and likely closer to 4500 m³/s with the gated spillway inoperable/partially inoperable (e.g. one radial gate unable to open). 	Sustained flow over crest (e.g. reservoir \geq 1114.5 m RL) OR Inflows continue to exceed outflows due to blockage of the spillway(s), and/or inability/failure to operate the gated spillway, and inability to reduce inflows, and are expected to continue until the dam overtops. NOTE: this is considered highly unlikely to occur as requires the combined flow released from Kiira and Nalubaale HPPs to be sustained at a very high level for a long time $OR > 4500 \text{ m}^3/\text{s}$ which would require full Owen Falls complex spillway operation coincident with power station operation (up to 5340 m³/s, i.e. 2940 m³/s from spillways and 2400 m³/s from power stations).			
	Seepage above core zone, leading to erosion, collapse and then overtopping of a section(s) of embankment dam — Water level exceeds 1112.5 m RL leading to widespread seepage through embankment above core, leading to internal erosion, gross enlargement, and collapse, with loss of crest level, overtopping, downwards cutting and breach of the dam. Water level exceeds 1112 m RL but is less than 1112.5 m RL, AND partial blockage to the siphon or gated spillway is identified and/or high winds are causing wave runup above water level. Evidence of localised seepage in the downstream face may or may not be identified. AND Bujagali Dam outflows can and are being increased/exceed inflows such that reservoir can be drawn down to lower safer level. NOTE this would require the combined flow released from Kiira and Nalubaale HPPs to be ≥ 1200 m³/s (siphon spillway capacity) and the gated spillway to be inoperable/partially inoperable (e.g. one radial gate		Water level exceeds 1112.5 m RL for a period of 30 mins or longer and is unable to be reduced immediately. Evidence of localised seepage in the downstream face may or may not be identified. Interventions to reduce inflows/increase outflows underway such that duration of high reservoir level is likely to be relatively brief. This may be aggravated by flood debris accumulation blocking the spillway(s), and/or inability/failure to operate the spillway(s), and/or high winds causing wave runup. NOTE this would require the combined flow released from Kiira and Nalubaale HPPs to be >> 1200 m³/s (siphon spillway capacity) and likely closer to 4500 m³/s with the gated spillway inoperable/partially inoperable (e.g. one radial gate unable to open).	Water level exceeds 1112.5 m RL for a period of 30 mins or longer and is unable to be reduced immediately, and/or evidence of widespread seepage in the downstream face has been identified and erosion is evident. Interventions to halt erosion (such as dumping large rock) are unsuccessful and dam failure is expected. This may be aggravated by flood debris accumulation blocking the spillway(s), and/or inability/failure to operate the spillway(s), and/or high winds causing wave runup. NOTE this would require the combined flow released from Kiira and Nalubaale HPPs to be >> 1200 m³/s (siphon spillway capacity) and likely closer to 4500 m³/s with the gated spillway inoperable/partially inoperable (e.g. one radial gate unable to open).			
	Scour damage to downstream toe of right or central embankment dams - During operation of the siphon and gated spillways under very high tailwater levels	Localised scour at around tailwater level that appears stable and can be controlled with preventative measures (such as dumped rock)/ intervention (reduced spillway flows) to prevent further scour towards dam.	Extensive scour at dam toe that may continue to undermine the downstream slope but the inflows are reducing, and/or gates can be closed/discharge reduced to enable repair.	Extensive scour at dam toe that appears to be undermining the downstream slope and interventions are unsuccessful (e.g. inflows cannot be reduced to enable spillways to stop operating, and/or gates cannot be closed, placement of rock into the void is unsuccessful) and failure of the embankment is expected.			
	Static instability – Noting tight operating range (0.5 m difference between FSL and MFL), instability during and/or due to high reservoir levels with or without increased internal water surface in dam (as monitored using the piezometers)	Piezometric pressures above alert level(s) and/or evidence of very small scale movement/ deformation/ settlement at the dam crest/shoulders that requires repair but unlikely to result in embankment dam failure, and drawdown can be undertaken to reduce the Bujagali Dam reservoir level.	Piezometric pressures above alert level(s) and/or evidence of larger scale movement/ deformation/ settlement / bulging at the dam crest and shoulders that could result in embankment dam failure unless urgently repaired, and significant flood/inflows are forecast/starting. May progress to Response Level 3 unless reservoir level can be drawn down and/or kept at a lower level and/or inflows reduced.	Evidence of larger scale movement/ deformation/ settlement/ bulging at the dam crest and shoulders that will likely result in embankment dam failure and intervention measures are not successful (e.g. emergency drawdown unsuccessful due to gate inoperability and/or large inflows released from Owen Falls).			
Concrete gravity dams							
Increased foundation seepage or pressures	Static instability – Increased foundation pressures due to seepage and/blockage of drains leading to uplift pressures and overturning or sliding failure of gravity block(s) – May be aggravated by high reservoir levels.	Increasing seepage into dam galleries with flow transporting increasing quantities of sediment, and rapidly increasing piezometer levels, OR rapidly increasing piezometer levels with reduced/no seepage flows into the dam galleries, AND no apparent distress to the dam, while interventions are implemented (i.e. emergency draw down of the Bujagali Dam reservoir).	Increasing seepage into dam galleries with flow transporting increasing quantities of sediment, and rapidly increasing piezometer levels that exceed trigger/safety alert levels OR rapidly increasing piezometer levels that exceed trigger/safety alert levels with reduced/no seepage flows into the dam galleries AND apparent distress to the dam, while interventions are being implemented (i.e. emergency draw down of the Bujagali Dam reservoir).	Increasing seepage into dam galleries with flow transporting increasing quantities of sediment, and rapidly increasing piezometer levels that exceed trigger/safety alert levels OR rapidly increasing piezometer levels that exceed trigger/safety alert levels with reduced/no seepage flows into the dam galleries AND apparent significant distress to the dam, with dislocation and new cracking/ enlarged cracks appearing while interventions are being implemented (i.e. emergency draw down of the Bujagali Dam reservoir) or			

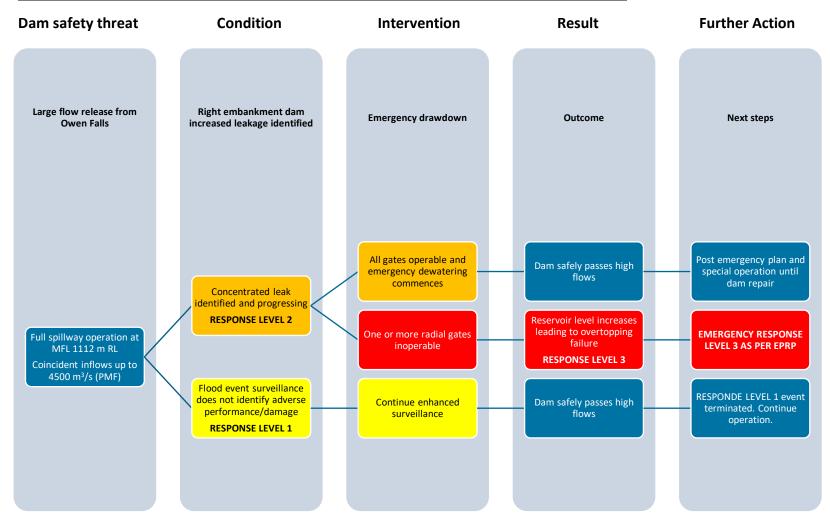
Potential safety threat (WHAT IS HAPPENING)	Potential failure mode (refer Section 3 for further details)	Example dam safety threat classification (Guidance and descriptions provided for context only. BEL Power station Asset Manager to consider specifics of event when setting response level) (HOW SERIOUS IS THE EVENT AND WHAT ACTION SHOULD BE TAKEN)					
	(HOW CAN THIS LEAD TO DAM FAILURE)	Response Level 1 - Internal event (Monitor/Act)	Response Level 2 - Potential Emergency (Save Dam)	Response Level 3 - Imminent Failure (Save People)			
Deterioration of concrete dam block	Static instability – Deterioration of concrete including joints leading to excessive seepage and/or pressure increases drains leading and overturning or sliding failure of gravity block(s)	Increasing seepage into dam galleries or through concrete joints, and rapidly increasing piezometer levels,	Increasing seepage into dam galleries or through concrete joints, and rapidly increasing piezometer levels that exceed trigger/safety alert levels	Increasing seepage into dam galleries with flow transporting increasing quantities of sediment, and/or through concrete joints and rapidly increasing piezometer levels that exceed trigger/safety alert levels			
-	– May be aggravated by high reservoir levels	OR rapidly increasing piezometer levels with reduced/no seepage flows into the dam galleries,	OR rapidly increasing piezometer levels that exceed trigger/safety alert levels with reduced/no seepage flows into the dam galleries	OR rapidly increasing piezometer levels that exceed trigger/safety alert levels with reduced/no seepage flows into the dam galleries			
	and/or earthquakes	AND no apparent distress to the dam, while interventions are implemented (i.e. emergency draw down of the Bujagali Dam reservoir).	AND apparent distress to the dam (such as cracking and dislocation), while interventions are being implemented (i.e. emergency draw down of the Bujagali Dam reservoir).	AND apparent significant distress to the dam, with dislocation and new cracking/ enlarged cracks appearing while interventions are being implemented (i.e. emergency draw down of the Bujagali Dam reservoir) conterventions are unsuccessful (i.e. unable to draw down quick enough).			
Earthquakes (any earthquake that is felt at the site)	Seismic instability - Cracking and/or movement due to a large (felt) earthquake that results in block dislocation and failure by sliding, overturning or loss of containment.	Evidence of very small scale movement/ deformation/ settlement that requires repair work but unlikely to result in dam failure, and drawdown can be undertaken to reduce the Bujagali Dam reservoir level.	Evidence of larger scale movement/ deformation/ settlement that could result in dam failure at high reservoir levels unless repaired, and significant flood/inflows are forecast/starting that may exceed the gated spillway capacity. May progress to Response Level 3 unless reservoir level can be drawn down and/or kept at a lower level and/or inflows reduced.	Evidence of larger scale movement/ deformation/ settlement that has reduced the dam freeboard and will likely result in dam failure and intervention measures are not successful (e.g. emergency drawdown unsuccessful due to gate inoperability and/or large inflows released from Owen Falls).			
All structures (embankme	nt dams, concrete gravity dams, power station, ga	ated and auxiliary spillway)					
Dam failure at Owen Falls (Kiira and/or Nalubaale) resulting in uncontrolled release of upstream reservoir volume (Cascade failure)	Overtopping (esp. embankment dam) – Inflows exceed outflow capacity at Bujagali resulting in reservoir level increase until one or more sections of the Bujagali Dam overtop and fail (e.g. as per one or more embankment failure modes related to flooding/high reservoir levels above).	Any notification of imminent and/or potential dam failure at either Kiira (embankment dam) or Nalubaale (concrete dam) HPP is highly unlikely to be an internal event. See Response Levels 2 and 3 adjacent.	Pre-emptive drawdown of the Bujagali Reservoir in advance of dam failure may be sufficient to prevent overtopping of the Bujagali Dam and cascade failure, provided the dam can withstand higher reservoir levels (> 1112.5 m RL top of core) in the short term and full spillway capacity (with some turbine discharge) is available following the event. This likely only applies to non flood conditions (i.e. normal maximum operating water levels in Lake Victoria ≤ 1135 m RL). Effective intervention will require close coordination with UEGCL Nalubaale/Kiira over a very long period of time (i.e. years). Flow releases to slowly drawdown Lake Victoria to a safer level will take an extremely long time, noting this is limited to several meters down to minimum operating level of 1131.9 m RL. Pre-emptive drawdown of Lake Victoria is unlikely to halt dam failure at Owen Falls unless other interventions provide time.	Imminent and/or potential dam failure at either Kiira or Nalubaale under flood conditions (Lake Victoria water level is > 1135 m RL) OR Pre-emptive drawdown of the Bujagali Dam reservoir in advance of dam failure is not achievable due to lack of warning and/or inflows exceeding available discharge capacity at Bujagali. A fully coordinated response with UEGCL Nalubaale/Kiira and UEGCL Isimba is essential for this situation to reduce the potential consequence of dam failure (i.e. emergency drawdown of Bujagali (where possible) increases inflows into Isimba which also should be drawdown to contain dam break flood waters from upstream without failing). NOTE: Isimba reservoir storage volume is expected to accommodate cascade failure flows without the dam overtopping provided the spillways remain operational.			
Hijacking/ sabotage / terrorist actions at Kiira and Nalubaale HPP such that there is loss of control at the dams	Overtopping (esp. embankment dam) due to malicious operation of Owen Falls complex (e.g. full opening of all gates and turbines) Resulting inflows exceed outflow capacity at Bujagali resulting in reservoir level increase until one or more sections of the Bujagali Dam overtop and fail.	Loss of control at Kiira and/or Nalubaale is highly unlikely to be an internal event See Response Levels 2 and 3 adjacent.	Pre-emptive drawdown of the Bujagali Reservoir and full operation of the spillways and the power station may be sufficient to prevent overtopping of the Bujagali Dam and cascade failure, from malicious discharges at Owen Falls. This is provided the dam can withstand higher reservoir levels (> 1112.5 m RL top of core) in the short term and full spillway capacity (with some or full turbine discharge) is available. This likely applies to normal operating and flood conditions with full opening/discharge BUT not flood conditions with full gate closure leading to overtopping and dam failure at Kiira (for example) – Refer Response Level 3	Imminent and/or potential dam failure at either Kiira or Nalubaale is expected following malicious operation (e.g. permanent gate closure during flood conditions leading to overtopping failure at Kiira and/or sabotage/ damage to dam structures leading to dam failure) OR Interventions at Bujagali are unsuccessful due to loss of spillway and/or generation capacity (e.g. transmission lines also damaged and onl no-generation flow is possible). OR Bujagali dam is showing signs of distress at higher reservoir levels and/or discharges (refer high reservoir level threat examples above). NOTE: Isimba reservoir storage volume is expected to accommodate cascade failure flows without the dam overtopping provided the spillways remain operational.			
Intentional damage (i.e. sabotage and/or terrorist acts) at Bujagali	Damage to any dam structures leading to failure via structural collapse/overtopping – Critical structures are damaged leading to uncontrolled release of the reservoir contents.	Communication of threat and/or discovery of suspicious object on or near dam or spillway. Explosion / collision / impact at dam or spillways that causes little or no damage and dam can continue to safely operate.	Explosion on gated or siphon spillway that causes uncontrolled release of water but is self-limited to spillway chute and does not immediately destabilise the adjacent embankment or concrete block dams. Upstream flows can be reduced to safe levels while repairs are undertaken to restore safe operation.	Explosion / collision / impact at dam that causes major damage and uncontrolled release of water, especially to a concrete gravity block or embankment dam section. A fully coordinated response with UEGCL Nalubaale/Kiira and UEGCL Isimba is essential for this situation to reduce the potential consequence of dam failure (i.e. emergency drawdown at Isimba to attempt to contain dam break flood waters from upstream without failing, and reduced inflows from Owen Falls).			

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	(HOW CAN THIS LEAD TO DAM FAILURE)	Response Level 1 - Internal event (Monitor/Act)	Response Level 2 - Potential Emergency (Save Dam)	Response Level 3 - Imminent Failure (Save People)			
Unintentional damage (e.g. fires, equipment failure, vehicle collisions, and operational damage)	fires, equipment and associated lifting equipment) or ce, vehicle collisions, structures leading to failure via overtopping dam can continue to safely operate.		Unintentional damage that requires substantial repair in order to restore operation but the dam can continue to safely operate provided suitable interventions remain in place until repairs can be undertaken (such as draw down of the reservoir and reducing inflows from Owen Falls (Kiira/Nalubaale HPPs)).	Unintentional damage that results in: a loss of operation (e.g. spillway gates can no longer open or spillway cannot be operated due to chute damage) AND inflows exceed discharge capacity leading to reservoir levels above 1112.5 m RL (typically requires a coincident large flood). b OR uncontrolled release of the reservoir contents/ dam breach And dam cannot continue to safely operate even with interventions (such as reducing inflows from Owen Falls (Kiira/Nalubaale HPPs)).			
Operational failures (e.g. due to equipment failure or intentional malicious operation due to sabotage/hijacking)	Gate maloperation leading to overtopping (esp. embankment dams) – Gates accidentally closed during high inflows (e.g. due to programming error) and unable to manually override in time leading to reservoir level increase and overtopping (e.g. as per one or more embankment failure modes related to flooding/high reservoir levels above).	Water level exceeds 1112 m RL but is less than 1112.5 m RL, AND partial blockage to the siphon or gated spillway is identified, and/or high winds are causing wave splashing over the crest (1114.5 m RL), but the damage is limited and can be safely repaired prior to drawdown of the reservoir. NOTE this would require the combined flow released from Kiira and Nalubaale HPPs to be ≥ 1200 m³/s (siphon spillway capacity) and the gated spillway to be inoperable/partially inoperable (e.g. one radial gate unable to open).	 Water level exceeds 1112.5 m RL and: partial blockage to one or more spillway sections has occurred and cannot be readily cleared, and/or, one or more radial gates cannot be opened, and/or high winds are causing wave splashing over the crest (1114.5 m RL) which is showing evidence of erosion, AND Bujagali Dam reservoir cannot be immediately drawn down. NOTE this would require the combined flow released from Kiira and Nalubaale HPPs to be >> 1200 m³/s (siphon spillway capacity) and likely closer to 4500 m³/s with the gated spillway inoperable/partially inoperable (e.g. one radial gate unable to open). 	Sustained flow over crest (e.g. reservoir \geq 1114.5 m RL) OR Inflows continue to exceed outflows due to blockage of the spillway(s), and/or inability/failure to operate the gated spillway, and inability to reduce inflows, and are expected to continue until the dam overtops. NOTE this is considered highly unlikely to occur as requires the combined flow released from Kiira and Nalubaale HPPs to be sustained at a very high level for a long time OR $>$ 4500 m³/s which would require full Owen Falls complex spillway operation coincident with power station operation (up to 5340 m³/s, i.e. 2940 m³/s from spillways and 2400 m³/s from both power stations).			
Loss of control at Bujagali due to sabotage/ hijacking / coercion / terrorist actions	Gate maloperation leading to overtopping (esp. embankment dams) – Gates deliberately closed during high inflows in an attempt to cause dam failure (i.e. sabotage/hijacking / coercion and terrorist actions) and unable to manually override in time (due to loss of control at the dam) leading the reservoir level increase and overtopping (e.g. as per one or more embankment failure modes related to flooding/high reservoir levels above).	Loss of control at Bujagali (especially the gated spillway and power station) is highly unlikely to be an internal event See Response Levels 2 and 3 adjacent.	Loss of control at the dam and gates are shut and power station inoperative with significant inflows causing reservoir level to rise, and water level may exceed 1112.5 m RL. Upstream flows can be reduced at Kiira/Nalubaale in sufficient time to prevent dam failure. NOTE: Reservoir level rise in this scenario would require the combined flow released from Kiira and Nalubaale HPPs to be >> 1200 m³/s (nominal siphon spillway capacity)	Loss of control at the dam and gates are shut and power station inoperative with significant inflows causing reservoir level to rise, and water level has exceeded 1112.5 m RL, AND upstream flows cannot be sufficiently reduced at Kiira/Nalubaale in time for whatever reason. A fully coordinated response with UEGCL Nalubaale/Kiira and UEGCL Isimba is essential for this situation to reduce the potential consequences of dam failure (i.e. emergency drawdown at Isimba to attempt to contain dam break flood waters from upstream without failing, and reduced inflows from Owen Falls where possible).			
Downstream population a	nd Isimba Dam (NOTE THIS IS NOT A DAM SAFETY	THREAT TO BUJAGALI DAM BUT IS AN IMPORTANT CONS	SIDERATION FOR PEOPLE BESIDE THE RIVER AND ISIMBA DAM – UEGCI	ISIMBA WILL FOLLOW THEIR EPRP – BEL TO COORDINATE WITH UEGCL)			
Unintentional operation of spillway gates (sudden release of water)	Sudden release due to mechanical failure of gate/s, operator error or deliberate action without warning – outflows lead to inundation of downstream areas (life safety risk e.g. at Itanda Falls) and potential increase to Isimba Reservoir level that may lead to damage/overtopping of the Isimba Dam without intervention (i.e. opening of the spillway gates to maintain a safe reservoir level and/or reduction in inflows from Owen Falls – Kiira and Nalubaale HPPs).	Unintentional operation of one or more of the spillway radial gates that cannot be immediately addressed (by closing the gates) BUT tailwater alarm and Isimba Dam spillways operational and can safely accommodate discharge. NOTE: Spillway gates operation technical instruction outlines sudden release procedures, including Response Level 1 alert for sudden releases up to 500 m³/s. Peak release ≤1465 m³/s (single radial gate capacity at MFL of 1112 m RL). Noting usual permissible discharge is set between 400 and 1400 m³/s.	Unintentional operation of both spillway radial gates (with or without flap gates down) that cannot be immediately addressed (by closing the gates within 10 mins). Peak release ≤ 1000 m³/s (note capacity of both gates is 2930 m³/s at MFL of 1112 m RL). This event presents: a a life safety risk downstream (rapidly increased flows/water levels with no warning) b and a dam safety threat to Isimba Dam IF it is unable to accommodate increased outflows (e.g. due to gates and power station being inoperable). NOTE: Isimba Dam has a reported spillway capacity of 5250 m³/s (allowing for one gate to be inoperable while passing the 4500 m³/s IDF). This is in addition to the turbine capacity of 1375 m³/s (which is the same as the Bujagali Power station). The actual discharge available at Isimba may be greater at higher reservoir levels.	Unintentional operation of both spillway radial gates and/or power station (with or without flap gates down) that cannot be immediately addressed (by closing the gates/shutdown within 10 mins) AND peak release > 1000 m³/s (note capacity of both gates is 2930 m³/s at MFL of 1112 m RL). This event presents: a a life safety risk downstream (rapidly increased flows/water levels with no warning) (e.g. at Wildwaters Lodge). b and a dam safety threat to Isimba Dam IF it is unable to accommodate increased outflows (e.g. due to gates and power station being inoperable). Response Level 3 applies where the Isimba gates are inoperable for a sufficient period that water levels in the Isimba Reservoir are increasing above Isimba MFL of 1055 m RL, AND inflows are not reduced at Owen Falls (such that increasing water levels at Isimba are expected). NOTE: This combination of events is highly improbable given the multiple interventions and back-up systems in place at all three dam sites to prevent this combination of adverse conditions leading to dam failure at Isimba.			

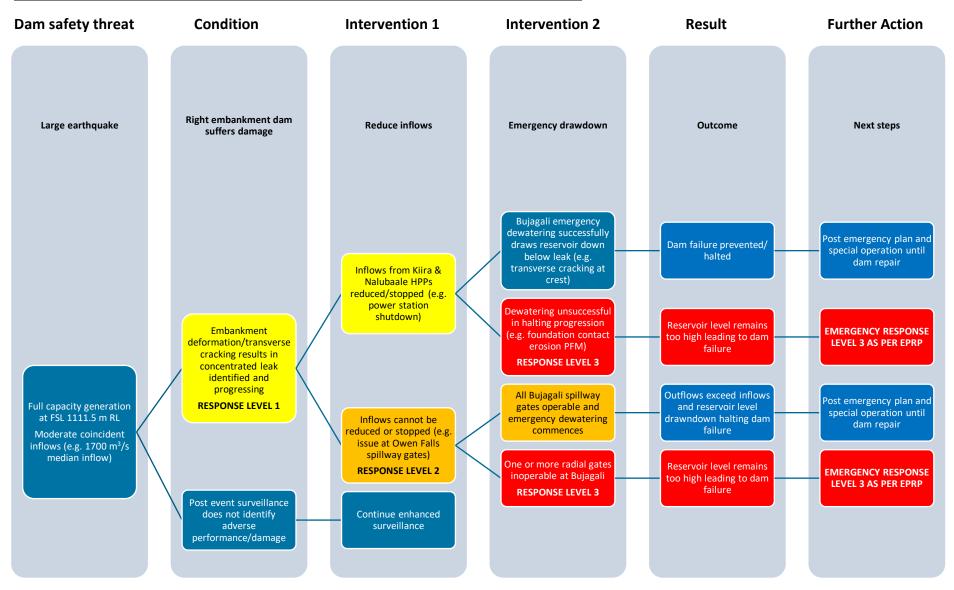
 Table B
 Emergency preparation and response roles and responsibilities

	Actions by organisation									
Event stage	Bujagali Energy Limited (BEL) - Dam Owner	Uganda Police Force (especially DPCs)	Uganda Peoples' Defence Forces (UPDF)	UEGCL Isimba, Kiira & Nalubaale	UETCL NCC	Ministry of Relief and Disaster Preparedness (Office of the Prime Minister)	National Emergency Coordination and Operations Centre (NECOC)	District Emergency Coordination and Operations Centres (DECOC)	Technical Adviser(s)	Public
Routine surveillance/ monitoring for potential threats.	BEL asset and dam safety management procedures followed.				No eme	ergency response required.				
Potential dam safety threat identified (e.g. large flood in progress or forecast, large earthquake, and/or signs of a potential failure mode developing).	BEL Asset Manager (or their delegate/alternate, Operator lead) notified of threat. Notification may come from operations staff, dam safety surveillance staff, UEGCL (e.g. Owen Falls HPPs), Uganda Police Force, or potentially members of the public.			Coordinate with BEL.	Coordinate with BEL.				Technical advice to BEL.	Identifies threat/ unusua behaviour and notifies Police and/or BEL.
Threat assessed and classified as below See also Figure A.	BELAsset Manager (or their delegate/alternate, t Operator Lead) assesses and classifies threat as an Incident, Internal Event, Potential Emergency or Imminent Failure and proceeds accordingly as below.									
RESPONSE LEVEL 0 Incident (not an emergency)	BELAsset Manager (or their delegate/alternate, Operator Lead) manages BEL response using Surveillance Manual and operating procedures (EPRP is not activated).				No eme	ergency response required.				
RESPONSE LEVEL 1 Internal event (Monitor/Act)	BEL Asset Manager (or their delegate/alternate, Operator Lead) manages BEL response.			Coordinate with BEL.	Coordinate with BEL.				Technical advice to BEL.	
RESPONSE LEVEL 2 Potential Emergency (Save Dam) Pre-emptive measures implemented.	BEL Asset Manager (or their delegate/alternate, Operator Lead) notifies relevant parties (using notification procedure). BEL leads pre-emptive measures, which may include emergency drawdown of the reservoir, and directing pre-engaged contractors to undertake physical works. Continue to monitor situation and update notified parties.	Implement initial response plans, prepare for potential escalation to Response Level 3.	Implement initial response plans. Standby for request for assistance from Uganda Police Force.	Activate UEGCL EPRP(s) and follow procedures for potential failure of Bujagali Dam.	Coordinate operation with BEL, generation instructions	Prepare to implement national/ regional response plans.	Standby for activation.	Standby for activation, (Uganda Police DPCs who lead the DECOCs are already informed). Inform district, sub-county and village level committees. District CAOs informed as part of DECO's.	Provide technical advice to BEL.	Follow directions of emergency responders. Voluntary evacuation of river margin, Nile Bend Resorts & Wildwaters Lodge.
RESPONSE LEVEL 3 Imminent Failure (Save People) Failure in progress or deemed imminent. EPRP processes followed by all organisations.	Call Uganda Police Force, then UEGCL Isimba, and then other agencies/parties. BEL to attempt emergency drawdown of reservoir and interventions to limit/stop breach including directing pre-engaged contractors to undertake physical works.	Initial lead for emergency response until NECOC takes over. Includes cordons around and evacuation of zone of potential inundation.	Support Uganda Police Force in emergency responses. Follow directions from NECOC and DECOC.	Activate UEGCL EPRP(s) and follow procedures for cascade failure of Bujagali Dam.	Coordinate operation with BEL, generation instructions	Declare Emergency. Activate NECOC to take over and coordinate emergency response	Activate and coordinate emergency response by DECOC's	Coordinate district level emergency response including Police and UPDF. Inform district, sub- county and village level committees.	Technical advice to BEL	Follow directions of emergency responders including evacuations.
EVENT TERMINATION Emergency phase over Dam failure has occurred, or has been successfully prevented, event declared over, and recovery phase begins	BEL Asset Manager (or their delegate/alternate, Operator Lead) formally declares the dam safety emergency event to be terminated in coordination with the NECOC (where activated). Implement post event actions (which may include dam repairs, special operation, and management procedures).	Support recovery as directed by Ministry of Relief and Disaster Preparedness (Office of the Prime Minister) – NECOC and DECOCs	Support recovery as directed by Ministry of Relief and Disaster Preparedness (Office of the Prime Minister) – NECOC and DECOCs	Coordinate wit recovery phase		Coordinate emergency recovery phase via NECOC	Coordinate emergency recovery phase with DECOCs	Coordinate district level emergency recovery.	Technical advice to BEL	Follow directions of recovery organisations

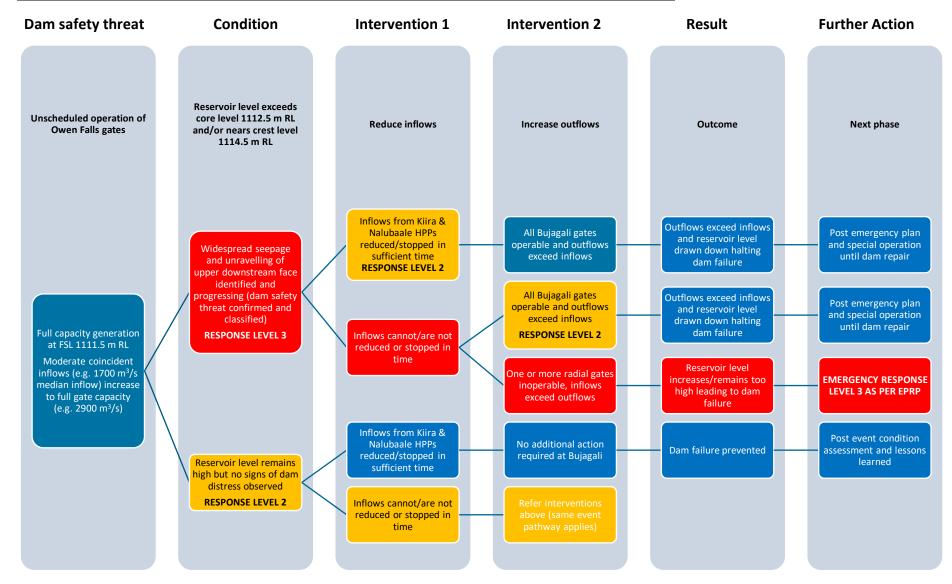
SIMPLIFIED EVENT TREE 1: Example high inflow/flood-induced potential failure mode (PFM)



SIMPLIFIED EVENT TREE 2: Example earthquake induced potential failure mode (PFM)



SIMPLIFIED EVENT TREE 3: Example operation induced potential failure mode - Unexpected inflows



SIMPLIFIED EVENT TREE 4: Example of internal erosion induced potential failure mode

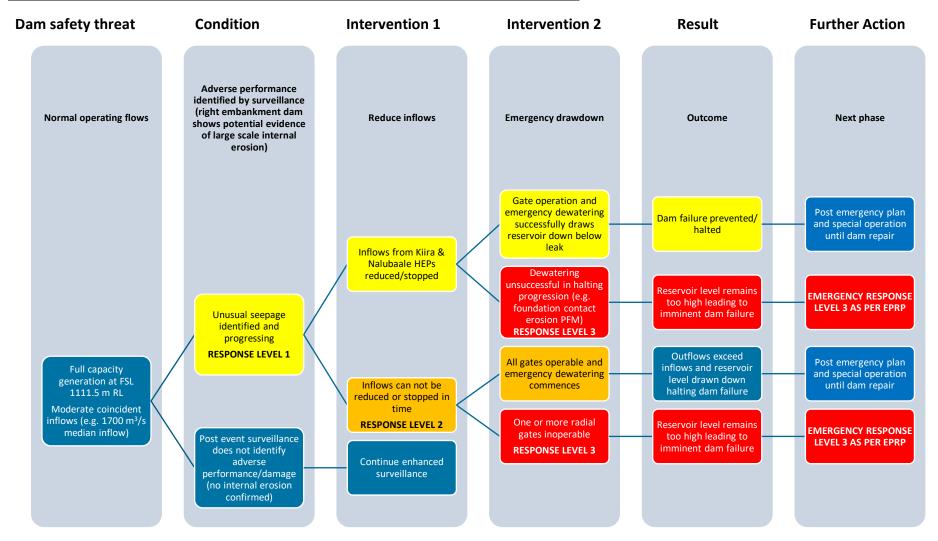


Table C Bujagali Dam EPRP Contact List

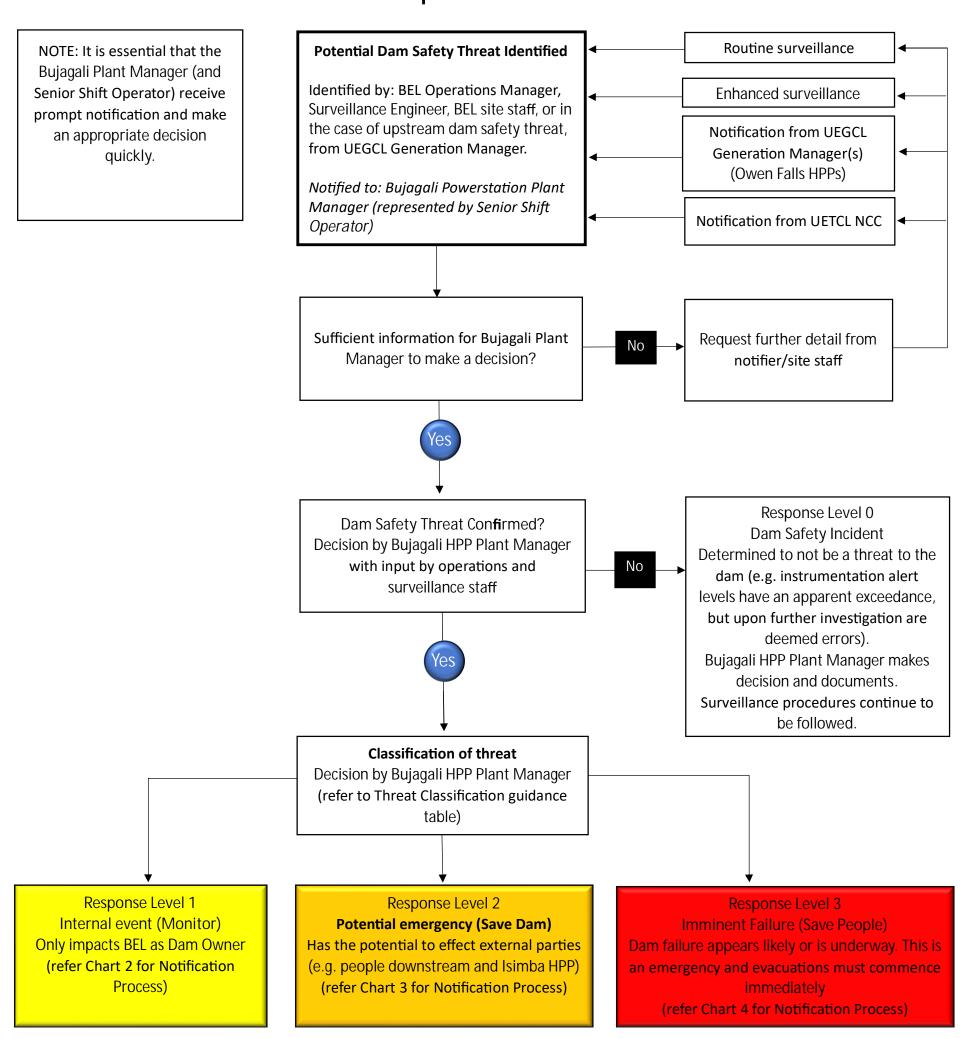
Organisation	Role/Contact	Identified person / notes	Contact number	Alternative number/contact
Bujagali Dam HEPP	Owner/Operator			
	General Manager	Alaister McDougall	0707 431 828	0752 237 719 0200 550 500
Bujagali Energy	Asset Manager	Francis Mwangi	0752 237 766	-
	Operator Lead at Control Room	Varies	0200 550 502	0783 950 775 0706 936 010 EXT 209
Limited	Operations Delivery Manager	Agaba Ismail	0704 213 421	0784 651 772
	Maintenance Delivery Manager	Yusuf Kadhigo	0772 714 132	-
	Civil Supervisor	Isaac Oonyu	0755 018 161	0774 018 161
	Dam Safety Specialist	Albert Kiggundu	0701 100 647	0774 523 292
	BEL Office	Varies	0200 550 500	-
Isimba Dam HEPP (Dwner/Operator (downstream of E	Bujagali Dam)		
	UEGCL Managing Director/ CEO	Eng. Harrison. E. Mutikanga	0772 429 990	harrison.mutikanga @uegcl.go.ug
UECCI Islanda	Generation Manager	Eng. Elias Tunguta	0783 061 033	-
UEGCL Isimba	Operations Manager	Mr. Phillip Lutaaya	0784 455 381	0781 414 895
	Shift Charge Engineer (Senior Shift Operator)/ Control Room)	Varies	0393 218 004	0312 372 233
Owen Falls Comple	x Dam Owner/Operator (Upstrean	n of Bujagali Dam) (Kiir	a and Nalubaale HEF	PPs)
	Generation Manager	Mr. Daniel Oluga	0775 199 927	0776 733 417
UEGCL Kiira and	Operations Manager	Mr. Peter Tentena	0775 460 719	
Nalubaale	Shift Charge Engineer (Senior Shift Operator)	Varies	0417 722 824	0417 722 810 0417 722 817
UETCL (Uganda Ele	ctricity Transmission Company Lim	ited)		
National Control Centre (NCC) –	LCC Operator	Varies	0417 802 576	0314 802 576 0393 261 360
Lugogo	Manager Control	Bright Masereka	0782 161 552	
Potential Affected	Locations Downstream (to aid volu	intary evacuations/rap	oid notification)	
Nile Bend Resort	Manager	Allen Mukasa	0782 717 969	0756 125 235
Wildwaters Lodge	Manager	Varies	0772 237 400	0754 237 500
Whispers of the Nile	Manager	Martin Elijah Yaa	0200 903 035	0770 622 516 0786 356 017 0709 785 385
Emergency respond	l Hers	<u> </u>		0,05,705,305
Uganda Police	DPC Buwenge (Kiira North)	Morris Oye	0774 052 177	
Force	OC Stn – Budondo Police Station	ASP. Alex Kyankaaga	0782 787 555	
	DPC Jinja (Kiira Central)	SP Innocent Mubangizi	0707 876 568	0700 213 094
	DPC Njeru	SP. Hussein Mugarura	0784 575 256	

Organisation	Role/Contact	Identified person / notes	Contact number	Alternative number/contact
	DPC Kayunga	Rosette Sikahwa	0753 885 798	0741 559 705
	DPC Kamuli	Rebecca Ayeta	0772 006 789	
Uganda Peoples' Defence Forces (UPDF)	Jinja Cantonment	Ms. Rachel Kagoya	0772 013 370	0705 568 339
Ministry of Relief, Disaster	Commissioner, Disaster Management	ТВА	ТВА	ТВА
Preparedness and Management (Office of the	Assistant Commissioner Disaster Management	Rose Nakabugo	0772 313 093	
Prime Minister)				
National	Toll free line	Varies	0800 177 777	N/A
Emergency Coordination and Operations	National Incident Commander (NIC)	Brig. Rugadya Akiiki	0783 180 466	
Centre (NECOC)	Military Assistant to the head of National Emergency Coordination and Operation Centre and the OPM	Capt. Stanley Osaba	0785 082 988	
District Emergency	Coordination and Operations Cen	tre (DECOC) / District D	isaster Management	t Committee (DDMC
DDMC & DECOC Jinja	Chief Administrative Officer (CAO) – Jinja (DDMC Chair)	Ms. Lillian Nakamatte	0772 408 609	
	Deputy CAO - Jinja	Elizabeth Adong	0772 671 068	0756 671 068
	DPC Buwenge	Refer above	0774 052 177	
DDMC & DECOC				
DDMC & DECOC Buikwe	Chief Administrative Officer (CAO) – Buikwe (DDMC Chair)	Mulondo Robert	0772 521 556	
		Mulondo Robert Mr. Gidongo Peter Wasagami	0772 521 556 0752 935 558	
	(CAO) – Buikwe (DDMC Chair)	Mr. Gidongo Peter		
	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe	Mr. Gidongo Peter Wasagami		
Buikwe DDMC & DECOC	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe DPC Njeru Chief Administrative Officer	Mr. Gidongo Peter Wasagami Refer above	0752 935 558	
Buikwe DDMC & DECOC	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe DPC Njeru Chief Administrative Officer (CAO) – Kayunga (DDMC Chair)	Mr. Gidongo Peter Wasagami Refer above Maalik Mahaaba Godfrey Kiiza	0752 935 558	
Buikwe DDMC & DECOC	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe DPC Njeru Chief Administrative Officer (CAO) – Kayunga (DDMC Chair) Deputy CAO – Kayunga	Mr. Gidongo Peter Wasagami Refer above Maalik Mahaaba Godfrey Kiiza Rwakijuma	0752 935 558	
DDMC & DECOC Kayunga DDMC & DECOC	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe DPC Njeru Chief Administrative Officer (CAO) – Kayunga (DDMC Chair) Deputy CAO – Kayunga DPC Kayunga Chief Administrative Officer	Mr. Gidongo Peter Wasagami Refer above Maalik Mahaaba Godfrey Kiiza Rwakijuma Refer above	0752 935 558 0772 553 726 0782 946 584	
DDMC & DECOC Kayunga DDMC & DECOC	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe DPC Njeru Chief Administrative Officer (CAO) – Kayunga (DDMC Chair) Deputy CAO – Kayunga DPC Kayunga Chief Administrative Officer (CAO) – Kamuli (DDMC Chair)	Mr. Gidongo Peter Wasagami Refer above Maalik Mahaaba Godfrey Kiiza Rwakijuma Refer above Mr. Nasser Mukibi Mr. Badru	0752 935 558 0772 553 726 0782 946 584 0772 373 399	
DDMC & DECOC Kayunga	(CAO) – Buikwe (DDMC Chair) Deputy CAO – Buikwe DPC Njeru Chief Administrative Officer (CAO) – Kayunga (DDMC Chair) Deputy CAO – Kayunga DPC Kayunga Chief Administrative Officer (CAO) – Kamuli (DDMC Chair) Deputy CAO – Kamuli DPC Kamuli	Mr. Gidongo Peter Wasagami Refer above Maalik Mahaaba Godfrey Kiiza Rwakijuma Refer above Mr. Nasser Mukibi Mr. Badru Ssentongo Waliggo	0752 935 558 0772 553 726 0782 946 584 0772 373 399	

Charts Notification flowcharts (Charts 1 to 5)

The processes for dam safety threat identification, classification, communication and notification for each response level are also presented in Charts 1 to 5 below.

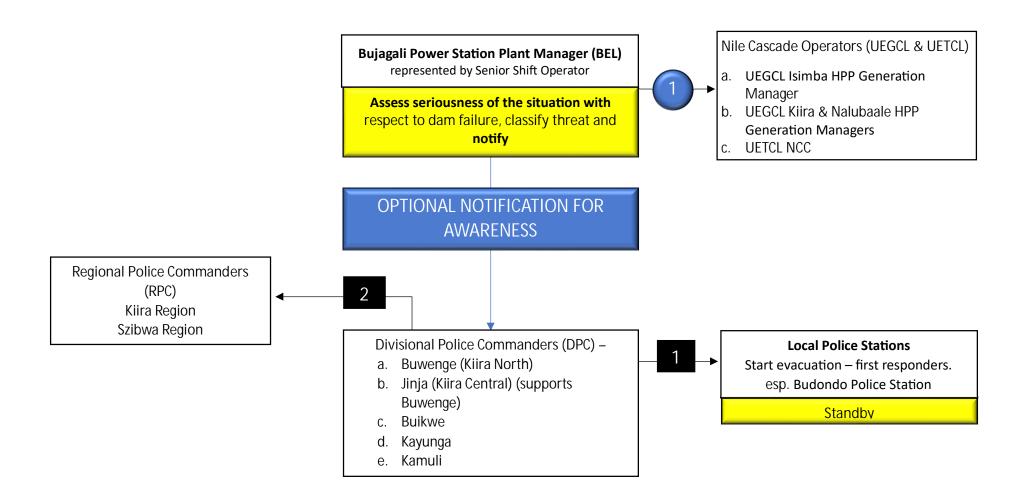
Chart 1: Dam safety threat identification and classification process



NOTE: BEL's role in the wider emergency response is to manage the dam, and to inform and communicate. Decisions and management of the downstream response actions are made by the appropriate agency (e.g. UEGCL, UETCL, the Uganda Police Force, UPDF, and Government of Uganda).

Chart 2: Notification & Actions – Response Level 1: Internal Event

Response Level 1: Monitor/Act (Internal event - serious dam safety threat identified, currently can be safely managed at the dam) - Be aware and take appropriate action at the Bujagali Dam.



NO FURTHER ACTION UNDER EPRP FOR RESPONSE LEVEL 1

Noting ongoing monitoring may lead to escalation to Response Level 2 and/or 3 (Charts 3 and 4) OR Event Termination (Chart 5)

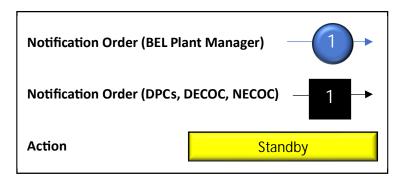


Chart 3: Notification & Actions – Response Level 2: Potential Emergency

Response Level 2: Save Dam (Potential Emergency - Has the potential to affect others, action being taken to save dam)

Prepare to commence evacuations and emergency response

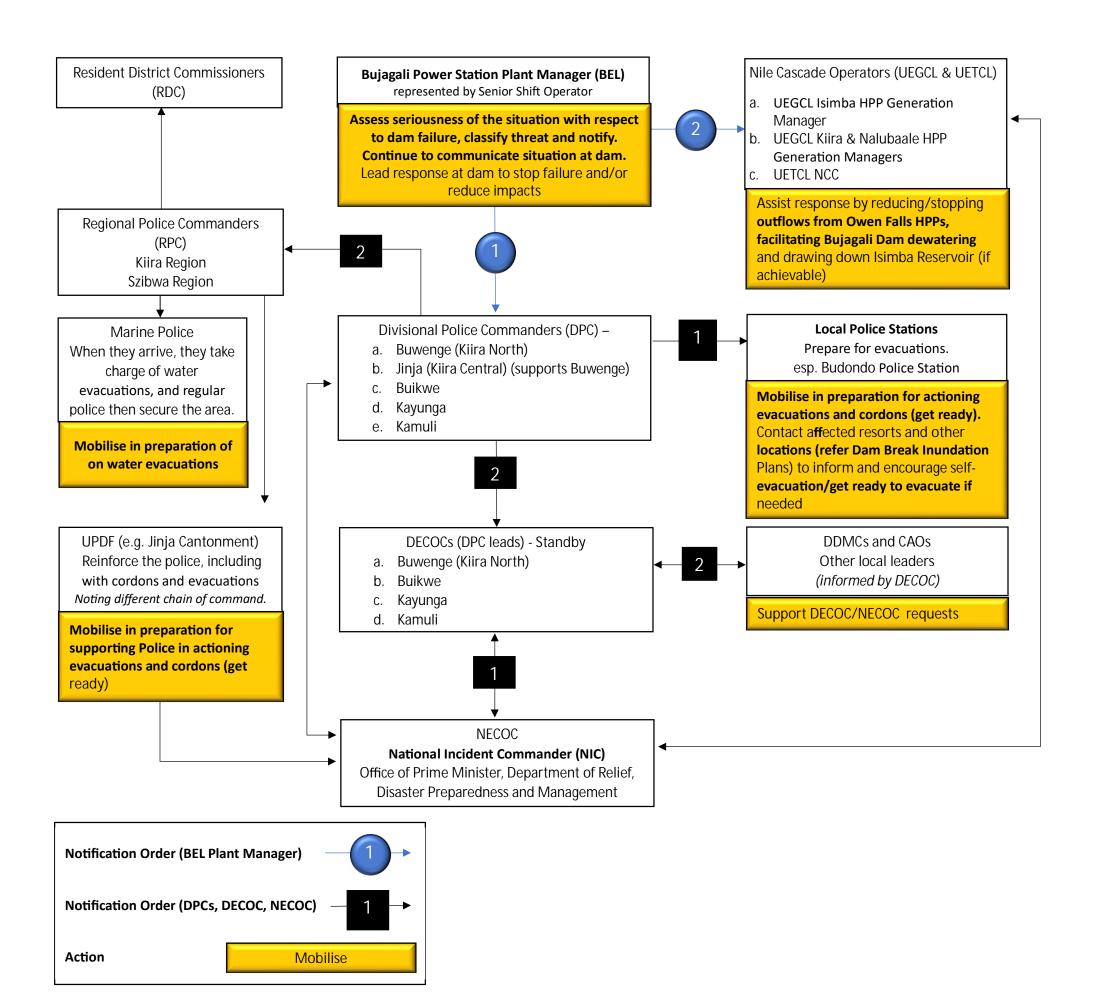
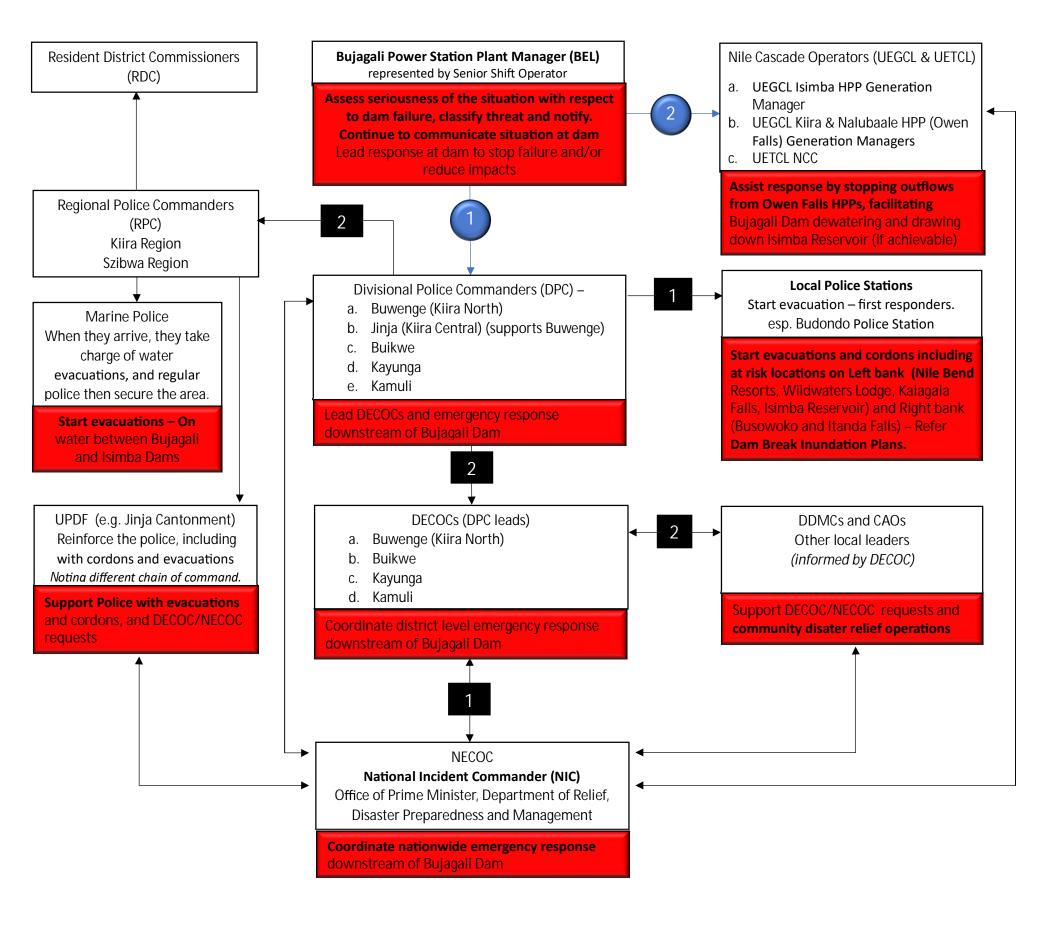


Chart 4: Notification & Actions – Response Level 3: EPRP Plan Implementation – Imminent Dam Failure

Response Level 3: Take action (Imminent Failure - Take action to save lives) - Commence evacuations and emergency response.



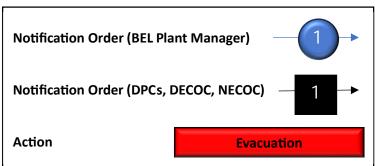
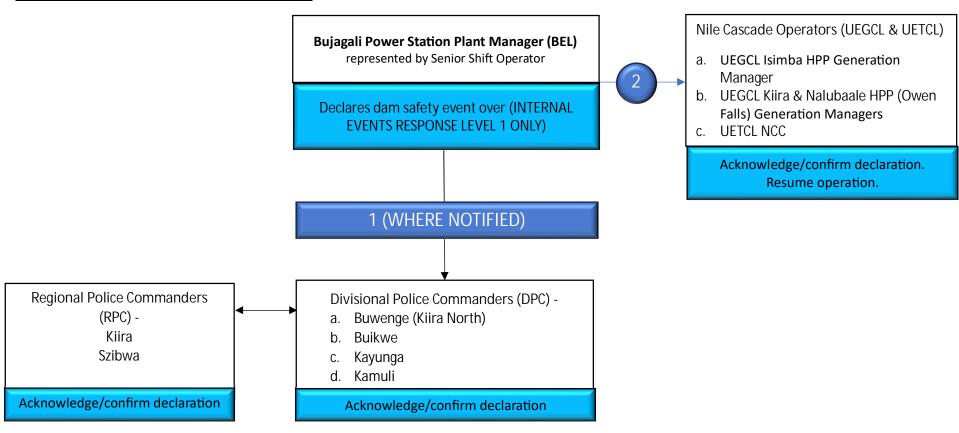


Chart 5: Notification & Actions – Event termination: Emergency response ends

INTERNAL EVENTS ONLY (RESPONSE LEVEL 1)



POTENTIAL EMERGENCY AND IMMINENT FAILURE SCENARIOS (RESPONSE LEVELS 2 AND 3)

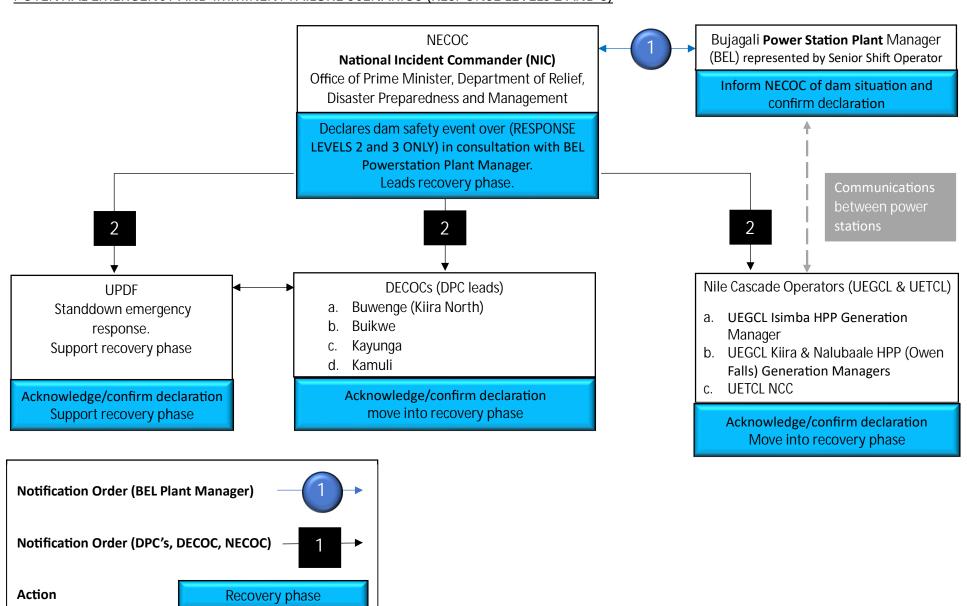


Table D Contact list for local construction material suppliers and contractors (TBC)

Organisation	Business Address	Phone number(s)	Description
CONSTRUCTION MA	ATERIAL SUPPLIERS		
			Riprap, gravels and other quarried material
			Sand bags
FARTHWORKS AND	GENERAL CONTRACTING		
			Local contractor with large scale earthworks capability
EQUIPMENT SUPPL	IERS		
			Earthmoving equipment, portable power generators, dewatering pumps and concrete mixers
CHARTER HELICOPT	ER OPERATORS	<u>'</u>	·
			Charter helicopter operator

Note this is not a complete list of all potential suppliers. It is intended that suppliers on this list have prearranged agreements with BEL to provide the potentially required services.

Flood hazard plans

Flood hazard plans for the assessed potential breach scenarios are included in the following pages. These flood hazard plans indicate the extent of inundation for the modelled breach scenarios and should be treated as indicative to help inform the emergency response, noting they are based on a set of assumed conditions and the specifics of an actual dam breach event may be different.

Figure 1 shows the overall extent of the area covered by this emergency preparedness and response plan. Figures 2 to 5 present the modelled potential inundation extents for two dam breach scenarios i.e. a non-flood (sunny day) breach of Bujagali Dam and a high inflow (rainy day) cascade failure (Owen Falls breach followed by Bujagali breach). Further details of each figure are summarised in Table E below.

The basis of the modelled dam breach scenarios and inundation extents is described in the Updated Dam Break Analysis and Inundation report. In total, six dam breach scenarios were modelled and their downstream inundation extents mapped. These are all described in the dam break report, and are:

- S1: Right embankment dam failure under normal (non-flood) inflow conditions (e.g. piping failure)
- S2: Gated spillway concrete block failure under normal (non-flood) inflow conditions (e.g. following an earthquake)
- S3: Right embankment dam failure under high flood inflows (e.g. overtopping failure)
- S4: Gated spillway concrete block failure under high flood inflows (e.g. gate operational failure and overturning)
- S5: Right embankment dam cascade failure initiated by dam break at Owen Falls Complex under normal (non-flood) inflow conditions
- S6: Right embankment dam cascade failure initiated by dam break at Owen Falls Complex under high flood inflows.

Only two have been selected to be displayed in this EPRP. These represent the critical cases for non-flood non-cascade failure of Bujagali Dam (scenario S1) and cascade failure of Owen Falls followed by Bujagali Dam in an extreme flood event (scenario S6).

Table E Dam breach flood hazard plan index

Figure Number	River/Area	Description
Figure 1	Victoria Nile downstream of Bujagali Dam to Isimba Dam	Shows the overall extent of the area covered by this emergency preparedness and response plan
Figure 2	Bujagali Dam to Busowoko Falls	Modelled inundation extents for (i) A non-flood
Figure 3	Busowoko Falls to Kalagala/Itanda Falls	(sunny day) dam breach of Bujagali Dam with normal operational flows in the Victoria Nile,
Figure 4	Kalagala/Itanda Falls to Isimba Reservoir	and (ii) A cascade failure caused by an extreme
Figure 5	Isimba Reservoir	flood (PMF) which causes a dam break at Owen Falls that results in a breach of Bujagali Dam.

The **red line** inundation scenario (sunny day Bujagali embankment dam failure) shown on these figures should be used for dam safety events not caused by extreme high inflows (e.g. when the downstream areas are not already flooded from high outflows from Lake Victoria). Under Response Level 3 (and potentially Response Level 2) these areas are to be evacuated.

The **blue line** inundation scenario (flood-induced (rainy day) cascade failure) shown on these figures should be used for dam safety events when the Victoria Nile Cascade dams are all releasing high discharges (likely coincident with high Lake Victoria levels) and a cascade failure is anticipated or occurring. These potential inundation extents assume the Victoria Nile River downstream of the Bujagali Dam is already in flood prior to a potential dam break. Under Response Level 3 (and potentially Response Level 2) these areas are to be evacuated.

The indicative flood arrival times, time to peak water level (i.e. indicative available warning and evacuation times after dam failure starts), peak water level rise and indicative flood water extents from the modelled dam break scenarios are presented for key locations on the flood hazard plans. These are also summarised in Table F below for ease of reference. This information is intended to support evacuations of the potentially affected areas.

Table F Dam breach flood hazard – Warning times for select locations (refer Figures 1 to 5)

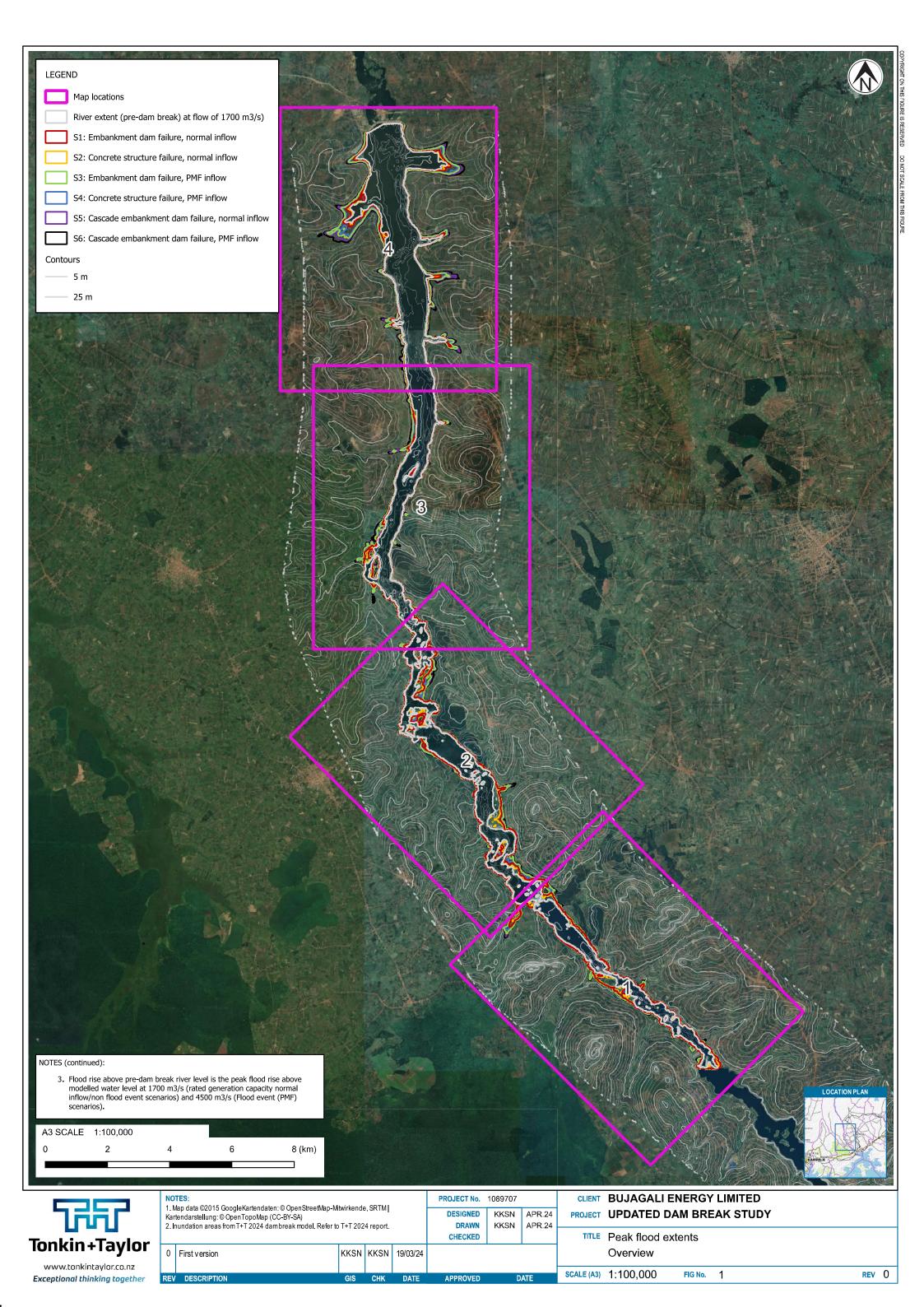
Location	Left Bank Nile Bend Resorts	Busowoko Falls	Right bank upstream of Bubogo	Wildwaters Lodge (Kalagala Falls)	Downstream of Itanda Falls	Left bank Nsiima	Isimba Reservoir
Distance downstream of Bujagali Dam (km)	3.5	8	11.5	15.7	17.5	22	34
Sunny day/normal i	nflows failure	of Bujagali D	am only (red lir	ne areas)			
Flood wave arrival time (hrs)	0.4	0.8	1.5	1.8	1.9	2.3	2.8
Time to peak water level (hrs)	1.6	2	2.5	2.7	3	3.5	4.5
Additional water depth (m)	8	6.5	5	2.5	4.3	2	0.8
High inflow with cas	cade failure	of Owen Falls	and Bujagali Da	ım (blue line area	ıs)		
Flood wave arrival time (hrs)	0.3	0.6	1	1.3	1.5	1.8	2.4
Time to peak water level (hrs)	1.5	1.8	2.1	2.3	2.5	3.1	4.3
Additional water depth (m)	11	10	8.5	4.2	8	5.5	3.4

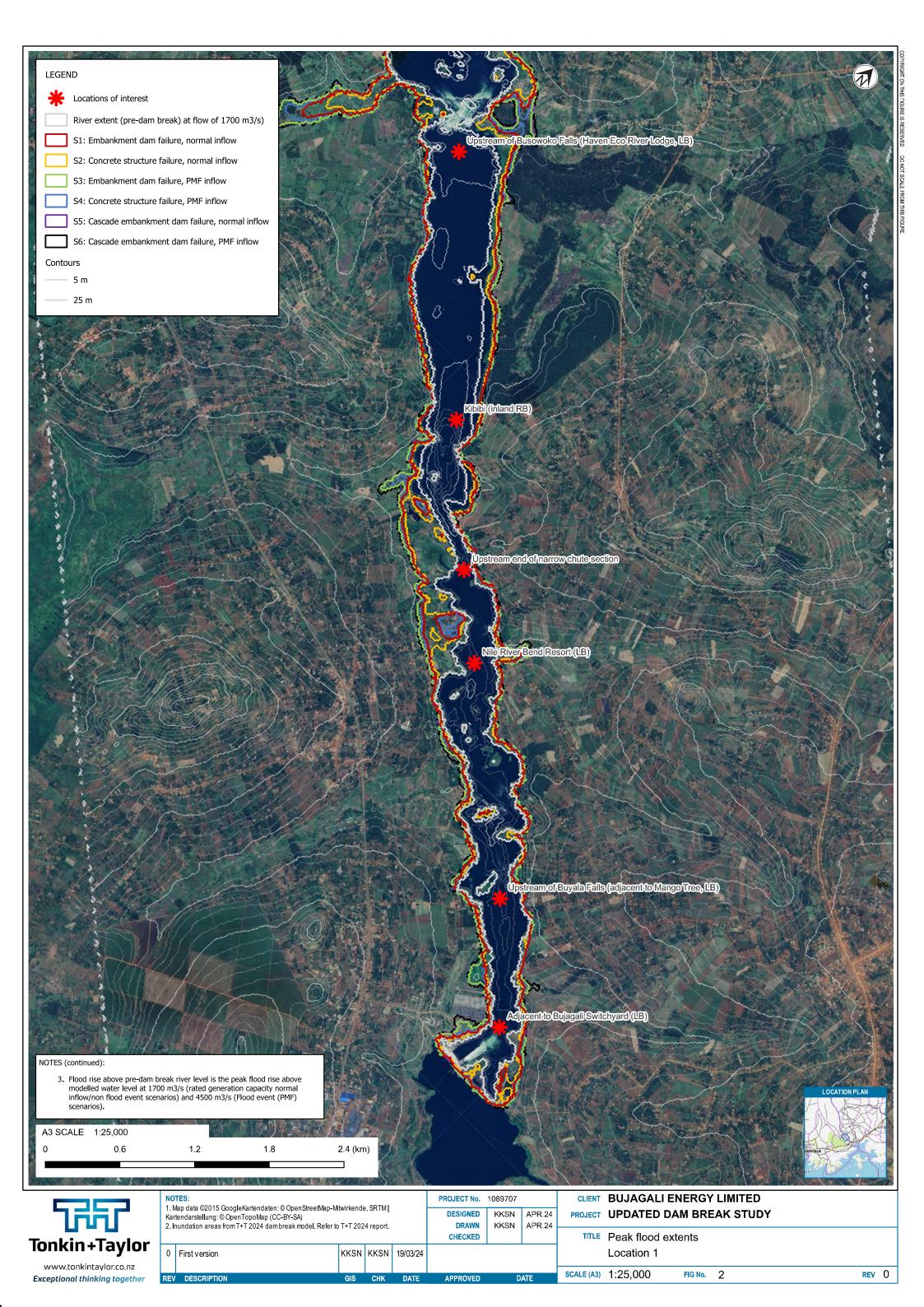
Potential Road Closures and Evacuations

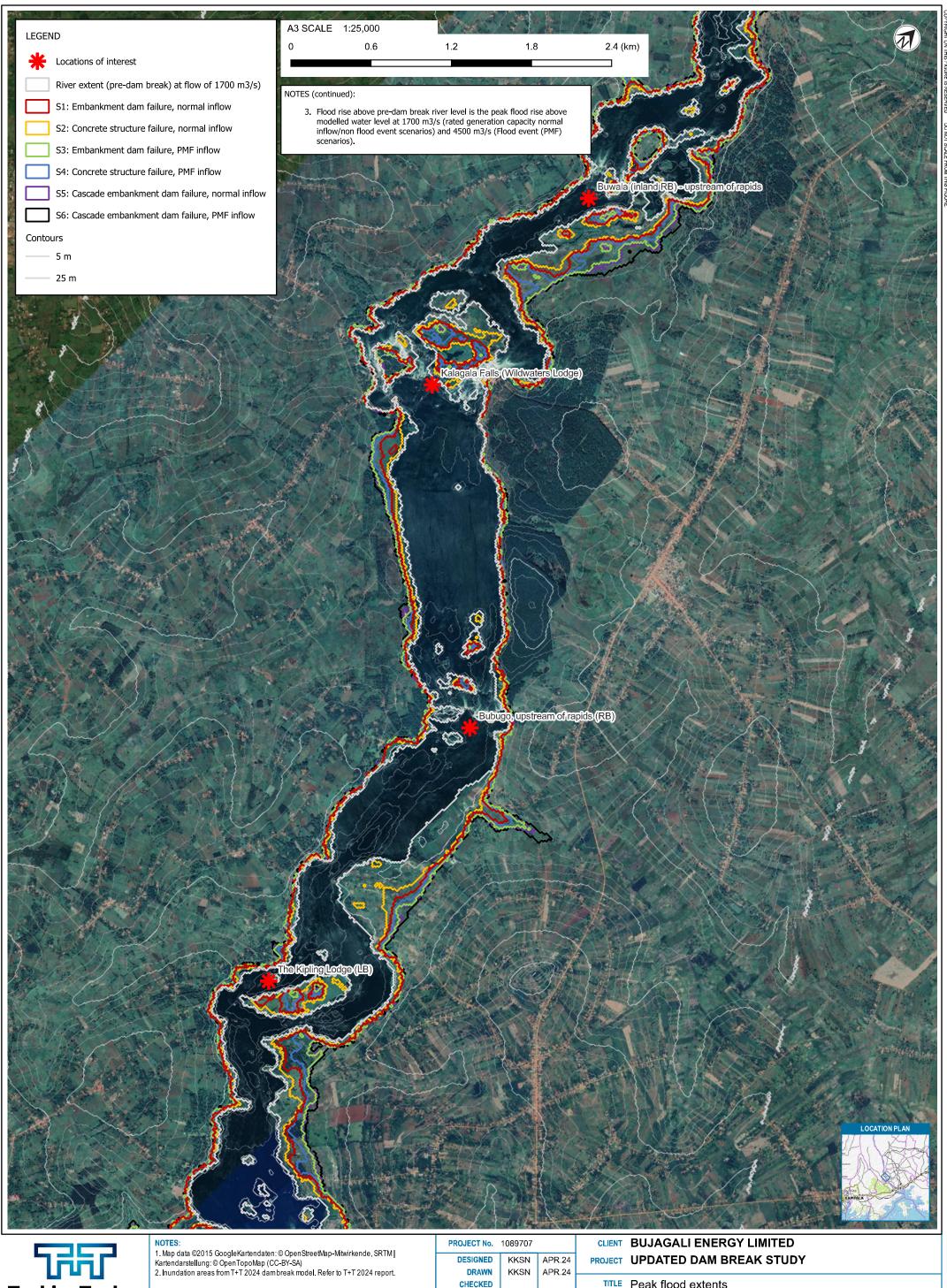
The Uganda Police Force (UPF) and the Uganda Peoples' Defence Forces (UPDF) both have the authority to close roads and order evacuations. The locations that require road cordons/closures and evacuations in the highly unlikely event of dam breach failure at the Bujagali HPP require assessment and confirmation to suit the specifics of each event. Key locations and considerations may include:

- The tailrace, gated spillway and siphon spillway outlet channels immediately downstream of the Bujagali Dam
- The Victoria Nile river corridor immediately downstream of the Bujagali Dam
- The resorts and dwellings near the river on the true left bank (including Nile Bend and Whispers of the Nile) ~ 3 to 4 km downstream of the Bujagali Dam as per Figure 2.
- Busowoko Falls (including adjacent resorts/lodges)
- Wildwaters Lodge (Kalagala Island beside Kalagala and Itanda Falls)

- Kalagala and Itanda Falls (including adjacent resorts/lodges)
- Isimba Dam reservoir and margin.

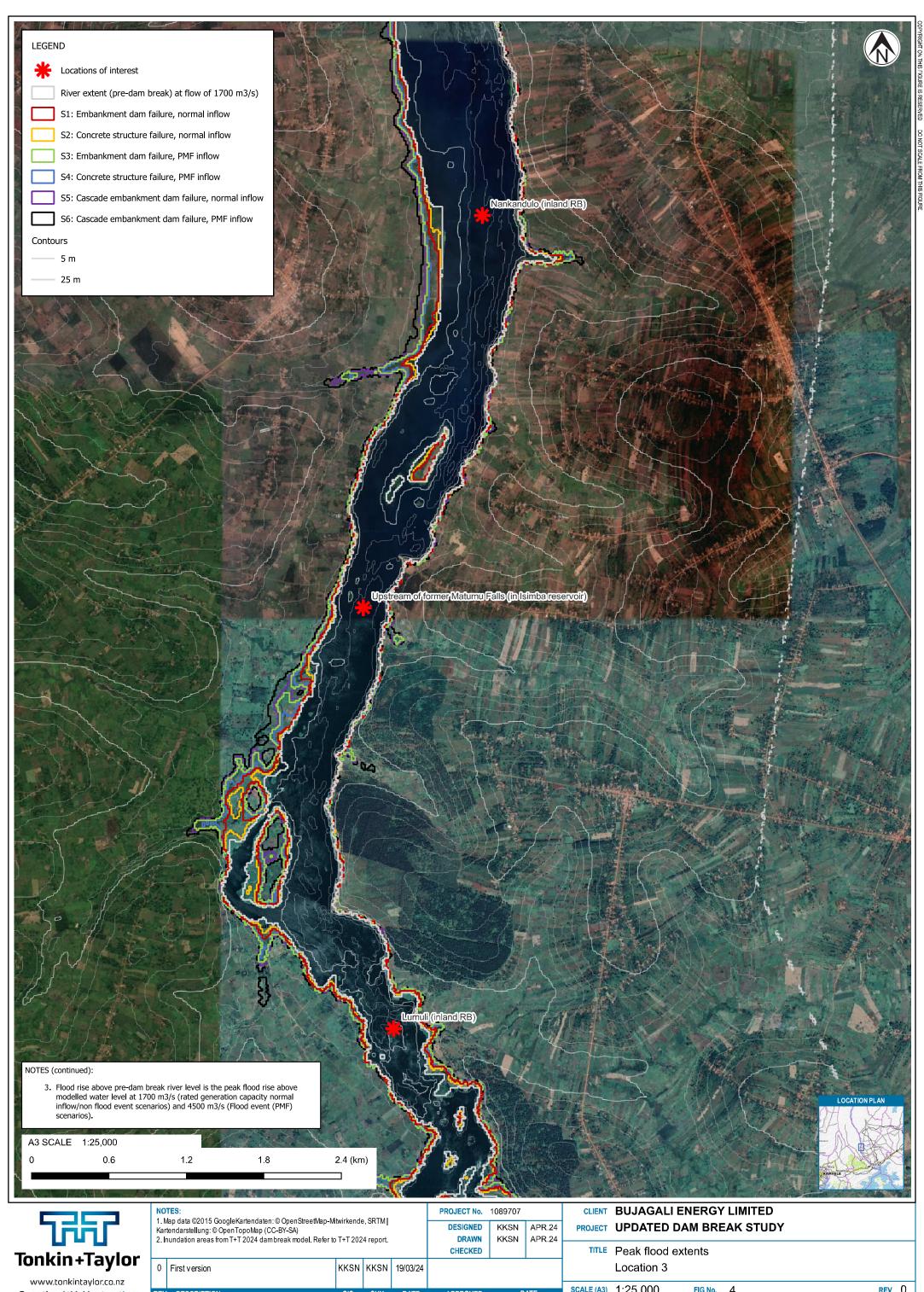






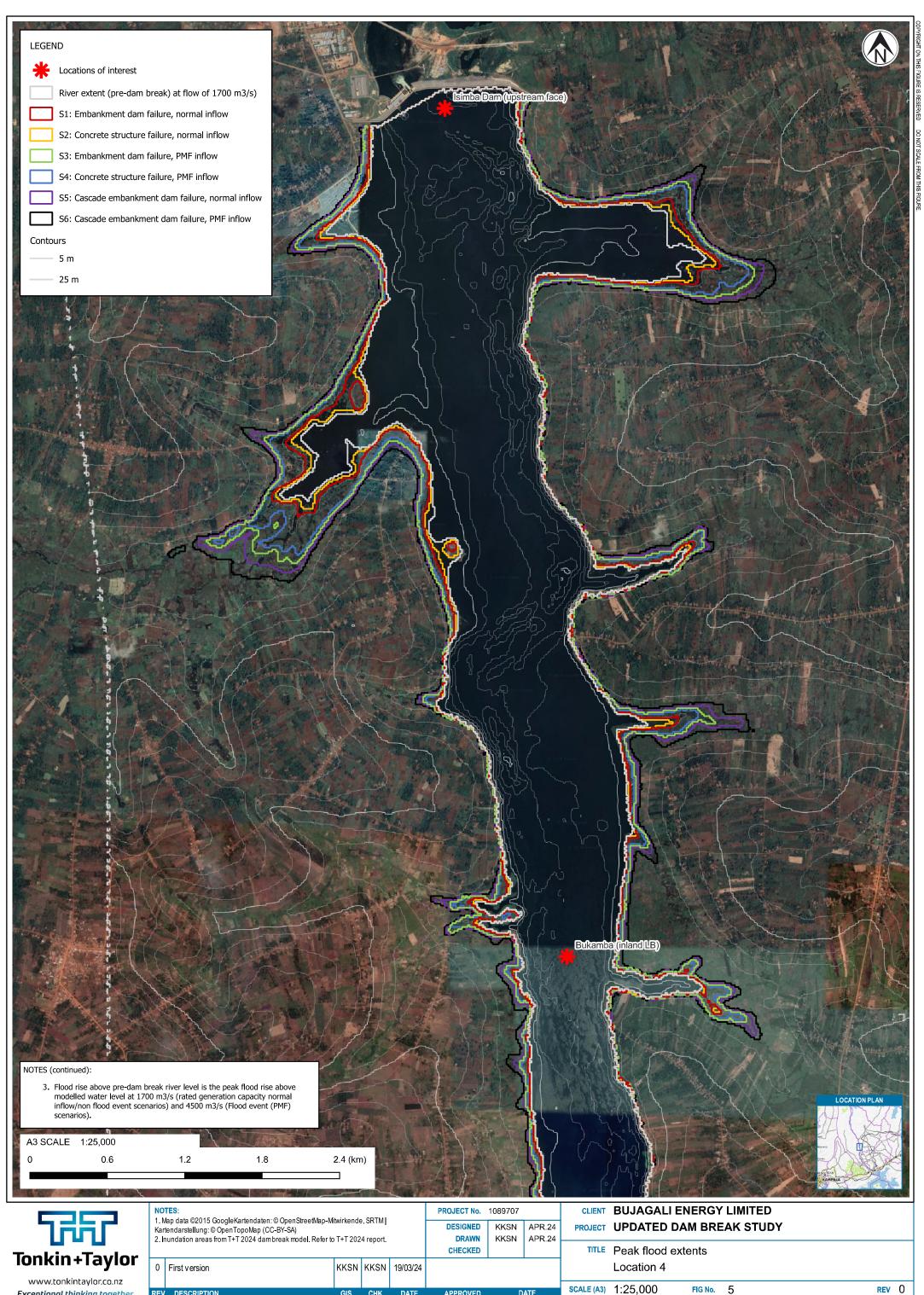
Tonkin+Taylor www.tonkintaylor.co.nz Exceptional thinking together

TITLE Peak flood extents CHECKED KKSN KKSN 19/03/24 Location 2 0 First version SCALE (A3) 1:25,000 REV 0 FIG No.





SCALE (A3) 1:25,000 REV 0 FIG No.



Exceptional thinking together

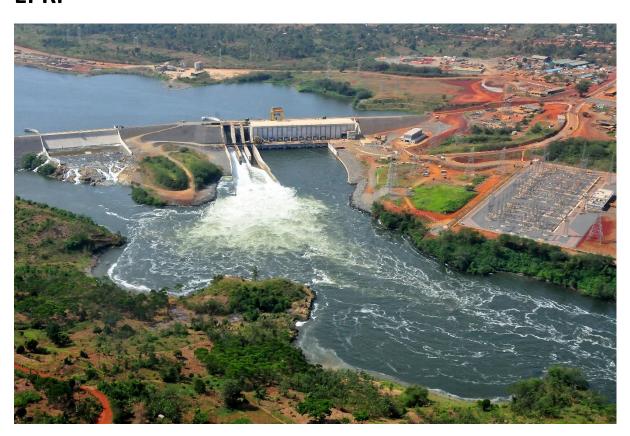




Bujagali Dam – Dam Break Emergency Preparedness and Response Plan

PART 2 OF 2

EPRP



Bujagali Dam from downstream (from BHPP Construction Report Appendix B)

Distribution

Organisation	Role	Controlled copy number		
Bujagali Energy Limited (BEL)	Dam Owner/Dam Operator – Power station Asset Manager	A.1 (Office copy)		
	Operator Lead (Control Room Copy)	A.2 (Office copy)		
	Dam Safety Specialist	A.3 (Electronic copy)		
UEGCL Isimba PS	Downstream dam owner/operator	B.1 (Electronic copy)		
UEGCL Kiira and Nalubaale PS (Owen Falls)	Upstream dam owner/operator	B.2 (Electronic copy)		
UETCL NCC	National Control Centre (NCC) generation coordination and instruction	C.1 (Office copy)		
Ministry of Relief, Disaster	Emergency preparedness and response –	D.1 (Office copy)		
Preparedness and Management (Office of the Prime Minister)	National level	D.2 (Office copy)		
Uganda Police Force (UPF)	Emergency response – DPC Buwenge	E.1 (Station copy)		
	Emergency response – DPC Buikwe	E.2 (Station copy)		
	Emergency response – DPC Kayunga	E.3 (Station copy)		
	Emergency response – DPC Kamuli	E.4 (Station copy)		
Uganda Peoples' Defence Forces (UPDF)	Emergency response – Jinja Cantonment	F.1 (Office copy)		
Chief Administrative Officer (CAO)	Emergency preparedness and response coordination – CAO Jinja	G.1 (Electronic copy)		
	Emergency preparedness and response coordination – CAO Kayunga	G.2 (Electronic copy)		
	Emergency preparedness and response coordination – CAO Buikwe	G.3 (Electronic copy)		
	Emergency preparedness and response coordination – CAO Kamuli	G.4 (Electronic copy)		
Hattingh Anderson Associates	Technical Adviser (Civil)	H.1 (Electronic copy)		
Terje Ellefsrod	Technical Adviser (E&M)	I.1 (Electronic copy)		

Document Control

Title: Bujaga	Title: Bujagali HEPP Dam break Emergency Preparedness and Response Plan							
Date	Version	Description	Pages	Prepared by:	Authorised			
				Organisation	Initials	by:		
May 2011	Version 1.0	Pre-commissioning EPRP	All	Tonkin & Taylor International Ltd	BGO/ DCL	RMD		
19 March 2024	Version 2.0 DRAFT 1	Full update in revised format to include as built and current operational arrangements, revised notification processes and parties, coordination with UEGCL Isimba HPP	All	Tonkin & Taylor International Ltd	DAF/ DCL	BGO		
29 October 2024	Version 2.0 Operative	Operative Version 2.0 with BEL inputs incorporated	All	Tonkin & Taylor International Ltd	DAF/ DCL	BGO		

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Introduction and overview

1 Introduction

1.1 Purpose of this Emergency Preparedness and Response Plan

This Emergency Preparedness and Response Plan (EPRP) provides an emergency response plan for implementation by Bujagali Energy Limited (BEL) for potential breach scenarios of the Bujagali Dam. The breach scenarios and associated flood hazard maps used in this EPRP should be treated as indicative examples to aid the emergency response, noting that an individual event may develop which differs from the example breach scenarios.

This section of the EPRP (Part 2) provides important details that are intended to support decision making as part of managing dam safety events. It is intended as background training information that decision makers are familiar with <u>prior</u> to an event. Part 1 of the EPRP (the Quick Reference Guide) is intended for use during events, with Part 2 used in a supporting capacity.

This plan does not cover dam spillway operation and is intended to supplement Bujagali Energy Limited (BEL) flood management procedures. Spillway operation procedures are documented in the latest version of the Technical Instruction Spillway Gates (refer to the BEL document register for current operative versions of operating procedures). This EPRP describes:

- The process for identification of potential dam threats that may require action and assessment of whether these require emergency response. Potential dam safety threats include significantly large inflows, high reservoir levels, high Lake Victoria water levels, deterioration of the dam and appurtenant structures, earthquakes, dam safety emergencies at Kiira or Nalubaale HPPs (Owen Falls), unintended operation/damage to spillway gates, and intentional damage scenarios such as sabotage, hijacking or terrorist actions.
- b Procedures for declaring a dam safety emergency (or Incident) and classifying which level of emergency response (Response Levels 1 to 3, i.e. Internal Event, Potential Emergency or Imminent Failure).
- c Procedures with specific actions during dam emergencies only, to avoid or otherwise reduce the potential for dam failure, and in the event of a dam failure to prevent and/or reduce the potential for loss of life and/or infrastructure, property, community and environmental damage within the area.
- d Communications protocols to provide timely warnings in a systematic way to the appropriate emergency management agency for their implementation.
 - In the case of an emergency affecting the integrity of a dam, procedures for initiating warning of endangered downstream populations are specified, consisting essentially of notification to the Uganda Police Force (followed by other emergency response parties) and UEGCL Isimba, Kiira and Nalubaale HPPs and UETCL NCC (to coordinate emergency response across the Victoria Nile cascade).

EPRPs are 'living' documents that require regular review and use. This EPRP is to be reviewed and updated by the Bujagali Energy Limited (BEL) regularly. At least annual review and regular updating of contact details (where necessary) and regular exercising/testing of the EPRP is strongly recommended consistent with international dam safety practice (e.g. as described by ICOLD Bulletin 154).

1.2 Overview of emergency preparation and response process

The following document outlines the process for preparing for and responding to potential and confirmed emergency events related to potential failure of the Bujagali Hydroelectric Power Plant Dam (also referred to as the Bujagali HPP or Bujagali Dam).

The process relies on dam surveillance and monitoring (as described in the surveillance procedures) to enable early identification of potential breach scenarios, assessment and where appropriate, activation and implementation of this Emergency Preparedness and Response Plan (EPRP) by Bujagali Energy Limited (BEL).

This surveillance includes awareness and coordination of flood forecasting prior to and during flood events, noting that flood flows into the Victoria Nile are associated with high Lake Victoria water levels, and the discharges from the Nalubaale and Kiira Hydropower HPPs (also referred to as Owen Falls in this document) which are upstream of the Bujagali Dam.

Once this EPRP has been activated, the process continues until the emergency event has passed and the emergency response is terminated/ended/ declared over by the relevant party (i.e. BEL and NECOC). Refer to the Quick Reference Guide at the front of this document for guidance on the decision-making process, and the roles and responsibilities of the various parties.

NOTE 1:

Should dam breach appear likely or in progress, this is an emergency situation (RESPONSE LEVEL 3 Imminent Failure). Call the Uganda Police Force (DPC's as per notification chart list) and request immediate evacuation of the Victoria Nile inundation zone downstream of the Bujagali Dam to Isimba Dam, then call UEGCL Isimba (Isimba Dam) to notify Imminent Failure, and activate this EPRP.

NOTE 2:

Bujagali Energy Limited (BEL) will respond to events and notify the relevant agencies as necessary based on the specifics of each event. In general terms this means:

- BEL assess potential threats and determine whether an emergency is occurring.
- Threats and events that only affect BEL are responded to by BEL only (Response Level 1 Internal Event scenarios).
- Emergencies that may/have the potential to affect external parties (e.g. the public, Isimba Dam) (Response Level 2 Potential Emergency scenarios) are initially responded to by BEL who should also notify the Uganda Police Force, Uganda Peoples' Defence Forces and UEGCL Isimba to provide early warning in case the situation escalates and requires external agency emergency response.
- Dam failure emergencies (Response Level 3 Imminent Failure scenarios) are to be immediately notified to
 the Uganda Police Force (to all four Division/District Police Commanders, DPCs), and the Uganda Peoples'
 Defence Forces (UPDF) (Jinja Cantonment), who will lead the initial emergency response with support
 from BEL and other agencies including UEGCL. The Uganda Police Forces typically lead the initial local
 emergency response (as first responders) until NECOC and the DECOC's are activated, after which they
 continue response under NECOC.
 - UEGCL Isimba will activate and follow their Isimba Dam EPRP in the event of an emergency situation at the Bujagali Dam.

1.3 Threat assessment and classification

The BEL Bujagali Power Station Asset Manager (or their delegate/alternate, and usually represented by the Operator Lead on-site) has the responsibility to assess and classify potential dam safety threats as they are communicated and based on the available information. A level of judgement is necessary when assessing potential threats and the classification matrix provided in the Quick Reference Guide is intended to guide and support decision making by the BEL Bujagali Power Station Asset Manager (usually represented by the Operator Lead).

Dam safety threats can be natural phenomena (e.g. flood, earthquakes) and/or result from the activity of people (or a combination of both). These may include:

- Deterioration of the dam, appurtenant structures, and critical valve and gate systems (including one or more of the embankment dams, concrete gravity block dam, foundations, flap gate and radial gate (service) spillway, siphon (auxiliary) spillway). This can be coincident with reservoir levels in the usual/normal or flood range.
- Significant inflows as released from Owen Falls (Kiira and/or Nalubaale HPPs) in either a controlled (scheduled or unexpected but deliberate operation, e.g. flood release to manage Lake Victoria water levels to Agreed Curve, noting this is a long duration event with substantial prior warning) or uncontrolled manner (e.g. inadvertent operation of spillway gates or powerplant generation flows, and dam safety emergency at the upstream Owen Falls dams, which typically would occur with little to no prior warning).
- High reservoir levels with significant inflows and/or high winds (e.g. significant inflows due to flow releases from upstream and/or coincident with gate malfunction/inoperability at Bujagali).
- Earthquakes (especially large earthquakes felt at the dam).
- Unintentional damage to the dam and/or appurtenant structures (e.g. power station and gates) due to misoperation of equipment (e.g. radial gate operation), accidents, fires, and/or medical emergency.
- Deliberate damage to the dam and/or appurtenant structures (e.g. power station and gates) due to sabotage, hijacking, coercion, terrorist activity, and/or war.

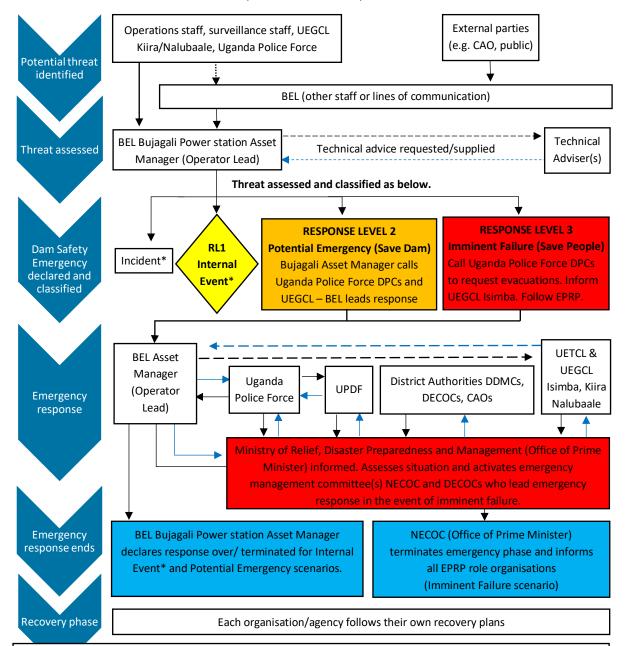
The following dam safety threat classifications are used in this EPRP along with response levels and descriptions for consistency with the UEGCL Isimba HPP EPRP (to aid coordination). The scenarios are colour coded in this document to aid identification.

Response Level 0	Incident (Not an emergency – follow surveillance and monitoring procedures)	
Response Level 1	Internal Event (Monitor)	
Response Level 2	Potential Emergency (Save Dam)	
Response Level 3 Emergency – Imminent Failure (Save People)		
Recovery Termination of event/event declared over – Post response actions (Recovery)		

Ongoing monitoring and assessment of potential safety threats is essential as the situation can rapidly change during an event and escalate from one type of emergency to another (for example a threat may be initially classified as an internal event and subsequently escalate to imminent failure). Threat classification is therefore made at a point in time based on the available information and must be reevaluated as the event progresses.

1.4 Communications process

Each organisation with a role in the EPRP should have their own internal communications plan that is specific to their organisation and reflects the requirements of this EPRP. The overview communications process is presented below and shows the communication flow at each step of an event as the event progresses (black lines show primary communication flows, blue lines show responses, dashed lines are secondary lines of communication). Detailed notification flow charts are included in the Quick Reference Guide (Part 1 of this EPRP).



Notes

*Incidents are not dam safety emergencies. Surveillance and operation procedures to be followed.

Potential Emergency scenarios are responded to by BEL who also notify the emergency responders (Uganda Police Force and Uganda People's Defence Forces (UPDF)) and the downstream dam operator (UEGCL Isimba HPP) to give advanced notice in case the situation escalates.

Imminent Failure scenarios are immediately notified to the Uganda Police Forces (by calling the DPCs) who initially lead the emergency response until the Ministry of Relief and Disaster Preparedness (Office of the Prime Minister) determines the appropriate organisation to continue the response.

^{*}Response Level 1 (RL1) Internal Event scenarios are responded to by BEL only.

1.5 Key contact list

The key contacts with roles in this EPRP are listed in Table C in the Quick Reference Guide (Part 1).

1.6 Emergency response area coverage

A high-level plan of the area covered by this EPRP is presented below in Figure 1.1. The area covered is from the Bujagali Dam down to the Isimba Dam (operated by UEGCL).

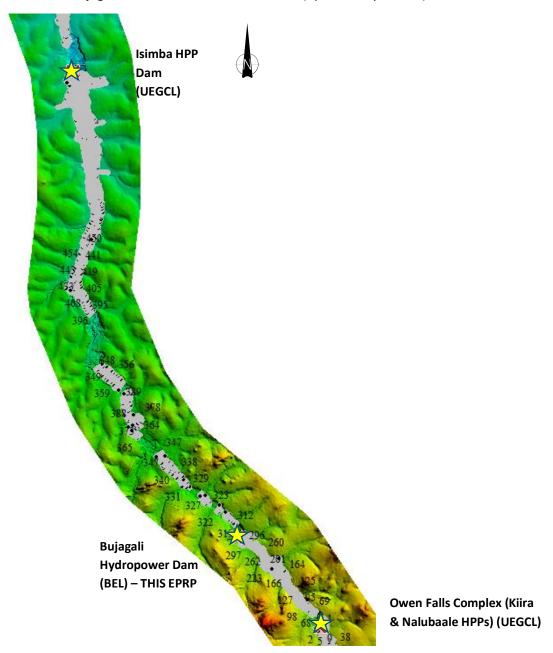


Figure 1.1 Emergency response area covered by this EPRP (Between Bujagali and Isimba Dams).

Flood hazard plans for each of the assessed potential breach scenarios (non-flood and flood-induced dam breach scenarios included cascade failures) are included in the Quick Reference Guide. These flood hazard plans should be treated as indicative to help inform the response, noting they are based on a set of assumed conditions and the specifics of an actual dam breach event may be different.

1.7 Integration with the emergency response agencies

In the event that a dam safety emergency has the potential to affect external parties (i.e. Response Level 2 Potential Emergency and Response Level 3 Imminent Failure scenarios), Bujagali Energy Limited (BEL) will notify the Uganda Police Force, UEGCL Isimba, Kiira and Nalubaale HPPs (other dam owner/operators for the cascade) and the Ministry of Relief, Disaster Preparedness and Management (Office of the Prime Minister).

The Ministry of Relief, Disaster Preparedness and Management (Office of the Prime Minister) may declare a District or National level emergency and take over leading the emergency response, with support from the other agencies including BEL. This is considered likely for Response Level 3 Imminent Failure scenarios where there is sufficient time to mobilise, and noting that in advance of the Ministry taking over, the emergency response will be led by the Uganda Police (with support from the UPDF) until such time that the emergency coordination and operation centre(s) (NECOC and/or DECOC) are able to take over coordination and management of the response.

It is important that implementation of this EPRP by all agencies in an emergency event is integrated within the National Policy For Disaster Preparedness And Management (2011) framework for Uganda. This policy outlines roles and responsibilities, and communication pathways for each government entity.

In summary, this policy may mean the following with regard to an emergency response to a potential breach of the Bujagali Hydropower Dam (e.g. Response Level 3 Imminent Failure scenario):

- First responders at the dam site are highly likely to be Bujagali Energy Limited (BEL) staff. BEL will retain management of the dam site response and has a primary role to inform and coordinate with emergency responders (noting the first parties for notification are the Uganda Police DPCs, followed by UEGCL Isimba, Kiira and Nalubaale HPPs), and implement measures at the dam to prevent dam failure or reduce the potential impacts of dam failure.
- In the event that evacuations are necessary (i.e. Response Level 3) the Uganda Police Force will be mobilised first (upon notification by BEL to the relevant Regional/Divisional Police Commanders, DPCs), followed by the UPDF (who will support the Police).
- The BEL Asset Manager will notify the Ministry of Relief, Disaster Preparedness and Management (Office of Prime Minister) who will likely activate the National Emergency Coordination and Operations Centre (NECOC).
- While the initial response and downstream evacuations are underway (led by the Uganda Police Force), inter-agency communications will be ongoing and it is likely that multiple notifications will be received by the Ministry of Relief, Disaster Preparedness and Management (Office of Prime Minister). The Uganda Police Force DPCs and UPDF will also be following their internal communication processes to notify their chain of command.
- Once the NECOC is activated, it will take over coordination of the emergency response, including evacuation and cordons for the potential inundation zone by the Uganda Police Force and UPDF (via the appropriate command chains).
- The NECOC is headed by a National Incident Commander (NIC) who reports to the Commissioner for Relief, Disaster Preparedness and Management. The NECOC will have seconded officers from the Uganda Police Force and UPDF to coordinate with these two forces.

- District Emergency Coordination and Operations Centres (DECOCs) will be activated by the NECOC which will be directly linked to each DECOC. For the Bujagali dam break inundation area, there are four relevant districts (and therefore DECOCs): Buikwe and Kayunga (western bank), and Jinja and Kamuli (eastern bank). (While Jinja is upstream of the Bujagali Dam, the district includes Buwenge subcounty which is immediately downstream of the dam).
- 8 Each DECOC is headed by the Regional/Divisional Police Commander (DPC) and operates from the district police station with a representative from the UPDF. This means the DPCs will already have been informed as part of the first notification, and are likely to have already commenced evacuations.
- There is additional complexity in that the districts do not completely align with the police divisions on the eastern side (Kiira Region), such that the relevant DPCs here (also referred to Divisional Police Commanders) are DPC Buwenge (Kiira North) Division (Jinja District), DPC Jinja (Kiira Central) Division (Jinja District) and DPC Kamuli (Kamuli District).
- The DECOCs are permanently functioning 24 hour centres. The DECOCs report back to the NECOC and the Chief Administrative Officers (CAOs) in the event of an emergency. The CAO for each district chairs the District Disaster Management Committee (DDMC) which oversees and supports the DECOC, and informs and coordinates with sub-county and village disaster committees.

The National Policy For Disaster Preparedness And Management (2011) should be referred for further details of this framework.

1.8 Relationship to other documents

Effective response to potential dam safety emergencies at the Bujagali Dam requires timely and effective coordination with the hydropower schemes located upstream (Kiira and Nalubaale HPPs) and downstream (Isimba HPP). These hydropower power plants are owned and operated by UEGCL. UEGCL have internal operations, surveillance and maintenance procedures and emergency preparedness and response procedures for each of these hydropower schemes.

Operation of the hydropower schemes on the Victoria Nile cascade is interlinked, with regulated flow release from Kiira and Nalubaale HPPs into the river broadly set in accordance with the Agreed Curve as overseen by the Directorate of Water Resources Management (DWRM). There is a regular and interlinked communication between the cascade schemes, including management level coordination meetings, automated sensor and alarm instrumentation (with programmed responses, e.g. the Kiira tailwater sensor high level alarm can trigger automatic opening the Bujagali Dam radial gates), and phone communications between the Asset/Generation Managers (and the Senior Shift Operators/Operator Lead). A coordinated response to dam safety emergencies at any of the dams on the Victoria Nile cascade is expected and necessary.

A defined demarcation is provided in this EPRP for the areas of responsibility covered by each of the cascade schemes. This is essential given the potential for overlapping responsibilities, and to avoid an uncoordinated emergency response with multiple or no notifications to the same agencies and potential confusion on the exact responsibilities of each party.

The geographical areas of responsibility for each of the cascade schemes are:

- The reach of the Victoria Nile from Owen Falls (Kiira and Nalubaale HPPs) to the Bujagali Dam reservoir is covered by the Owen Falls Emergency Preparedness Plan (including future updates to this document).
- This Bujagali Dam EPRP covers dam safety emergencies at the Bujagali Dam only, and the downstream area of responsibility is from the Bujagali Dam reservoir to the Isimba Dam reservoir only.
- The reach of the Victoria Nile from Isimba Dam reservoir (Isimba HPP) to Lake Kyoga is covered
 by the Isimba Emergency Preparedness and Response Plan (including future updates to this
 document).

This demarcation of responsibilities enables each scheme to follow their own emergency response procedures and take ownership of these, while maintaining the essential coordination between the schemes.

An example of how this is intended to work, is where a dam safety emergency is identified at Kiira or Nalubaale Dams. In this case, UEGCL would notify BEL, and each organisation would implement their own EPRP procedures. Should the emergency progress to Response Level 3 Imminent Failure, UEGCL would notify the emergency responders for the area downstream of Owen Falls to the Bujagali Dam reservoir, BEL would notify the emergency responders for the area downstream of Bujagali Dam to Isimba Dam reservoir, and UEGCL Isimba would notify the emergency responders for the area downstream of Isimba Dam to Lake Kyoga.

Regular coordination between the scheme operators and the Uganda Police Force and Office of the Prime Minister will be essential for any emergency response regardless of the demarcation in areas. BEL staff and other personnel with a role in the emergency preparedness and response for the Bujagali Dam should also maintain familiarity with the UEGCL procedures and EPRPs to aid coordination in an event. Joint emergency response exercises that involve relevant personnel from each of the schemes in the cascade will facilitate this.

The dam safety management document register provides the latest version of all operative documents including the UEGCL EPRPs for Owen Falls and Isimba HPPs for reference.

BEL has a separate EPRP to cover emergencies that are confined to the Bujagali HPP complex itself such as fires, hazardous materials incidents, bomb threats, vehicle accidents, and severe weather (BEL, SP-0001). This dam break EPRP relates to actual or potential dam break incidents, where the majority of impacts will likely be off-site, and thus will require assistance from external parties such as government, local administrations or aid agencies. While some of the material in this EPRP and BEL (SP-0001) is common, they are not identical, and thus each should be read in conjunction with each other.

1.9 Site context and scheme description summary

The Bujagali HPP (including the Bujagali Hydropower Dam) is a 250 MW hydroelectric power scheme located on the Victoria Nile River approximately 11 km downstream of the Source of the Nile on Lake Victoria. Construction of the Bujagali HPP scheme began in 2007 and the scheme was commissioned in 2011/2012.

It is the second power station complex on the river, located ~8 km downstream of the Owen Falls complex that consists of the Nalubaale and Kiira hydropower stations (Nalubaale and Kiira HPPs). The Isimba HPP is located ~35 km downstream of the Bujagali HEPP and was constructed between 2015 and 2019 (commissioning). These three hydropower schemes/complexes are referred to in this EPRP as the Victoria Nile Cascade.

Flows in the Victoria Nile (and therefore inflows into the Bujagali Dam reservoir) are regulated at the Owen Falls schemes. Effective coordination between the cascade schemes is essential for safe dam operation and emergency preparedness and response. Figure 1.2 below shows the location of the Owen Falls, Bujagali and Isimba HPP schemes.

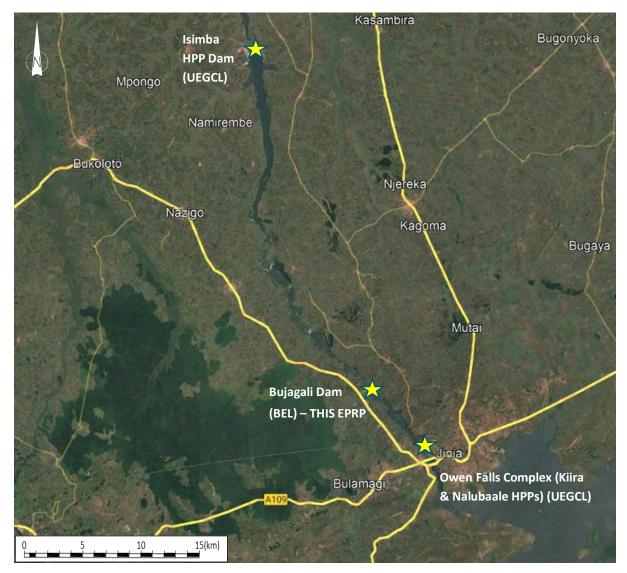


Figure 1.2 Victoria Nile River with the locations of the cascade schemes indicated (image sourced from Google Earth).

Layout figures and a summary description of the Bujagali Hydropower Dam along with example photos are provided below to assist with familiarisation by users of this EPRP (Figures 1.3, 1.4 and Table 1.1).



Figure 1.3 General arrangement/layout of the Bujagali Hydropower Dam (aerial sourced from Google Earth)

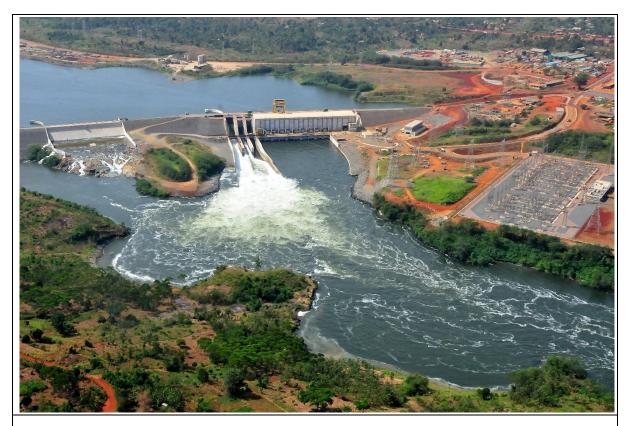


Figure 1.4 Annotated aerial photo of the Bujagali Hydropower Dam

Table 1.1 Bujagali Hydropower Dam description

Parameter	Value/Description		
General			
Dam type(s)	Composite (concrete gravity block, earthcore rockfill embankments)		
Construction date	2007 to 2012		
Potential Consequence Classification (PCC) / Impact Classification (PIC)	High PIC (as per NZSOLD New Zealand Dam Safety Guidelines) adopted for the purposes of this EPRP. Assumed to be High or Very High PCC using ENTRO Reference Dam Safety Guidelines for Eastern Nile Countries (2014).		
Design dam crest level	1114.5 m RL		
Total crest length	870 m (total)		
Embankment dams (left, central	and right)		
Dam type	Zoned earthcore rockfill dam (ECRD)		
Dam height	29.5 m (left), 34.5 m (central), 32.5 m (right) (crest to downstream toe)		
Crest width	10 m		
Crest length	136 m (left), 145 m (central), 332 m (right)		
Upstream slope	1V:1.6H		
Downstream slope	1V:1.6H		
Concrete gravity dam (power sta	tion)		
Dam height	34.5 m (crest to downstream toe)		
Crest width	9 m		
Crest length	45 m (dam section only, excluding power station intake block)		
Upstream slope	Vertical		
Downstream slope	1V:0.48H		
Spillways			
Spillway (s) description	 Gated (service spillway) comprising of 1 No. flap gate (6.2 m high and 12 m long) and 2 No. radial gates (low level outlet, opening to 10.5 m high and 9.5 m wide each) with total rated capacity at MFL of 3300 m³/s (~350 m³/s flap gate, 1465 m³/s per radial gate). Siphon (auxiliary spillway) comprising 16 No. bays (each 5 m wide by 2.1 m tall opening) with total rated capacity at MFL of 1200 m³/s. Total spillway capacity at MFL 4500 m³/s. 		
Inflow design flood (IDF)	4500 m ³ /s (described as the PMF)		
Full supply level (FSL)	1111.5 m RL		
Maximum Flood Level (MFL)	1112.0 m RL		
Design freeboard (m)	From FSL: 1.0 m to top of core, 3.0 m to dam crest From MFL: 0.5 m to top of core, 2.5 m to dam crest		
Power station			
Туре	115 m long concrete powerhouse structure with integral intakes (5 No.)		
Turbines	5 No. double regulated Kaplan turbines combined discharge capacity at FSL of 1375 m³/s (275 m³/s per unit)		
Minimum operating level (MOL)	1109.5 m RL (for normal turbine operation)		
Maximum tailwater levels	1089.6 m RL (at full generation outflow, 1375 m 3 /s), 1094.1 m RL (4500 m 3 /s discharge, PMF)		

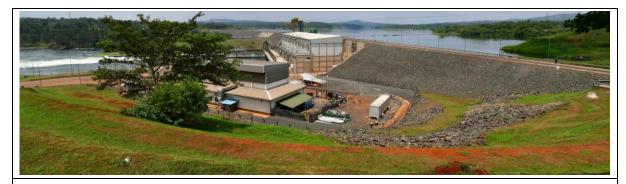
Example condition photos (From BHPP Construction report and August 2023 EPRP site visit)



Oblique aerial photo of scheme from downstream (looking upstream from left to right, siphon spillway, gated spillway (flap gate and one radial gate in operation), power station/gravity dam and left embankment dam.



Upstream face (power station inlet)



Left embankment dam downstream face (from BEL Office)



Central embankment dam downstream face



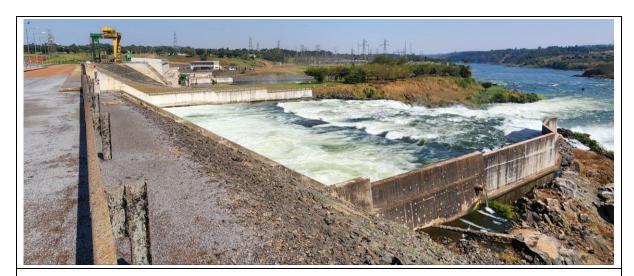
Right embankment dam downstream face



Gated spillway (outlet channel, two radial gate bays (left and central bays), and flap gate on right)



Gated spillway (flap gate)



Siphon spillway outlet channel (looking to left bank and downstream)



Power station tailbay/tailrace

1.10 Owen Falls Complex (Nalubaale and Kiira HPPs)

To aid event coordination between the cascade scheme operators, and for the purposes of this EPRP, an overview of the Owen Fall Complex is provided below. Figure 1.5 shows the general layout of the Kiira and Nalubaale HPPs.



Figure 1.5 General layout of the Owen Falls Complex (Nalubaale and Kiira HPPs)

Nalubaale HPP is a concrete gravity dam with sluiceways (6 No. and an inline power station (10 No. 18 MW turbines, total capacity of $1200 \, \text{m}^3/\text{s}$). Kiira HPP features a headrace canal with earthcore rockfill dams, an inline power station (5 No. 40 MW turbines) ($1100 \, \text{m}^3/\text{s}$ capacity) and spillway gates (3 No. radial gates). The combined generation discharge is $2300 \, \text{m}^3/\text{s}$, and the combined spillway discharge is $2940 \, \text{m}^3/\text{s}$, from the Owen Falls complex. The design IDF for Bujagali Dam is $4500 \, \text{m}^3/\text{s}$, which is a flow that can only be realised if both spillways are discharging at the same time as both power stations at maximum generation.

1.11 Bujagali Dam Drawings

Select as-built drawings are included below to aid interpretation of this EPRP.

Roles and responsibilities

2 EPRP roles and responsibilities

2.1 Organisational responsibilities

The organisational responsibilities outlined in this EPRP are summarised below.

Organisational responsibilities

Organisation	Organisation responsibilities	
Dam owner and operato	or	
Dam owner and operator - Bujagali Energy Limited (BEL)	 Overall management of the dam. Maintain a 24/7 call service for notification. Maintain, operate and test the EPRP. Provide suitably trained, empowered, and authorised staff to implement the EPRP. Identification, ongoing monitoring, and assessment of dam safety threats. Seek technical advice from relevant Technical Adviser(s) where necessary. Declaration and classification of dam safety emergencies (as Internal Event, Potential Emergency, or Imminent Failure). Lead the response of Internal Events (where potential breach is not assessed as likely). Notification to emergency responders where dam breach is assessed as possible or likely (Potential Emergency and Imminent Failure Scenarios, which are safety emergencies that may affect external parties). In the event that dam breach is occurring or appears imminent, call the Uganda Police Force (refer communications procedure and contact list) and request immediate assistance and evacuation downstream of Bujagali Dam. Then call UEGCL Isimba HPP Generation Manager. Then call Nile Bend, Whispers of the Nile, and Wildwaters Lodge Resorts to notify voluntary evacuation. Lead the initial coordination and communications between the relevant emergency services and other involved organisations. Lead the implementing of preventative and emergency actions at the dams (noting evacuations are the responsibility of the emergency services where a National Emergency is declared by NECOC, including provision of advice on evacuation areas. Terminating, notifying and documenting a dam safety emergency (unless an emergency is declared by Office of the Prime Minister, in which case NECOC will determine when the emergency event is terminated). 	

Organisation	Organisation responsibilities
Other dam owners/ope	rators, grid operator of the Victoria Nile Cascade
UEGCL (Isimba, Kiira and Nalubaale HPPs)	Identify potential dam safety threats (e.g. high flow releases) and notifying BEL.
	Coordinate with BEL, Uganda Police Force, UPDF, NECOC and DECOCs.
	Support the emergency response as directed by NECOC.
	Review and provide feedback to BEL on this EPRP.
	Participate in EPRP test exercises, where requested by BEL.
UETCL (Uganda Electricity	UETCL NCC may identify potential dam safety threats (e.g. high flow releases) and notify BEL.
Transmission Company	Issues instructions to increase/decrease generation.
Limited) National Control Centre (NCC)	Coordinate with generators to facilitate emergency response interventions that include increasing generation outflows at Bujagali and/or emergency generation shutdown at Owen Falls.
	Review and provide feedback to BEL on this EPRP.
	Participate in EPRP test exercises, where requested by BEL.
Emergency responders	
Uganda Police Force	Notify BEL if received calls from the public raising potential dam safety threats.
	 Uganda Police Force will likely be the first responder for coordinating mandatory evacuations and cordons downstream of the dam. Lead DECOCs (DPCs) and providing police officers for emergency response. Notify and request assistance from UPDF in the event of an emergency. Review and provide feedback to BEL on this EPRP.
	Participate in EPRP test exercises, where requested by BEL.
Uganda Peoples' Defence Forces (UPDF)	 May also receive calls from the public raising potential dam safety threats, and should notify Uganda Police Force, BEL and UEGCL.
	 Coordinate with BEL, and the other emergency response services (including seconded staff to NECOC and DECOCs).
	 Assist the Uganda Police Force with timely evacuation of people from potential inundation areas downstream of the dam, and cordons to prevent access to the evacuated areas.
	Implement emergency response and recovery activities as directed.
	Review and provide feedback to BEL on this EPRP.
	Participate in EPRP test exercises, where requested by BEL.
Minister of Relief, Disaster Preparedness and Management (Office of the Prime Minister)	 Declaration of a national emergency and mobilisation of any necessary resources. Activate the NECOC to lead the emergency response. Review and provide feedback to BEL on this EPRP.
National Emergency Coordination and Operations Centre (NECOC)	 Specific responsibilities as per National Policy For Disaster Preparedness and Management 2011 Coordinates the DECOC district level responses and overall national response to emergency event and post event recovery.

Organisation	Organisation responsibilities	
District Disaster Management Committee (DDMC)	 Chaired by Chief Administrative Officer (CAO) Responsible for supporting the Uganda Police DPC to maintain a permanently functioning 24 hr DECOC ready to respond to local emergency events. Specific responsibilities as per National Policy For Disaster Preparedness and Management 2011 	
District Emergency Coordination and Operations Centres (DECOCs)	 Specific responsibilities as per National Policy For Disaster Preparedness and Management 2011. Leads district level response to emergency event and post event recovery. 	
Technical Advisers		
Technical Adviser	The responsibilities of the Technical Adviser(s) shall be by agreement with the Dam Owner (with a pre-agreed service agreement), and for this dam this may include supply of technical advice to support assessment and classification of potential dam safety threats.	
	Where required by BEL continue to provide technical advice to support the emergency response.	
	Review and provide feedback to BEL on this EPRP as relates to specific technical expertise.	
	Participate in EPRP test exercises, where requested by BEL.	

2.2 Summary of roles during an emergency

The specific emergency response roles within each organisation are summarised below. It is important that the decision makers within each organisation are identified and understand the specific requirements of their role under this EPRP and the role of others. For example:

- If operations and/or dam surveillance staff identify a dam safety issue on site (which is typically
 how these events would be identified) they need to be clear on their delegated authority and
 what decisions must be made by the BEL Power station Plant Asset Manager (via the Operator
 Lead).
- When the Operator Lead is made aware of a potential dam safety threat or issue, they need to take prompt and appropriate actions including notifying the BEL Engineering Services Manager/Maintenance delivery Manager, and where appropriate, activation of this EPRP and notification to the relevant parties.

This EPRP does not provide internal communication plans for each organisation, as each organisation will have their own internal processes to be followed during implementation of the EPRP.

An important consideration for an effective response to dam safety emergencies is a clear understanding of who can/must make what decisions and when. Consistent with ICOLD Bulletin 154 Dam Safety Management, it is recommended that the responsible on-site manager for the operation's technical personnel (i.e. the BEL Operator Lead) is vested with sufficient authority to order/undertake emergency preventative and response measures without first requiring additional authorisation from BEL management. The Operator Lead has an important role with regard to dam safety for the Bujagali Dam and should be thoroughly familiar and trained in the use of this EPRP.

Further role specific details are provided in the subsections below.

Summary of emergency response roles

Organisation	Role	Responsibility	Comments	
NOTE: Should dam bread processes in this EPRP	ch appear likely or in progre	ess, this is an emergency situation. Call the Uganda Police Force and request immediate evacuations and assista	nce and follow the	
Bujagali Energy Limited (BEL)	24-hour contact call centre	 Receive potential dam safety threat notification and observations from the public. Notify BEL Bujagali Power station Plant Asset Manager (via Operator Lead). Implement BEL Communications Plan. Call Uganda Police, UPDF, and UEGCL in the event of an emergency. 	24/7 contact line including after hours	
	BEL Operations Delivery Manager	Provide inflow forecasting and water level monitoring information and advise Bujagali Power station Asset Manager of flooding-related potential safety threats.		
	Bujagali Power station Asset Manager/ Operator Lead (Control Room)	 Safety threat identification and assessment. Declaration of dam safety emergency. Calls Uganda Police Force in the event of an emergency. Leads BEL emergency response inputs including dam safety decisions and directing emergency works. 		
	Dam surveillance engineer	 Dam safety threat identification. Notify BEL Engineering Services Manager/ Maintenance Delivery Manager. 		
UEGCL Isimba	Generation Manager	Coordinates with BEL Bujagali Power station Asset Manager in the event of EPRP activation.		
	Operations Manager	Coordinates with BEL Bujagali Power station Asset Manager in the event of EPRP activation.	UEGCL personnel	
	Shift Charge Engineer	Notify BEL Bujagali Power station Plant Asset Manager (via Operator Lead) of dam safety threats.	will be following	
UEGCL Kiira and	Generation Manager	Coordinates with BEL Bujagali Power station Asset Manager in the event of EPRP activation.	UEGCL EPRP	
Nalubaale	Operations Manager	Provide inflow forecasting and river/lake level monitoring information and advise BEL Bujagali Power station Plant Asset Manager of flooding-related potential safety threats.	procedures for each facility	
	Shift Charge Engineer	Notify BEL Bujagali Power station Plant Asset Manager (via Operator Lead) of dam safety threats		
UETCL NCC	NCC Shift Manager	 Notify BEL Bujagali Power station Plant Asset Manager (via Operator Lead) of dam safety threats. Coordinate generation during emergency response. 		
Uganda Police Force	Regional Police Commander (RPC) - Central	 Receive notification from DPCs. Coordinate regional wide police response. Mobilise Marine Police to aid evacuations. 	Specific roles and persons as per	

Organisation	Role	Responsibility	Comments
		Likely first responder (noting Bujagali Dam is within division area, but there is only a small area downstream before Kayunga District & Division)	Uganda Police Force procedures
	DPC Njeru	Lead evacuations where required.	
		Coordinate with NECOC.	
		Lead DECOC – Buikwe.	
		Likely first responder.	
	DDC Kayunga	Lead evacuations where required.	
	DPC Kayunga	Coordinate with NECOC.	
		Lead DECOC – Kayunga.	
	Regional Police	Receive notification from DPCs.	
	Commander (RPC) -	Coordinate regional wide police response.	
	Eastern	Mobilise Marine Police to aid evacuations.	
		Likely first responder.	
	DPC Buwenge (Kiira	Lead evacuations where required.	
	North)	Coordinate with NECOC.	
		Lead DECOC – Buwenge/Kiira North.	
	- 1 - 1 - 11 - 11	Likely first responder.	
	Budondo Police Station – OC Stn	Set up road cordons.	
	oc sai	Lead evacuations where required.	
	DPC Jinja (Kiira Central)	Support DPC Buwenge.	
		Lead evacuations where required.	
	DPC Kamuli	Coordinate with NECOC.	
		Lead DECOC – Kamuli.	
Uganda Peoples' Defence Forces (UPDF)	Jinja Cantonment	Support evacuations.	Specific roles and
			persons as per UPDF procedures.
Ministry of Relief, Disaster Preparedness	Commissioner, Disaster Management	Oversees the national level emergency response and NECOC.	Specific roles and responsibilities as

Organisation	Role	Responsibility	Comments
and Management (Office of Prime Minister)	Assistant Commissioner, Disaster Management	Supports Commissioner.	per National Policy For Disaster Preparedness and
National Emergency Coordination and Operations Centre (NECOC)	National Incident Commander (NIC)	 Reports to the Commissioner for Relief, Disaster Preparedness and Management (Disaster Management) Coordinates the emergency response institutions (e.g. Uganda Police Force, UPDF Emergency Support Units, DECOCs, etc) 	Management 2011
	Principal Disaster Management Officer(s)	Supports NIC.	
District Disaster	CAO Jinja	Chair the DDMC for district.	
Management Committees (DDMCs)	CAO Buikwe	Coordinate and implement disaster preparedness and management interventions, and disaster related activities in the district. Act as District Disaster Relief Coordinator upon declaration of a state of National Disaster. Facilitate the DPC in maintaining a permanent functioning DECOC.	
	CAO Kayunga		
	CAO Kamuli		
District Emergency Coordination and Operations Centres (DECOCs)	Lead by DPCs	 DPC responsibilities. Reporting to NECOC and the District CAO. Assign four police officers to manage the DECOC on a 24-hour rotation basis during non-emergency/normal times. 	
Hattingh Anderson Associates	Technical Adviser (Civil)	Assists BEL with identification and assessment of dam safety threats and technical advice to support emergency response.	
Terje Ellefsrod	Technical Advisor (Mechanical & Electrical)	Assists BEL with identification and assessment of dam safety threats and technical advice to support emergency response.	

2.3 General Responsibilities

2.3.1 BEL responsibilities for notification and coordination

The Bujagali Power station Plant Asset Manager (who may be represented by the Operator Lead) is responsible for:

- Classifying dam safety threats and declaring a response level, followed by notification to the relevant parties.
- Initial notification to the four Uganda Police Force Division Police Commanders (DPCs) in the event of Response Level 2 (Potential Emergency) or Response Level 3 (Imminent Failure) threat.
- Requests to the Uganda Police Force DPCs for immediate evacuation in the event of Response Level 3 (Imminent Failure) threat.

The Bujagali Power station Plant Asset Manager assumes responsibility as overall co-ordinator and will initiate further notifications as required. Notifications shall be via cellular and land line telephone systems. The Bujagali Power station Plant Asset Manager is authorised to contact and update the emergency response agencies with information concerning the emergency.

2.3.2 Responsibilities for evacuation (Response Level 3 Imminent Failure)

2.3.2.1 Evacuation of the Bujagali facility

2.3.2.1.1 Site sign in, evacuation and All Clear procedure

The Operator Lead is initially responsible for the timely and safe evacuation of BEL's personnel, contractors and other visitors from threatened or damaged areas of the Bujagali facility. The Operations Delivery Manager may subsequently assume these responsibilities.

Response Level 3 (Imminent Failure) will require immediate evacuation of all parts of the dam site and power station below the dam crest level to higher ground. Evacuation points are designated at the cul-du-sac on the East Bank abutment and the guard building on the West Bank, and staff should proceed immediately to the nearest of these points. These locations are at elevations that exceed the expected peak flood water level and should be secure from any inundation or erosion effects on higher ground that may occur during a dam break.

If an evacuation is called, BEL's on-site staff (led by the Asset Manager and/or Operator lead) and any other persons on the site are to immediately leave their stations and proceed to the nearest evacuation point. BEL staff and site security will assist any personnel unfamiliar with the site to the evacuation points.

As part of evacuation training, all employees are to be made aware of their evacuation point(s). Similarly, all contractors should be made aware of their evacuation point(s). Visitors should be informed of their evacuation point as part of their Sign In procedures and/or escorted by BEL staff.

When an evacuation is ordered, or required, all employees, contractors, visitors and guests will report to their assigned evacuation sites. Everyone will remain at the evacuation points until a head count is completed and one of the following has occurred: the All Clear is sounded; people are instructed that removal to a shelter is required; or people are instructed to go home.

If instructed to go home, notice of an All Clear is communicated by site paging system, staff radios, a notice delivered to the shelter, or other means as appropriate. Under no circumstances shall any employee, contractor, visitor, or guest re-enter the power plant prior to a notice of All Clear.

If required, employees with hearing or sight disabilities that occurred as a result of the emergency will be assisted out of the plant. Employees with disabilities will be identified and provided a support person to assist in an emergency as needed.

2.3.2.1.2 Responsibilities of BEL Managers/Supervisors and Contractor Managers / Supervisors

When an evacuation is ordered, or required, managers and supervisors will report directly to the assigned evacuation site(s). Managers/supervisors will complete an accurate head count of department employees at the evacuation site, using the employee daily sign in sheet to verify employees on duty that have reported to the evacuation site. Managers/supervisors will communicate the head count results to the Plant Asset Manager.

Under no circumstances should a manager/supervisor or employee re-enter the powerplant to look for a missing person. Managers/supervisors will provide follow up instructions to the employees in their evacuation site area as needed.

2.3.2.2 Evacuation of downstream areas

Four Districts are located along the Victoria Nile downstream of the Bujagali facility, along a length of the river that is predicted to be affected by floodwaters after a dam break from the Bujagali Dam. These are Jinja and Kamuli (east bank), and Buikwe and Kayunga Districts (west bank).

This EPRP covers the area from the Bujagali Dam reservoir to the Isimba Dam reservoir located downstream. The areas downstream of the Isimba Dam reservoir are covered by the Isimba EPRP. For avoidance of doubt, this EPRP does not contain specific provisions for evacuation of areas downstream of Isimba Dam.

In the event that Response Level 3 Imminent Failure is declared by the Bujagali Power station Asset Manager (who may be represented by the Operator Lead), he/she will call the Uganda Police Force DPCs (starting with DPC Buwenge & DPC Njeru, followed by DPC Kayunga and DPC Kamuli) to notify them and request immediate evacuation of the areas downstream (as shown on the inundation plans included in this EPRP).

The DPCs are responsible for leading the evacuations, and will mobilise local police forces, and request assistance from the UPDF (Jinja Cantonment). The DPCs will also inform the Regional Police Commanders (RPCs for Central and Eastern Regions) and the relevant District Disaster Management Committees (DDMCs) to request assistance in alerting district, local and village officials to direct residents living along the river margins within these districts to immediately move to high ground.

2.3.3 Responsibility for Event Termination and follow up

The responsibility for declaring Event Termination and the order for stand down after an event will depend on the Response Level declared as follows:

- For **Response Level 1** (Internal Event) and **Response Level 2** (Potential Emergency) BEL Bujagali Power station Plant Asset Manager. This is because under these scenarios, the dam has not failed and the effects are contained at the Bujagali Dam site and are managed by BEL who will have the highest level of situational awareness regarding the dam condition.
- For Response Level 3 (Imminent Failure) The National Incident Coordinator (NIC) (or other appropriate official) from the National Emergency Coordination and Operations Centre (NECOC). This is because under this scenario, dam failure has occurred or is expected to occur such that evacuations have occurred downstream and nationally coordinated response across the affected districts is likely necessary.

2.4 Bujagali Power station Asset Manager

The Bujagali Power station's Asset Manager has a key role in this EPRP. They are responsible for assessing the seriousness of dam safety threats and classifying and declaring/notifying the response level (including escalating the response level if the situation deteriorates). The Plant Asset Manager is also responsible as Operator for the safety of the Bujagali facility and its workforce, including directing every effort to avoid a dam break event and to mitigate its consequences.

It is recognised that the Asset Manager will not be present at the site at all times. In the absence of this individual, responsibility and authority for implementing EPRP actions will be devolved to the Operator Lead in charge of the station at any given time.

Emergency response to an event is likely to require continuous coordination by the Asset Manager / Operator Lead with the other response parties. Events may also be very long duration. This means that the Asset Manager / Operator Lead(s) will require assistance/support from EPRP coordinator/communications staff and an alternate to take over this role after a set shift time (i.e. 12 hour rotating shifts with handover to cover long duration events).

2.5 **UEGCL Managing Director**

Following notification of an event at the Owen Falls complex (Nalubaale/Kiira), the Managing Director of UEGCL, as owner of Nalubaale/Kiira, has responsibility for taking mitigation actions and avoiding a dam break at that complex (Jacobs, 2003). BEL is the owner of the Bujagali facility, and therefore UEGCL does not have direct responsibility for dam break avoidance or mitigation options there.

However, for a number of reasons (including conjunctive use of the facilities for electricity generation, and the potential for a dam break at the upstream facility to affect the downstream facilities), it is essential that the UEGCL Managing Director (who may be represented by the UEGCL Generation Managers or Operations Managers for Nalubaale/Kiira and Isimba HEPs) and the Bujagali Asset Manager stay in close communication in the case of an actual or potential dam break event at a facility.

2.6 Uganda Police Force District/Division Police Commanders

The District/Division Police Commanders (DPCs) have a key role in the implementation of emergency response activities for the potentially affected downstream areas in the event of a dam break emergency. The DPCs for Buwenge (Kiira North), Njeru, Kayunga and Kamuli will receive notification from the Bujagali Asset Manager (or Operator Lead) in the event that Response Level 2 (Potential Emergency) or Response Level 3 (Imminent Failure) threats are declared.

The DPCs are responsible for:

- Ordering and leading the evacuations (from the areas of potential inundation identified on the dam break flood maps/plan included with this EPRP).
- Requesting assistance from the UPDF (Jinja Cantonment).
- Informing the Regional Police Commander(s) (RPC).
- Coordinating with their District Disaster Management Committee (DDMC) (via the Chief Administrative Officer, CAO).
- Leading the District Emergency Coordination and Operations Centre (DECOC) (in accordance with the National Policy For Disaster Preparedness and Management) (where activated).
- Coordinating with the National Emergency Coordination and Operations Centre (NECOC) (where activated).

For this purpose it is intended to use the established police radio network to contact the police outposts. Prior arrangements for passing the alert through local councils for individuals so as to reach quickly the affected population must be arranged on an ad hoc basis for each affected locality. The availability of transport and/or mobile phones should be clarified and the individual policemen briefed as to their participation in the chain.

Primarily, the objective is to rapidly move the affected population out of the area that might be flooded, which will depend on the seriousness of the dam breach incident. Advance warning should facilitate the eventual move. In parallel the DDMCs will be alerted and responsible for organising transport or refugee facilities to meet the need.

The DPCs will also be responsible for public order and control of the civil population around Jinja, in a situation in which electricity and water supplies may become unreliable. The UPDF will be put on standby by the DDMC, and invited to support the DPC if needed.

2.7 District Disaster Management Committees

Because of the distance involved and the fact that flooding may interrupt roads, transmission lines and water supplies in the inundated areas, it falls to each District (via its Disaster Management Committee) to organise support for the affected inhabitants and their relocation. The Chief Administrative Officer (CAO) chairs the DDMC for their district.

The urgency of the situation will be dependent on the exact location. The measures needed to combat this emergency will be identified and incorporated in local emergency plans already in existence for many Districts.

The probability of failure leading to dam break at Bujagali is extremely low, and adequate warning is expected for most scenarios under the provisions of this Bujagali Dam Break EPRP. Once the estimated extent and probable duration of flooding have been notified, the movement of local population may need immediate assistance in the form of transport and shelter and this should be ear-marked in advance.

Subsistence in the medium term for displaced population may require national support via the Ministry for Relief, Disaster Preparedness and Management (Office of the Prime Minister) or Aid Agencies.

The National Emergency Coordination and Operations Centre (NECOC) provides emergency response support and coordinates the DECOCs. Each District is responsible for co-coordinating local efforts and any external aid. They will have to ensure adequate drinking water supply, for example if wells or pump intakes affected by the dam break become unstable or electricity supplies cut.

2.8 UETCL National Coordination Centre (NCC)

The Uganda Electricity Transmission Company (UETCL) National Coordination Centre (NCC) is responsible for the purchasing of electricity (including from the Victoria Nile Cascade hydropower stations) and operation of the transmission grid (part of the Uganda National Grid).

UETCL may issue operating instructions to all grid-connected power stations in Uganda to bring on or reduce generation to match demand. This means that coordination with UETCL is an important component of the emergency response, where this requires use of the Bujagali hydropower plant to release additional flow as part of an emergency response (be this under speed-no-load conditions, or generation conditions).

UETCL receives information such as reservoir/headpond and tailwater levels at Owen Falls in real time, and can issue appropriate instructions to the operators of the Kiira and Nalubaale power station facilities to increase or reduce outflows. They may also receive requests from BEL as part of the emergency response to facilitate reduced inflows from Owen Falls and/or dewatering of the Bujagali Reservoir. Appendix C to this EPRP presents calculations of the rate at which water in the Bujagali Dam reservoir can be drawn down.

2.9 Organisational Structure for Emergency Response

The overall organisational structure for emergency response is set out in the Quick Reference Guide (Refer Part 1).

Dam potential safety threats

3 Dam potential safety threats and classification

3.1 Potential threats

3.1.1 Deterioration

Deterioration of the dam, foundations and/or appurtenant structures (i.e. conduit and spillway) may result in increased vulnerability of failure under normal reservoir operation and/or flood conditions. Deterioration dam safety threats may occur from the following mechanisms, which theoretically could ultimately lead to dam breach without successful intervention:

- Internal erosion (in the dams and/or foundations) where the soils are eroded and potentially resulting in:
 - Piping (a hole through the dam or foundation that gets larger, collapses and breaches the dam).
 - Sinkhole formation in the upstream face and/or crest that results in loss of freeboard and the reservoir flows into the sinkhole and causing overtopping of the dam and breach).
- Concentrated leakage through a layer/crack in the dam embankment leading to erosion and failure by piping or overtopping.
- Concentrated seepage along the outside of the concrete structures (i.e. gated spillway, siphon spillway, or power station gravity dam block) leading to erosion and failure by piping.
- Age related deterioration of concrete (including joints and embedded parts) leading to increased seepage and uplift pressures destabilising the gravity dam.
- Age related deterioration of dam safety critical equipment (including gates and associated lifting and power supply equipment) leading to loss of functionality/operation during vulnerable periods (e.g. when the gates need to operate during flood conditions). This threat is usually addressed by a comprehensive inspection, testing and maintenance programme (as is in place at the Bujagali Dam).

3.1.2 Large inflow floods resulting in high reservoir levels

A key safety threat for the dam is flooding as this may potentially lead to dam breach by the potential failure modes/mechanisms outlined above. The potential for all failure modes generally increases with higher reservoir levels as this increases the loads on the dam.

Flood related dam safety threats may result in the following potential failure modes:

- Overtopping of the embankment dams leading to dam breach.
- Seepage through the embankment zone above the core (above 1112.5 m RL) leading to instability and breach.
- Hydraulic scour to the spillway channels during operation that may cut sideways/backwards towards the right and central embankment dams. Significant erosion to the concrete and/or underlying rock surfaces would need to occur before this could potentially affect the embankment dams and become a dam safety threat.

• Static instability due to high reservoir level with and without increased internal water surface in dam (as monitored using the piezometers and foundation drains).

Floods and high reservoir levels can be predicted and/or identified from coordination with UEGCL Kiira and Nalubaale (for scheduled and expected releases, from inflow forecasting, instrumentation (such as telemetered water level recorders and automated alarm systems, which for Bujagali includes the alarm and gate operation fallback trigger based on high tailwater level measured in the Kiira tailrace) and visual inspection at the dam. Section 3.2 provides further details on how the potential safety threats can be identified and monitored.

3.1.3 Unscheduled large flow release from Owen Falls

The maximum combined gate discharge capacity of the Owen Falls complex (Nalubaale and Kiira HPPs) is considerable, if simultaneous use of the sluices, spillways and power stations were to occur. This is however considered to be a highly unlikely and adverse combination of events (unless deliberate maloperation is intended – refer to specific maloperation threat below). For this specific event to occur, maximum generation would likely need to be occurring at Owen Falls followed by gate opening (which would require specific overrides/control system failure to occur).

The sum of the maximum discharges from Owen Falls at FSL (1134.5 m RL) is theoretically 5,240 m 3 /s (assuming full operation of the power stations coincident with full spillway operation), and at dam crest level (1137 m RL) is theoretically higher 6000 m 3 /s, noting water levels this high are extremely unlikely and would be predicted/forecast well in advance based on Lake Victoria levels. These flows are larger than the formal IDF capacity at Bujagali Dam (4500 m 3 /s at MFL of 4112 m RL) and the long-term flow that would follow a major dam failure at Owen Falls (approximate 4500 m 3 /s) (Jacobs, 4200 m 3 /s) (refer cascade failure threat below).

While short duration discharges from Owen Falls may unintentionally exceed the formal capacity at Bujagali (4500 m³/s at MFL, noting additional capacity expected above this level) it is highly improbable that these could or would continue for longer durations without intervention (unless maloperation is occurring – refer below for maloperation threats). Operation of the Bujagali power station would increase the available capacity by up to approximately 1375 m³/s (assuming tailwater does not significantly reduce outflow) which theoretically means maximum discharge from Owen Falls can be passed without overtopping the dam.

Water level sensor controls (for tailwater at Kiira tailrace and reservoir level at Bujagali Dam) enable real time monitoring of reservoir levels and automated gate operation.

3.1.4 Cascade failure

Failure of one of the Owen Falls structures (Kiira and/or Nalubaale Dams) resulting in uncontrolled release of upstream reservoir contents presents a significant dam safety threat to the Bujagali Dam. The predicted dam break outflows and volumes are significant and effective emergency response requires rapid operation of the Bujagali dam spillways, and ideally power station, to pass the flood flows. The reservoir level is expected to exceed the MFL of 1112 m RL in this scenario.

Flood-induced (rainy day) failure at Owen Falls (e.g. Kiira embankment dam) is expected to be the more adverse scenario (compared to a normal lake level (sunny day) scenario) due to large outflows that would likely precede upstream dam failure. This reduces the response time and ability to increase

discharges at Bujagali to prevent overtopping. Dam failure at Kiira and Nalubaale is a Response Level 2 or 3 event at Bujagali Dam (refer Table A for further guidance).

Full coordination with UEGCL (Owen Falls and Isimba) and successful intervention/emergency response at Bujagali (i.e. increase outflows to maximum safe discharge) may prevent cascade failure of Bujagali Dam.

3.1.5 High winds

High winds are unlikely to be a dam safety threat for the Bujagali Dam (based on reservoir fetch and regional winds in this location) but are included herein for completeness. In theory, high winds may result in the following potential failure mode:

Wave action eroding the upstream face and reducing freeboard resulting in overtopping of dam.
 This may occur during normal reservoir levels with very high winds or during floods, noting a
 dam safety threat due to high winds is typically elevated during flood conditions due to the
 reduced remaining dam freeboard (but is considered unlikely for the Bujagali Dam).

This dam safety threat (and associated potential failure modes which are considered to be very unlikely/potentially not credible), is included in this EPRP for completeness and noting that high winds in combination with high reservoir levels may have some limited influence on dam safety.

3.1.6 Earthquakes

3.1.6.1 Seismic hazard

The Bujagali Dam is located in a region with relatively low seismic activity, midway between the eastern and western sections of the African Rift System (which have relatively high levels of seismic activity). The dam is sufficiently distant from the rift system that ground motions arising from typical seismic events are expected to be insignificant (as per Knight Piésold/Merz & McLellan, 1998). A closer potential seismogenic source follows the regional Rwenzori fold belt, which extends from the west to east rift systems through the north end of Lake Victoria. This zone, known as the Katonga Break, is the location of moderate levels of seismicity with a surface wave magnitude (M_s) of up to M_s 6 (Knight Piésold/Merz & McLellan, 1998).

In 1991, Acres International conducted a seismic hazard analysis for the Kiira Dam project. Given the proximity of the Kiira Dam to the Bujagali Hydropower Facility, the earthquake-induced ground accelerations are likely to be similar at both sites (Knight Piésold/Merz & McLellan, 1998). Acres evaluated the seismic hazard and ground motion design parameters based on deterministic and probabilistic methods.

The deterministic analysis found a maximum credible earthquake (MCE) to be an M 7.5 event on the Katonga Break, approximately 50 km south of the site, which will produce a Peak Ground Acceleration (PGA) of 0.2 g and 0.3 g for rock and soil foundations respectively. The probabilistic analysis determined a low probability of occurrence on the Katonga Break (PGA of 0.175 g), with a slightly higher figure for the 200 km radius area (PGA of 0.27 g). This PGA determination was based on an extremely low annual probability of exceedance (0.0001).

The Bujagali Dam was designed to withstand the Safety Evaluation Earthquake (SEE) ground motion design values given in Table 3.1 (previously referred to as a Maximum Design Earthquake, MDE). These are based on the deterministic estimates for the maximum credible earthquake (MCE). This means the Bujagali Dam is expected to withstand the largest credible earthquake predicted at the time.

Table 3.1: Design Peak Ground Accelerations (PGA) for SEE at the Bujagali Dam

Condition	Peak Ground Acceleration (g)		
Condition	Horizontal	Vertical	
Rock Foundation	0.25	0.17	
Soil Foundation (up to 30 m thick)	0.37	0.25	

Note: Maximum Design Earthquake (MDE) is the maximum credible event that the dam and associated structures must survive without a failure (defined as loss of life or catastrophic failure in the water retaining capabilities of the dam). However, the dam and its associated structures may sustain substantial damage that is repairable. Source: Knight Piésold, 1998, as modified by Z Matus, MWH, December 2010.

3.1.6.2 Seismic threat

Large earthquakes may result in damage to the dam that could affect performance. While the dam structures have been designed with withstand very large earthquakes without failing (as per Table 3.1), some damage to the structure is usual and expected even in much smaller events. Earthquake damage may contribute to other dam safety threats (i.e. while the dam structures may remain intact following a large earthquake and aftershocks, damage from these events may lead to a dam safety emergency by another mechanism, such as gate inoperability or concentrated leakage via a crack).

Damage is usually identified during post-earthquake inspections. Visual inspection and surveillance of the dam condition (at each structure) following a large earthquake is essential (as per surveillance procedures) to determine what action is necessary to maintain safe operation of the dam. Post earthquake deformation surveys may also be necessary to assess the extent of deformation.

Earthquakes may result in the following issues, which theoretically could ultimately lead to dam breach without successful intervention:

- Seismic instability of dam resulting in deformation (e.g. settlement, slope movement), loss of freeboard and overtopping.
- Seismic instability leading to toppling and/or sliding failure of the concrete gravity dam (one or more blocks) (either during an earthquake or following this due to damage).
- Earthquake damage forming transverse crack(s) in dam embankments. Concentrated seepage along transverse cracks can lead to erosion and dam breach.
- Earthquake movement between the embankment dams and reinforced concrete abutments at
 the siphon spillway, gated spillway or power station concrete gravity dam resulting in interface
 seepage and concentrated leakage (which may lead to gross enlargement, backwards erosion
 and collapse piping failure).
- Earthquake actions causing damage to one or more radial gates, followed by large flow releases from Owen Falls leading to insufficient flood discharge capacity and overtopping failure.

3.1.7 Intentional damage/loss of control (e.g. sabotage / hijacking / coercion / terrorist attack)

Given the strategic nature of all the hydropower schemes in the Victoria Nile Cascade, and the damage that could be inflicted by deliberately malicious actions, they must be regarded as potential targets. Interference with the safe operation of any one of the cascade structures is a serious threat, and loss of control at Owen Falls and/or Bujagali Dam should be treated as a potential emergency (Response Level 2) or Imminent Failure scenario (Response Level 3) due to the ability to cause dam failure by releasing too much water (damaging a downstream dam) OR prevent discharge (causing the upstream dam to overtop and fail).

The relatively small size of the Bujagali Dam and reservoir when compared to the downstream Isimba Dam and reservoir means that failure of the Bujagali Dam would not likely lead to cascade failure of Isimba Dam, unless an extremely adverse combination of issues were to occur. For example, if both the Bujagali Dam radial gates were destroyed, the resulting outflow and volume would still be accommodated by the Isimba Dam reservoir (and be similar to a maximum design discharge scenario).

The Bujagali "site" EPRP (BEL, SP-0001) contains procedures for dealing with actual or potential sabotage and terrorist incidents, including bomb threats.

3.1.8 Unintentional damage

The Bujagali "site" EPRP (BEL, SP-0001) contains procedures for dealing with threats that may cause unintentional damage such as fire, improper operation of equipment, medical emergency and vehicle related accidents. Unintentional damage may lead to a dam safety issue, if this compromises the structural integrity of a water retaining element or prevents safe operation of the dam (e.g. damage to a spillway or gate reducing flood capacity).

3.1.9 Maloperation of Owen Falls

Maloperation of Owen Falls is the operation with the intention/effect of causing damage and/or affecting dam safety. This may be from discharging (i.e. opening all of the gates — refer unscheduled operation of Owen Falls threat above), or preventing discharge (closure of all the gates during a large flood resulting in increasing reservoir levels noting this would require a long time — refer cascade failure threat above).

Loss of control at Owen Falls should be treated as a Potential Emergency (Response Level 2) or Imminent Failure scenario (Response Level 3) at Bujagali Dam.

3.1.10 Maloperation of the Bujagali Dam spillways

Maloperation of the spillway gates is the incorrect operation of the gates with the intention/effect of causing damage and/or affecting dam safety. This may be from discharging (i.e. opening all of the gates), or preventing discharge (closure of all the gates resulting in increasing reservoir levels).

Unexpected operation/opening of the Bujagali Dam spillway gates may present a dam safety threat to downstream populations and the Isimba Dam. This is not strictly a dam safety threat to the Bujagali Dam itself (unless it occurs during some unusual situation, such as where work is occurring in the spillways or the like).

A sudden release of water may possibly result from the unauthorized or improper opening of the spillway gates such as operator error, mechanical failure of the gates, or by destruction /hijacking / coercion caused by outside third parties¹. However, gate opening takes place over an extended period of time and is monitored at the control room such that corrective actions could be taken. This may include actions taken at Isimba Dam to accommodate increased outflows.

Preventing discharge (i.e. closure of the gates) reduces the flood routing capacity, noting the siphon spillway is an uncontrolled/passive system (with no moving parts) and can pass at least 1200 m³/s. If the upstream discharges from Kiira and Nalubaale HPP exceed the discharge at Bujagali, this can lead to reservoir level rise and if not addressed, overtopping failure. Emergency response actions may include reducing/stopping upstream discharge (which requires coordination with UEGCL and/or an automated water level control trigger that results in failsafe shutdown when the Bujagali reservoir level exceeds a set level).

Loss of control at Bujagali Dam should be treated as a Potential Emergency (Response Level 2) or Imminent Failure scenario (Response Level 3) at Bujagali Dam.

3.2 Potential failure modes/mechanisms

3.2.1 Overview

Review of the applicable potential failure modes (PFMs) and event scenarios has been included in this EPRP. These are described below by each structure type (i.e. embankment dams, concrete gravity block, gated spillway block and siphon spillway). A formal failure modes and effects analyses (FMEA) workshop was undertaken for the Bujagali Dam as part of the first Comprehensive Dam Safety Review in 2024. The FMEA workshop risk register is attached to this EPRP and should be referred to for further details on the assessed credible PFM's and their assessed relative likelihoods and risk ranking.

These mechanisms are based on assessed theoretical susceptibility and do not consider the likelihood/probability of occurring (i.e. while the dam could theoretically breach in one or more of these ways this does not mean it will or that it is likely to, further noting these PFMs assume no effective intervention to prevent, halt or lessen the failure mechanisms).

3.2.2 Earth core rockfill dams (left, central and right embankment dams)

The earth core rockfill embankment dams were constructed from locally sourced clay fill, sands and rock fill. There are three discrete embankment segments (left, central and right) which are founded on treated rock foundations with the underlying rock treated with dental concrete, slush grouting, blanket grouting and a grout curtain (for foundation seepage control).

The following potential failure modes (PFMs)/mechanisms are examples that are considered credible/possible but unlikely for these specific structures (as presented below by dam safety threat for consistency with Table A and Section 3.1):

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 $^{^{1}}$ The maximum rated discharge at MSL (1112 m RL) through the two main radial gates is 2,930 m 3 /s (1,465 m 3 /s per gate), through the flap gate is $^{\sim}$ 350 m 3 /s and through the siphon spillway is 1,200 m 3 /s.

Deterioration of embankment dam(s)

- Interface seepage concentrated leak failure Internal erosion of the dam due to seepage along the spillway and gravity dam block interfaces that leads to concentrated leakage, ongoing erosion of the dam, and development of a pipe/hole/void/crack (essentially a hole in the dam) that enlarges overtime and leads to a breach.
- Concentrated leakage and/or internal erosion in the dam leading to piping failure (e.g. a hole in the dam) Internal erosion of the dam due to material properties or a weaker/more permeable layer that leads to concentrated leakage, ongoing erosion of the dam, and development of a pipe/hole/void/crack that leads to a breach.
- Internal erosion in the dam leading to sinkholes and overtopping failure Internal erosion of the dam due to material properties that leads to development of sinkhole(s) at the crest, and loss of dam level/freeboard/flood capacity that leads to overtopping and breach.
- Internal erosion in the foundations leading to piping failure (e.g. a hole in the foundations) Internal erosion of the foundation material under the dam due to material properties that leads to concentrated leakage, ongoing erosion, development and enlargement of a pipe/void/crack that leads to a breach (may include pipe collapse and loss of a dam section) (e.g. right embankment contact erosion with foundation rock if foundation treatment and/or grouting were ineffective).

High reservoir levels (due to high inflows/flood flows and/or other flow releases from Owen Falls)

- Flooding leading to overtopping failure Overtopping of a section(s) of dam during a flood to scour and erosion at the crest and downstream face, downwards cutting and breach of the dam. This may be aggravated by winds causing wave runup and/or flood debris accumulation blocking the spillway and/or gate inoperability.
- Seepage above core zone, leading to erosion, collapse and then overtopping of a section(s) of embankment dam – Water level exceeds 1112.5 m RL leading to widespread seepage through embankment above core, leading to internal erosion, gross enlargement and collapse, with loss of crest level, overtopping, downwards cutting and breach of the dam.
- Static instability Slope failure (especially during higher reservoir levels) due to loss of material strength, loss of freeboard and overtopping leading to progressive downwards cutting and breach of a dam section. Embankment instability could take the form of settlement and/or slip circle failure. Any failure of this sort is likely to be progressive and therefore affords some measure of warning. The length of breach is constrained by adjacent concrete sections and rock abutments or weathered rock profiles.
 - Noting tight operating range (0.5 m difference between FSL and MFL), instability may occur during and/or due to high reservoir levels with or without increased internal water surface in dam (as monitored using the piezometers). Instability may be the result of other mechanisms such as internal erosion and/or seepage above the core level.
- Scour damage to downstream toe of right or central embankment dams Erosion/scour of the spillway outlet channel progressing towards the dam resulting in slope failure/ undermining and breach of the dam section, especially during operation of the siphon and gated spillways under very high tailwater levels.

Earthquakes

- 9 **Seismic instability** Slope failure, settlement, cracking and/or movement due to a large earthquake that results in concentrated seepage and erosion, and/or overtopping, scour and downward cutting leading to dam breach at one or more locations.
- 10 Concentrated seepage along transverse crack due to earthquake damage in dam embankment section Concentrated leak, scour and gross enlargement leading to piping failure.

NOTE: While the coincident probability/likelihood of a large earthquake occurring followed by a large flood is very low, a sizeable discharge from Owen Falls may still occur while the Bujagali Dam is being repaired for seismic damage. The potential for a large earthquake damaging the dam during usual/normal reservoir operating conditions should also be considered in the context of susceptibility to overtopping/breach during high inflow conditions subsequent to the earthquake damage.

3.2.3 Concrete gravity dams

The powerhouse intake structure and concrete gravity dam blocks are located upstream and on the true left of the power station. The gravity dam is a mass concrete structure with reinforced concrete facing (four blocks for the gravity dam). The intake is a reinforced concrete structure (with openings for the five turbines) that abuts the gravity dam and gated spillway. The concrete gravity dam features a grouting and drainage gallery that extends through the intake structure and under the gated spillway. Seepage flows are monitored in the gallery for the concrete block vertical joints (including expansion joints between the gravity dam, intake and gated spillway blocks) as are the flows in the foundation uplift pressure relief drains (bored drains into the foundation rock downstream of the grout curtain).

The following potential failure modes (PFMs)/mechanisms are examples that are considered credible/possible but unlikely for these specific structures (and predominantly apply to the gravity dam) (as presented below by dam safety threat for consistency with Table A and Section 3.1):

Increased joint and/or foundation seepage and/or pressures

- Static stability Increased foundation pressures due to seepage and/or blockage of drains leading to uplift pressures and overturning or sliding failure of gravity block(s) May be aggravated by high reservoir levels. While this potential failure mode is considered to be unlikely based on the design stability assessments it has been included in this EPRP for completeness.
- 2 **Static instability** Deterioration of concrete including joints leading to excessive seepage and/or pressure increases leading to overturning or sliding failure of gravity block(s) May be aggravated by high reservoir levels and/or earthquakes.

Earthquakes

3 **Seismic instability** – Cracking and/or movement due to a large earthquake that results in block dislocation and failure by sliding, overturning or water flows through open joints. While this potential failure mode is considered to be unlikely based on the design stability assessments, it has been included in this EPRP for completeness.

NOTE: While the coincident probability/likelihood of a large earthquake occurring followed by a large flood is very low, a sizeable discharge from Owen Falls may still occur while the Bujagali Dam is being repaired for seismic damage. The potential for a large earthquake damaging the dam during usual/normal reservoir operating conditions should also be considered in the context of susceptibility to failure during high inflow conditions subsequent to the earthquake damage (e.g. earthquake damage to the grout curtain and/or pressure relief drains leads to high uplift during subsequent floods).

3.2.4 Gated spillway

The following potential failure modes/mechanisms are examples that are considered credible/possible but unlikely for this specific structure (not separated by threat for clarity):

- Static stability Sliding failure, due to increased foundation seepage and/or blocked uplift relief drains leading to uplift induced instability.
- 2 **Seismic stability** Sliding failure and/or structural failure of walls due to seismic actions.
- 3 **Gate failure** Loss of spillway capacity leading to overtopping of embankment sections.
- 4 **Hydraulic damage** Spillway operation results in damage to the reinforced concrete slabs, which are lifted up/jacked and progressively scoured from the channel undermining the gated spillway block and leading to failure. This mechanism is considered very unlikely, given the gated spillway can be isolated (gate closure and/or upstream stoplogs) UNLESS there is a very large and long duration flood in progress.
- Intentional damage /sabotage / terrorist attack Gated spillway (and/or gates and lifting equipment) is intentionally damaged (e.g. explosion or mechanical attack) preventing operation and subsequent high inflows lead to dam overtopping failure (noting siphon spillway operation may still occur and high inflows are necessary to cause dam failure).
- Unintentional damage Gated spillway is unintentionally damaged (e.g. blocked or collision damage, incorrect operation resulting in damage) preventing operation and subsequent high inflows lead to dam overtopping failure. This PFM is considered highly unlikely unless it is combined with another threat (such as a large flood) given there are two radial gates and a flap gate, and the siphon spillway and power station can discharge substantial flows.

3.2.5 Siphon spillway

The following potential failure modes/mechanisms are examples that are considered credible/possible but unlikely for this specific structure (not separated by threat for clarity):

- Static stability Toppling/overturning of one or more internal ogee weir blocks (due to unknown structural issue) and/or sliding failure for one block along foundation interface, due to increased foundation seepage and/or blocked uplift relief drains leading to uplift-induced instability and/or unknown structure defects or damage.
- Seismic stability Toppling/overturning of one or more internal ogee weir blocks (due to unknown structural issue) and/or sliding failure for one block along foundation interface or horizontal lift joint due to seismic actions, and/or subsequent damage leading to static instability (as above).

- 3 **Hydraulic damage** Siphon spillway operation results in damage to the reinforced concrete surface(s), which are lifted up/jacked and/or progressively scoured from the spillway undermining the siphon block and leading for failure. This mechanism is considered very unlikely, given the gated spillway and power station can be operated to halt siphon operation (by lowering the reservoir level) UNLESS there is a very large and long duration flood in progress, and the power station cannot be operated.
- 4 **Intentional damage / sabotage / terrorist attack** Siphon spillway is intentionally damaged (e.g. blocked, explosion or mechanical attack) preventing operation and subsequent high inflows lead to dam overtopping failure.
- Unintentional damage Siphon spillway is unintentionally damaged (e.g. blocked or collision damage) preventing operation and subsequent high inflows lead to dam overtopping failure. This PFM is considered highly unlikely for this structure.

3.3 Identification of threats

3.3.1 Surveillance and monitoring procedures

Surveillance and monitoring procedures for the Bujagali Dam and power station is described in Fichtner (2009a) and Fichtner (2009b).

The Bujagali Dam is manned on a 24-hour per day basis during which the operations staff and security personnel perform routine patrols and visual inspections of the entire site. The powerhouse control room contains electronic monitoring systems that provide alarms when certain conditions exceed specified normal limits (e.g. reservoir and tailwater levels, gate position and rated discharges). The control room is manned continuously (24/7) by an Operator Lead who has the delegated authority to activate and implement this EPRP.

Daily, weekly and monthly visual inspections of the dam and appurtenant structures are undertaken by trained engineering personnel in accordance with surveillance procedures which enable early detection of unusual conditions and/or performance. These are supplemented by annual dam safety inspections and comprehensive dam safety reviews carried out by specialist dam safety consultants. Similar systematic monitoring and evaluation of dam performance instrumentation data is also undertaken. Written logs are produced that are regularly reviewed by senior management.

Regular visual inspections of the dam condition are essential as part of ongoing surveillance for assessment of potential dam safety threats. Identification of a dam safety threat may occur following visual inspection by maintenance or operations staff. Visual inspection of the dam should be undertaken regularly as part of the asset management practices (in accordance with surveillance procedures), and especially during and following large flood events, and after large earthquakes.

Earlier identification of unusual behaviour enables earlier assessment of a situation, and improved emergency response where this is required. Unusual behaviour that may be considered a dam safety threat includes:

Visual seepage at the downstream face of the embankment and concrete gravity dams, or at
the toe of the dams or immediately downstream (e.g. wet areas, seeps, springs) and especially
if this is discoloured and/or sediment laden.

- New, unusual or increasing seepage at the monitoring locations (e.g. gravity dam, intake and gated spillway gallery drains or joints) or new locations (e.g. horizontal lift joints, vertical block joints).
- Water levels approaching or exceeding the maximum flood level of 1112 m RL (noting this would be determined from the reservoir level instrumentation).
- Wave erosion damage to the upstream face of the embankment dams.
- Settlement, deformation, movement, slumping and/or cracking at the embankment dam crest, downstream face or toe.
- Evidence of movement, joint enlargement, block tilting and/or new cracking in the exposed concrete faces (concrete gravity dam, intake, gated spillway and siphon spillway).
- Sinkholes in the upstream face or crest of embankment dams.
- Visible scour at the toe of an embankment dam.
- Visible damage to the siphon or gated spillway during or immediately following operation.
- Any alert level exceedance or departure from established historic trends from the instrumentation that cannot be verified as an error.

Surveillance also includes the ongoing monitoring of the dam performance using instrumentation. The installed instrumentation is described in the Dam Instrumentation Method Statement (Volume 1 to 3)², and consists of (by location):

Reservoir and tailrace

- Two sets of hydraulic measuring devices, Main and Check, in the reservoir (headwater level)
 and the tailrace (tailwater) level. Each set consists of an electronic gauge of the submersible
 pressure transducer type. The Main stations also include a visual mechanical float-operated
 gauge.
- Staff gauges for monitoring water levels downstream of the power station, in the Unit No. 1 powerhouse (in the tailrace channel), and in the tailrace below the siphon spillway.

Embankment dams (left, central and right)

- 36 No. vibrating wire piezometers (VWP) installed in the dam core and permeable foundation material.
 - 9 No. VWP in the left embankment (VWP 01 to 9)
 - 10 No. VWP in the central embankment (VWP 10 to 19)
 - 17 No. VWP in the right embankment (VWP 20 to 36)
- 8 No. standpipe piezometers installed in left and right embankment dam fill, foundations and abutments (SP-01 to SP-04, and BH-03, 05, 06 & 08). The water level in the standpipe piezometers is read using a water level probe.
- 14 No. crest settlement monuments (deformation markers) (DM 1 to DM 14).

² Bujagali Hydro-Electric Power Project Dam instrumentation – Method Statement SA-D-GE-TR-1021-0 Volume 1, 2 & 3

- 4 survey reference points installed outside the influence range of the dam and auxiliary structures, in the abutments upstream and downstream of the dam for each of the right and left embankment dams.
- Seepage collection drains and measurement weirs (v-notch weir at right embankment dam).

Concrete gravity dam

- Seismograph located in the drainage gallery (near the dam foundation).
- 15 No. uplift relief drainage monitoring holes (GDH 1 to 16). Manually read with bucket and stopwatch.
- 2 No. piezometers installed in gravity dam foundations (PV 1A & 1B).
- 3 No. settlement markers (SM 1 to 3).

Powerhouse/intake structure

- 4 No. piezometers installed in powerhouse foundations (PV 02 to 05).
- 24 No. uplift relief drainage monitoring holes (PDH 1 to 24). Manually read with bucket and stopwatch.
- 6 No. settlement markers (SM 4 to 9).
- 3 No. combined powerhouse drainage monitoring holes. Manually read with bucket and stopwatch.
- Vertical joint drainage monitoring points, including rectangular weir installed in the drainage gallery combined discharge channel (located below the floor level) by turbine Unit No. 4 that enables measurement of leakage through the expansion joint between the gated spillway block and the turbine Unit No. 5 concrete structure.

Gated spillway

- 17 No. drainage monitoring holes (GSD 1A to 18). Manually read with bucket and stopwatch.
- 2 No. piezometers installed in the foundation (PV 06 and 07).
- 3 No. settlement markers (SM 10 to 12).

Siphon spillway

- 32 No. drainage monitoring holes (SSD 1 to 32). Manually read with bucket and stopwatch.
- 2 No. piezometers installed in the foundation (PV 08 & 09).
- 3 No. settlement markers (SM 13 to 15).

3.3.2 Operational procedures

Operation of the Bujagali Dam is tightly controlled with multiple systems and processes in place to ensure safe operation. These systems include automated actions (such as controlled gate opening and closure based on preset levels, and power station startup and shutdown) with appropriate oversight and manual action/confirmation undertaken from the control room.

There are primary (main) and backup (alternate) systems in place, with independent sensor/instrumentation and control systems. Manual override of automated systems is possible from the control room. Physical override is also possible on site (e.g. in the highly unlikely event of complete

equipment failure, backup actuation equipment to raise the radial gates can be manually operated with portable equipment from the deck).

These operational procedures include automated notification of alarms and/or alerts of unexpected and/or adverse operation/performance. Primary identification of many of the dam safety threats is expected via these procedures.

BEL operations procedures should be referred for details (including the latest Technical Instruction for the Spillway Gates). These include alarm levels for high reservoir level and discharges relevant to early warning of dam safety threats and sudden release issues (e.g. incorrect gate operation).

3.3.3 Communications and coordination with UEGCL and UETCL

Dam safety threats to the Bujagali Dam may be identified first by UEGCL (dam owner/ operator of the other dams in the Victoria Nile Cascade) or UETCL NCC (transmission grid operator, national control centre). For example, misoperation of the spillway and/or sluice gates and/or power station at Kiira and Nalubaale may be notified to the Bujagali Dam Operator Lead (or Asset Manager) in advance/in parallel with automated alarms.

Effective communications and coordination between the Victoria Nile Cascade schemes and the electricity transmission grid operator (UETCL) will enable dam safety threats to be identified sooner, verified (e.g. an automated alarm followed by a phone call to confirm it is real) and classified/assigned the appropriate response level. This is especially the case for flow discharge and loss of control related threats.

3.3.4 River water level monitoring

BEL own and operate automatic water level recorder stations in the reservoir (upstream water level) and the tailrace (downstream water level). UEGCL own and operate a water level recorder located downstream of Kiira HPP (in the Kiira tailrace), which is used to coordinate operation of the hydropower schemes and acts as an early flood warning instrument for the Bujagali Hydropower Dam.

Water levels are monitored by BEL and pre-set alarm levels are used to inform gate operation and reservoir water level management. BEL operations procedures should be referred to for flood/high inflow procedures and preset alarm levels (including the latest Technical Instruction for the Spillway Gates). These procedures include sudden release alarms for unexpected/unintentional / incorrect operation of the gates (that may introduce a life safety risk to people along the river margin downstream of the dam, such as Wildwaters Lodge).

3.3.5 Flood/ high inflow forecasting

Severe weather forecasting is undertaken by Directorate of Water Resources Management (DWRM) of the Ministry of Water and Environment and high water levels in Lake Victoria are managed through discharges from Owen Falls in accordance with the Agreed Curve and/or otherwise as directed by DWRM. High flow release warnings are communicated by UEGCL to BEL as part of normal operation and coordination procedures.

This early identification of potentially significant high flow discharges through the Victoria Nile Cascade can enable more effective emergency preparation and response (where required). It is important to note that multiple dam safety threats relate to high inflows, and that unscheduled/

unexpected high flow releases can theoretically be of a similar magnitude to large flood discharges (and in extremely adverse situations, exceed the formal spillway capacity at Bujagali Dam).

Dam safety threats associated with forecast/scheduled high flow releases can be addressed at Bujagali Dam via operational procedures and high flow condition surveillance and monitoring. Reliable gate operation (and in some extreme instances, power station operation) are essential for safely managing high inflows.

3.3.6 Earthquakes

A seismograph (strong motion recorder) is located in the gravity dam drainage gallery. This instrument is the primary source of recording of at-site seismic actions in the event of an earthquake. As the site is fully manned, any earthquake that is felt at the site is considered to be a dam safety threat. Any earthquake felt at the Bujagali Dam should trigger a post event inspection (in addition to other earthquake procedures related to trip/shutdown of the power station and building safety).

The recorded peak ground accelerations (pga) should also be compared to the stated design seismic pgas (refer also Section 3.1.6) when assessing the severity of the seismic loads (and associated threat) against the observed post-earthquake performance (as determined by post-earthquake inspection, surveillance and monitoring procedures).

3.4 Assessment

Effective assessment of potential dam safety threats requires on site assessment by trained BEL and other operational staff together with sufficient information being gathered and interpreted, and with overall situational awareness (for example, are downstream river and/or reservoir levels likely to fall, are increased flow releases from the Kiira/Nalubaale HEPPs forecast/expected, observations about dam integrity at a location). Assessment also requires a level of judgement and should be undertaken with the support of specific training and technical advice.

Threat assessment is undertaken at a point in time, and ongoing surveillance, monitoring, review and reassessment will be necessary (for example over the duration of a flood event). Ongoing visual inspection of the dams is a critical part of the ongoing threat assessment process. The classification matrix (Table A in the Quick Reference Guide section) should be referred to for further guidance on assessing potential dam safety threats.

3.5 Classification and response levels

3.5.1 Overview

Should the potential dam safety threat assessment result in a dam safety emergency being declared, the level of emergency needs to be classified to determine the required emergency response actions. Table A of the Quick Reference Guide provides a classification matrix to assist this and this should be referred to for classification of Emergencies. Dam safety threats may be classified as follows based on the level of assessed urgency.

3.5.2 Response Level 1 - Internal Event

Internal Events only impact on the Dam Owner (BEL) and the response can be managed internally by BEL. Examples of Internal Events include:

- Observations of unusual seepage flow through the embankment dams and/or foundations and/or interfaces between concrete and embankment fill that is steady, not discoloured and can be controlled with preventative measures/ intervention (such as dumping rockfill, grouting and/or emergency drawdown of the Bujagali Dam reservoir) (internal erosion/concentrated leak failure modes). May follow a large earthquake or occur under normal operation.
- Small scale sinkhole/movement/ deformation/settlement/cracking in the embankment dams that has not resulted in significant loss of freeboard but requires repair to reduce risk of overtopping during higher reservoir levels, and drawdown can be undertaken to reduce the Bujagali Dam reservoir level. May follow a large earthquake or occur under normal operation.
- Changes in seepage/uplift pressures at the concrete dams (such as increasing seepage into
 concrete dam galleries or through concrete joints, and rapidly increasing piezometer levels, OR
 rapidly increasing piezometer levels with reduced/no seepage flows into the dam galleries,
 AND no apparent distress to the dam, while interventions are implemented (i.e. emergency
 draw down of the Bujagali Dam reservoir).
- High reservoir levels that exceed 1112 m RL but are less than 1112.5 m RL, and any damage/seepage on the downstream face / overtopping of the crest due to wave action from winds (noting this is considered unlikely) is limited and can be safely repaired and/or drawdown of the reservoir is underway (overtopping failure mode).
- Damage (unintentional or deliberate) to dam structures that requires repair but the dam can continue to safely operate.
- Temporary gate operation failure that can be resolved without presenting a threat to the dam (e.g. loss of primary power requiring secondary power and/or backup actuation systems to be used). This may require reduced outflows from Owen Falls for a short period of time until the gate is returned to operation.
- More permanent gate damage that can be resolved without presented a threat to the dam (e.g.
 gate jamming following an earthquake or other operation that results in damage). This may
 require reduced outflows from Owen Falls for a moderate period of time until the gate is
 returned to operation.
- Unintentional operation of one or more of the spillway radial gates that cannot be immediately addressed (by closing the gates) BUT tailwater alarm and Isimba Dam spillways operational and can safely accommodate discharge. NOTE: sudden release discharges up to 500 m³/s trigger Response Level 1 due to potential life safety risk to downstream people (refer Spillway Gates Technical Instruction).

3.5.3 Response Level 2 - Potential Emergency

A Potential Emergency scenario is where an event has the <u>potential</u> to affect external parties. In the event of a Potential Emergency, call the Uganda Police Force (DPCs for Buwenge, Buikwe, Kayunga, and Kamuli) to provide initial warning of a Response Level 2 Potential Emergency, and then contact

UEGCL Isimba and Kiira/Nalubaale. The Uganda Police Force will also notify the Uganda Peoples' Defence Forces (UPDF).

The purpose of this step to enable early warning and communication of a potential issue that may develop into something requiring the emergency services to respond (for example a Potential Emergency that subsequently develops into an Imminent Failure). This Response Level 2 does not call for immediate evacuations downstream.

Examples of Potential Emergencies include:

- Observations of unusual and large seepage flows through the embankment dams and/or foundations and/or interfaces between concrete and embankment fill that is increasing but not discoloured and preventative measures/ intervention (such as dumping rockfill, grouting and/or emergency drawdown of the Bujagali Dam reservoir) are being attempted but may not be successful (internal erosion/concentrated leak failure modes). May follow a large earthquake or occur under normal operation.
- Evidence of foundation seepage and erosion that is increasing (e.g. new seepage zones and/or sand boils at downstream toe) with steady/increasing reservoir levels. Significant visual changes on embankment crest and slopes such as development of settlement, cracking depressions, bulges and slides AND Bujagali Dam reservoir can be drawn down for repairs to be implemented but extent of erosion requires significant repairs with associated long timeframes.
- Moderate sinkhole/movement/ deformation/settlement/cracking that has not resulted in significant loss of freeboard but require immediate repair to reduce risk of overtopping during higher reservoir levels. May follow a large earthquake or occur under normal operation.
- Changes in seepage/uplift pressures at the concrete dams (such as increasing seepage into
 concrete dam galleries or through concrete joints, and rapidly increasing piezometer levels, OR
 rapidly increasing piezometer levels with reduced/no seepage flows into the dam galleries, AND
 apparent distress to the dam (such as cracking and dislocation) while interventions are
 implemented (i.e. emergency draw down of the Bujagali Dam reservoir).
- Water level exceeds 1112.5 m RL and downstream face is showing evidence of erosion and/or widespread seepage (internal erosion/concentrated leak failure modes) AND Bujagali Dam reservoir cannot be immediately drawn down.
- Extensive scour at embankment dam toe (central or right) that may continue to undermine the
 downstream slope but the inflows are reducing, and/or Bujagali Dam gates can be
 closed/discharge reduced to enable repair.
- Unscheduled/unintended very high discharge from Owen Falls.
- Loss of control at Owen Falls due to hijacking / sabotage / coercion or terrorist attack during normal lake levels.
- Loss of control at the Bujagali Dam, with the gates shut and power station inoperative with significant inflows causing reservoir level to rise, and water level may exceed 1112.5 m RL. BUT upstream flows can be reduced at Kiira/Nalubaale in sufficient time to prevent dam failure.
- Dam failure at Owen Falls during normal operation (non-flood), and pre-emptive drawdown of the Bujagali Reservoir in advance of dam failure may be sufficient to prevent overtopping of the Bujagali Dam and cascade failure.

- Unintentional operation of one or more of the Bujagali Dam spillway radial gates that cannot be immediately addressed (by closing the gates within 10 mins) and Isimba Dam spillways may not be immediately operational but there is still time to safely accommodate discharge by increasing discharges at Isimba. NOTE: Sudden release discharges from 500 to 1000 m³/s trigger Response Level 2 due to potential life safety risk to downstream people (refer Spillway Gates Technical Instruction).
- Explosion on gated or siphon spillway that causes uncontrolled release of water but damage is self-limited to spillway chute and does not immediately destabilise the adjacent embankment or concrete dam. Upstream flows can be reduced to safe levels while repairs are undertaken to restore safe operation.

3.5.4 Response Level 3 - Imminent Failure

An Imminent Failure scenario is when an event that <u>will affect</u> external parties is underway or is inevitable. For this EPRP, this means a dam breach has either occurred, is occurring or is obviously about to occur. In the event of Imminent Failure, call the Uganda Police Force DPCs (Buwenge, Njeru, Kayunga, and Kamuli) immediately and request immediate evacuation of the potentially affected areas(s) using the attached Hazard Plans in the Quick Reference Guide.

The Uganda Police Force will typically act as the initial lead for the emergency response (including contacting the UPDF, and the Ministry of Relief, Disaster Preparedness and Management (Office of the Prime Minister), until such time as the NECOC and DECOCs are activated and operational. The Dam Owner (BEL) should also immediately notify the relevant internal BEL persons in accordance with the BEL internal communications plan.

Examples of Imminent Failure scenarios include:

- Observations of unusual and large seepage flows through the embankment dams and/or foundations and/or interfaces between concrete and embankment fill that is increasing and discoloured and preventative measures/intervention (such as dumping rockfill, grouting and/or emergency drawdown of the Bujagali Dam reservoir) have been attempted but are not successful (internal erosion/concentrated leak failure modes). May follow a large earthquake or occur under normal operation.
- Evidence of foundation seepage and erosion that is increasing (e.g. new seepage zones and/or sand boils at downstream toe) with steady/increasing reservoir levels. Significant visual changes on embankment crest and slopes such as development of settlement, cracking depressions, bulges and slides AND Bujagali Dam reservoir cannot be drawn down to halt failure.
- Large sinkhole/movement/ deformation/settlement/cracking that has resulted in significant loss of freeboard and interventions are not successful such that overtopping is expected. May follow a large earthquake or occur under normal operation.
- Apparent distress to the dam (such as cracking and dislocation) and interventions are unsuccessful (i.e. emergency draw down of the Bujagali Dam reservoir).
- Water level exceeds 1112.5 m RL and downstream face is showing evidence of erosion and/or widespread seepage (internal erosion/concentrated leak failure modes) AND Bujagali Dam reservoir cannot be immediately drawn down.

- Extensive scour at embankment dam toe (central or right) that may continue to undermine the downstream slope AND the inflows are not reducing, and/or Bujagali gates cannot be closed/discharge reduced to enable repair.
- Unscheduled/unintended high discharge from Owen Falls that is of long duration and includes full discharge for gates, sluiceways and power stations.
- Loss of control at Owen Falls due to hijacking / sabotage / coercion or terrorist attack and imminent and/or potential dam failure at either Kiira or Nalubaale is expected following malicious operation or damage to dam structures
- Dam failure at Owen Falls during flood operation, and pre-emptive drawdown of the Bujagali Reservoir in advance of dam failure is unlikely to be sufficient to prevent overtopping of the Bujagali Dam resulting in cascade failure.
- Loss of control at the Bujagali Dam, with the spillway gates shut and power station inoperative
 with significant inflows causing reservoir level to rise, and water level has exceeded 1112.5 m
 RL, AND upstream flows cannot be sufficiently reduced at Kiira/Nalubaale (e.g. due to flood
 response).
- Unintentional operation of one or more of the Bujagali Dam spillway radial gates that cannot be immediately addressed (by closing the gates) and Isimba Dam spillways are not operational and there is unlikely to be time to safely accommodate discharge by increasing discharges at Isimba (such that failure of Isimba Dam is possible) and upstream flows are not able to be reduced at Owen Falls to reduce inflows. NOTE: Sudden release discharges > 1000 m³/s trigger Response Level 3 due to potential life safety risk to downstream people (refer Spillway Gates Technical Instruction).
- Explosion / collision / impact at the Bujagali Dam that causes major damage and uncontrolled release of water, especially to a concrete gravity dam block or embankment dam section.

3.6 Example event scenarios

Determining and monitoring a dam safety threat, classifying the threat, and assigning an appropriate response level for the specific combination of variables at each point in time is a complex and challenging process. This EPRP provides a decision making and action framework with examples of potential dam safety threats and emergencies but is not and cannot be an exhaustive list of all conceivable combinations of events and situations. Additional examples of potential credible events are provided in the Quick Reference Guide (as simplified event trees) to aid exercising of this EPRP and to provide additional guidance on how to implement this framework in response to a specific combination of events.

Emergency preparedness

4 Emergency preparedness

4.1 Overview

In addition to the measures in place for early detection, evaluation, classification and notification of emergency response levels and conditions under this EPRP, BEL has also carried out extensive planning and preparation to enable early identification and response to dam safety threats and other adverse conditions that could potentially develop at the facility.

Emergency management planning to respond to, and manage such conditions have been developed and established as standard operating procedures at the Bujagali Dam. Responses cover the spectrum from preliminary actions such as observation and recording of the developing emergency condition to management and mitigative actions such as control of development of the condition, by addressing the root cause, or repair of the damage.

Preparedness planning to limit impacts and damage resulting from emergency conditions include the following operational rules and warning procedures:

- Flood Operation Rule.
- Flood Warning Manual.
- Dam Discharge Warning Manual.
- Other operational constraints as imposed by UETCL NCC.

This section of the EPRP outlines the emergency preparedness measures and supporting information to support preparations for dam safety emergencies at the Bujagali Dam.

4.2 Preventive measures

The measures in place to prevent emergency conditions from developing at the Bujagali Dam include:

- Sound engineering standards and practices used for design, construction, operation, maintenance and surveillance of the Bujagali Dam and appurtenant structures to minimize the risk of failure.
- Operation and maintenance staff who are skilled and well trained in operation and maintenance practices and timely response to emergencies.
- A fully manned site on a 24-hour per day basis and regular and systematic surveillance carried out as described below.

4.3 Surveillance procedures

All BEL O&M and security personnel are responsible for bringing abnormal conditions that may or may not represent emergency conditions to the immediate attention of the Operator Lead or the Asset Manager.

Dam performance indicators are continuously observed, controlled and recorded in the powerhouse control room. Key water levels such as reservoir and tailwater elevations are alarmed to draw immediate attention to unusual conditions. Remote video monitors are also positioned at selected sites to enable direct visual observations and confirmation of remote sensors.

The majority of BEL staff, including senior management, maintenance and administrative personnel are on duty from Monday through Friday during the daylight hours. Reduced manpower shifts are on duty during the nights, weekends and holidays. These shifts generally consist of control room operators and site security personnel.

During the daytime shifts, the Asset Manager is usually on site — or if absent, a designated senior manager is designated as the "acting" Asset Manager. During evening and weekend shifts, the Operator Lead is the senior representative for the dam.

During normal conditions, the Asset Manager's staff, led by Operator Lead, will inspect all key dam features, recording their findings on the Daily Report Log. Senior management reviews these reports at least daily. Routine inspections include:

- Visual inspection of the dam crest, the upstream and downstream slopes and the abutment interfaces, and the dam toe (earth embankments and concrete gravity dams).
- Visual reading of reservoir level.
- Visual inspection of the spillway gates, gated spillway structure, and siphon spillway.
- Observation and recording of the concrete dam seepage drains, and right embankment drain.
- Review of weather forecasts.

Weekly inspections consist of:

- Visual inspection (walk-through) of all dam and spillway galleries.
- Test operation of all emergency diesel generator sets.
- Inspection of spillway gate mechanical and hydraulic systems.

During adverse, unusual or emergency operation conditions, the frequency of inspections may be increased and/or additional dam features may be added to the inspection process as determined by the Asset Manager.

4.4 Early warning and Control Systems

4.4.1 Summary

The following systems are in place at Bujagali for early detection and warning of development of emergency conditions:

- Long term water level records for Lake Victoria (informing awareness of potential for high discharges and increased hazard for cascade failure scenarios).
- Online access to flow and water level records from Owen Falls (Nalubaale/Kiira Power stations) (manually entered into spreadsheet).
- A continuous and telemetered water level recorder located in the Kiira HEP tailrace.
- Dam monitoring instrumentation including seismic instrumentation.
- Access to Uganda wide seismic event monitoring and notification (via publicly available sources such as USGS).
- Specific warning and control systems for the gates (refer below).

4.4.2 Spillway gate systems

Each spillway gate has a local control console, providing local monitoring and control facilities. In addition, remote monitoring and control facilities are available at the Control Room. Lockable local/remote selection is provided at the local control consoles.

Controls include open/stop/close and emergency close and these will be supplemented by indications of gate position, gate fully open/fully closed indications, and gate cracked open indication. Local gauges indicating percentage gate opening are also provided. An alarm panel is provided at each local control console to display essential alarms. These are repeated back for remote monitoring and logging at the Control Room.

Facilities are provided on all equipment to permit the transmission of appropriate indications, alarms and controls by telemetry to the UETCL National Coordination Centre (NCC). Alarm equipment is provided on the plant control panels and is equipped with interface equipment to allow transmission of each alarm to the Control Room.

Multi-way alarm annunciators are provided on each control panel for the display of alarms for the circuits controlled from that control panel. Initiation of the alarm shall cause an individual alarm window to give flashing illumination and an audible alarm to sound.

Alarm annunciator ways are suitable for initiation by contacts closing or opening and for transient or persistent alarms. Each alarm annunciator is provided with accept, reset and lamp test facilities. Operation of the "Accept" facility causes the individual alarm window to be steadily illuminated and the audible alarm to silence.

A common audible alarm silence facility is provided on the control board to silence the audible alarm without causing change in alarm window illumination. Initiation of another alarm will cause the audible alarm to re-sound.

Transducers are used to provide telemetering signals to the powerhouse Control Room.

The following water level recorders are used as part of the warning and alarm systems:

- a An electronic gauge located in a stilling well in the Head Pond (Bujagali Dam reservoir) to measure the level of water in the Head Pond. There are two backup water level sensors in the headpond.
- b An electronic gauge located in a stilling well in the Tail Water to measure the level of water in the Tail Water.

Signals are sent over the serial data link to the Bujagali HV substation, for onward transmission to the UETCL National Coordination Centre (NCC), to indicate (among other parameters) Head Pond and Tail Water levels. These systems shall provide electronic signals to the NCC, via the UETCL SCADA system, and the Control Room DCS, at a sampling rate of at least once every six seconds.

The spillway gates can be operated remotely or locally. In addition, the Control Room has a switch which allows further remote gate operation to take place at the Bujagali switchyard or at the NCC.

As such, there are 4 levels of control of the equipment:

- LEVEL 0 LOCAL-LOCAL CONTROL FROM THE EQUIPMENT CONTROL CUBICLE
- LEVEL 1 LOCAL CONTROL FROM THE UNIT LOCAL CONTROL CUBICLE
- LEVEL 2 REMOTE CONTROL FROM MAIN CONTROL ROOM VIA OPERATOR STATIONS
- LEVEL 3 REMOTE CONTROL FROM NCC LUGOGO (DISPATCHING CENTRE)

In case of power failure, the control systems can be powered by battery or standby generator. In addition, the gated spillway is designed to close by gravity, and thus can be closed with power off.

4.4.3 Downstream warning systems

The Bujagali Dam features an automated spillway gate operation warning siren (that activates 30 seconds in advance of gate opening as per TI-0216) and that is audible for approximately 2 km downstream of the dam. This warning siren can also be operated manually to warn the general public immediately downstream of any potential or imminent failure of the dams by breach.

4.5 Site access

4.5.1 Dam location

The general location of the dam is shown in Figure 4.1 below.

4.5.2 Road access

The main road access routes to the dam are shown in Figure 4.1. Permanent road access to the dam is only from the western side (true left bank). Alternative access from the eastern (true right bank) via local roads is also possible in an emergency.



Figure 4.1 Bujagali Hydropower Dam access routes from Jinja and/or Njeru (image sourced from Google Earth)

Main road access to the Bujagali Hydropower Dam includes:

- From Jinja, follow the A109 highway across the Jinja Nile bridge to Njeru (west/true left bank) and then,
- From Njeru, follow the Kampala Jinja Highway north to the Bujagali Dam site access turn off.

Typical road travel time to the Bujagali Hydropower Dam is roughly 40 minutes from Jinja and 30 minutes from Njeru. The gates and security clearance at the site entry are operated during normal business hours only. Out of hours access to the dam will require access to be arranged with BEL.

4.5.3 Alternative access routes to site

As the Bujagali Dam is a continuously manned on site operated facility, there are personnel on site at all times (i.e. 24 hours/7 days a week). This reduces the reliance on needing to access the dam site during an emergency to effect operational measures and/or undertake surveillance, provided the on site staff are suitably trained and experienced to respond to dam safety events (in the unlikely event that this occurs).

Emergency access to the dam site for vehicles may be necessary for construction plant/equipment where the emergency response involves earthworks (e.g. placement of large rock and/or mass concrete into a forming breach). There is the potential for secondary access to the dam site from the eastern bank via local roads/tracks (refer Figure 4.2).

Should the local roads be impassable by vehicles, alternative access to the dam for personnel only is by foot. Alternative personnel and light equipment access may also be possible by chartered helicopter (refer below) where road access routes are closed or inaccessible.



Figure 4.2 Bujagali Hydropower Dam primary and alternative access routes (image sourced from Google Earth)

4.5.4 Helicopter operators

In the event that vehicle and foot access to the dam is not available or safe, and visual inspection is required, charter helicopter services may be available to provide alternative access. Refer to the Quick Reference Guide for contact details of potential charter helicopter operators.

4.6 Response during darkness

Noting that the dam crest features street lighting along the upstream face, in case of a potential emergency occurring during night time, the following should also be considered:

- Ensure 24/7 access to a number of battery and vehicle operated spotlights are available.
- Where preventative and/or intervention works are required, hire of portable spotlights and associated power supply where needed (see below).

4.7 Response during adverse weather conditions

Noting that the site is fully manned, they may still be a necessity for key staff and/or emergency responders to access the dam site (i.e. to relieve on call staff and/or implement emergency response procedures such as physical works to save the dam). In case of a potential emergency occurring during adverse weather conditions, the following should be considered:

- If the roads are affected by adverse weather or are reasonably anticipated to be or become affected, consider the alternative access routes (outlined above).
- EPRP response personnel should have access to appropriate clothing and equipment, suitable for the weather conditions.

4.8 Response during weekends & holidays

If an emergency occurs over a weekend or holiday, the responsibilities and notification procedures remain unchanged. The Operator Lead leads the EPRP response and the operations staff on duty will conduct initial preventive or mitigative actions. Immediately thereafter, all on-call personnel and senior management will be advised and appropriate response actions initiated.

4.9 Response personnel safety plans

Each organisation with a role in this EPRP should have their own safety plans and procedures that are specific to their personnel and roles, and compliant with the relevant Uganda legislation.

4.10 Communications systems

This section briefly describes the communications systems that are typically available along the dam and which may be used during emergency preparation and response.

A dedicated fibre optic connection is available between the Bujagali Asset Manager's office, Owen Falls (Nalubaale and Kiira power stations) and the UETCL NCC. This route should be used in the first instance for coordination between these organisations.

Alternative (and on site) means of communication are:

- Mobile phone. Network coverage is generally available at or near the dam site, but may not be available during some emergency events (if the mobile network is down).
- Landline phone. There are fixed line phones at the BEL Offices, Control Room and power station.

The Dam Owner (BEL) should ensure that these communication systems are maintained and remain operable as far as is reasonably possible. The emergency contact details are provided in the Quick Reference Guide.

Emergency contact phone numbers are displayed on the walls at the administrative office, the powerhouse Control Room and the spillway and intake gate control buildings. The posted information shall be updated by BEL whenever there is a change to the notification contacts.

4.11 Sources of emergency materials, supplies and equipment

The materials, supplies and equipment required for the emergency response will depend on the specifics of the dam safety event. BEL should have pre-arranged agreements with the suppliers listed in this EPRP to enable timely mobilisation if their services are needed during an emergency.

Contact details for potential local sources and suppliers of materials, supplies and equipment are summarised in the Quick Reference Guide. Generally earthmoving plant is large, slow to move and therefore due allowance must be made for the time it will take to reach the site. Wherever possible equipment located in the vicinity of the dam should be used.

The dam site is equipped with accommodation and provisions/food for the site personnel to operate for a minimum of 7 days without relying on any outside assistance. The accommodation is located in the administration office near the powerhouse. This office contains all information (documents, manuals, drawings, reports, etc.) relating to the Dam and project features. The administration office is also adjacent to the warehouse that contains materials, tools, supplies, vehicles and equipment for normal and emergency conditions.

4.12 Technical and operational support resources

Managing an emergency is demanding on staff and additional resources may be required if the emergency is likely to extend beyond 10 hours. Specialist technical advice may be required from Technical Advisers and additional operational staff may need to be mobilised.

BEL should have pre-arranged agreements with Technical Adviser(s) suppliers listed in this EPRP to enable timely mobilisation if their services are needed during an emergency. BEL is responsible for dam safety decision making, and technical advice (where provided) is intended to aid BEL's decision making only.

Contact details of key operational staff and the Technical Adviser(s) are provided in the Quick Reference Guide.

4.13 Power supply and communications infrastructure

The following services and infrastructure exist at or near the power station, and therefore are at potential risk if an event were to occur:

- Power and control cables to the gates on the dam.
- 220 kV Transmission line from Bujagali to Kawanda substation.
- 132 kV Transmission line from Bujagali to Tororo transmission line.
- 132 kV Transmission line from Bujagali to Nalubaale substation.
- Optical fibres on all the above transmission lines.

The vulnerability of this infrastructure should be considered as part of emergency preparedness with consideration of the available backup systems that may be required in specific emergency events.

Emergency response

5 Emergency response

5.1 Process

The response process for dam safety emergencies is described in this section. The response process follows identification of a safety threat, assessment, and declaration of a dam safety emergency and classification (where appropriate) as summarised in the Quick Reference Guide and described in more detail in Section 3. The response process covers notification to the relevant parties (as appropriate), actions, and termination of the event and documentation of the event and response. Response flow charts are presented in Charts 1 to 5 attached in the Quick Reference Guide.

NOTE 1:

Should dam breach appear likely or in progress, this is an emergency situation (Imminent Failure), call the Uganda Police Force (DPCs) first and request evacuations, then call UEGCL Isimba to notify, and follow this EPRP including event specific interventions to attempt to halt failure and/or draw down the reservoir.

NOTE 2:

BEL will respond to events and notify the relevant agencies as necessary based on the specifics of each event. In general terms this means:

- BEL assesses potential threats and determines whether an emergency is occurring.
- Safety threats that only affect BEL are responded to by BEL only (Response Level 1 Internal Event scenarios).
- Emergencies that may/have the potential to affect external parties (e.g. the public, UEGCL Isimba) are
 responded to by BEL (Response Level 2 Potential Emergency scenarios) who should also notify the Uganda
 Police Force and UEGCL to provide early warning in case the situation escalates and requires external
 agency emergency response.
- Dam failure emergencies (Response Level 3 Imminent Failure scenarios) are to be immediately notified to the Uganda Police Force and UEGCL. The Uganda Police Force will lead the initial emergency response (downstream evacuations) with support from UPDF, BEL and UEGCL. UEGCL Isimba will activate and follow their EPRP which covers the area from the Isimba Dam reservoir down to Lake Kyoga.
- At Response Level 3 Imminent Failure, the Ministry of Relief, Disaster Preparedness and Management (Office of the Prime Minister) will activate the National Emergency Coordination and Operations Centre (NECOC) and then the District Emergency Coordination and Operations Centre (DECOC) for each affected district (i.e. Njeru, Buwenge/Jinja, Kayunga, and Kamuli). The DECOCs are led by the relevant Uganda Police DPC and draw on support from the UPDF.

5.2 Notifications

5.2.1 Information to be provided by BEL to other EPRP parties

The BEL should provide following information (where it is available) when communicating with the Uganda Police Force (DPC and DECOC), District CAO, UPDF, UEGCL, UETCL, Ministry of Relief, Disaster Preparedness and Management (Office of Prime Minister) (NECOC) and/or other external parties to the EPRP:

- 1 Name of person making report and organisation they represent.
- 2 Date and time of notification.
- 3 If evacuation is requested due to Response Level 3 Imminent Failure scenario.
- 4 Name of the dam and location, and reference to this EPRP (i.e. Bujagali Hydropower Dam).
- 5 Description of problem.

- 6 Location of problem:
 - a Physical location along the dam and relative to other visible key features.
 - b In relation to dam face (e.g. halfway up from toe).
 - c In relation to crest.
 - d In terms of what part of the dam is affected (e.g. Right Embankment Dam upstream slope, downstream slope, crest, toe, radial gate 1, siphon spillway)
- 7 Spillway operation including which gates are open and estimated discharge.
- 8 An estimate of the quantity of any unusual flow, as well as a description of flow quality (e.g. clear, cloudy, muddy, etc.).
- 9 A reading/estimate of the reservoir level (read from instrumentation and/or estimated relative to dam crest level).
- 10 An indication of whether the reservoir water level appears to be rising, stable or falling.
- 11 If known, the forecast water release from Owen Falls.
- 12 An indication of whether the situation appears to be worsening, remaining stable, or improving.
- 13 An indication of whether the situation appears to be containable or not.
- 14 Anything else that the caller considers to be important.

A Notification Form is provided below to prompt information gathering and communication. The Emergency Contact List is provided in the Quick Reference Guide.

5.2.2 Notification of Response Level 1 Internal Event

At Response Level 1, no external notification is required (as the event can be safely managed by BEL at the dam site), however, coordination with UEGCL and UETCL is recommended. Preventative Action/Intervention action(s) should be implemented as detailed in Sections 5.4 and 5.5, and on Chart 2. Should notification to external parties occur, it should be put into effect with the statement that:

"This is a Response Level 1 Initial Notification that there is an active dam safety threat to the Bujagali Dam. This is being managed by BEL. No specific **action** is required at this time and you should await further notification. This is not a drill.".

Repeat the statement.

The receiving party will be asked to acknowledge their understanding of the message.

The information requirements set out in Section 5.2.1 shall then be supplied.

5.2.3 Notification of Response Level 2 Potential Emergency

At Response Level 2, the Notification and Preventative Action/Intervention requirements detailed in Sections 5.4 and 5.5, and on Chart 3 should be put into effect with the statement that:

"This is a Response Level 2 Potential Emergency notification of an emergency at the Bujagali Dam that is being responded to, but may lead to dam failure. This is not a drill. You should prepare to implement the Emergency Preparedness and Response Plan including preparing for immediate evacuation should a Response Level 3 Imminent Failure notification follow".

Repeat the statement. Make clear that this is Response Level 2, and follow up notification should be expected if immediate evacuation is necessary.

The receiving party will be asked to acknowledge their understanding of the message.

The information requirements set out in Section 5.2.1 shall then be supplied.

5.2.4 Notification of Response Level 3 Imminent Failure

At Response Level 3, the Notification and Preventative Action/Intervention requirements detailed in Sections 5.4 and 5.5, and on Chart 4 should be put into effect with the statement that:

"This is a Response Level 3 Imminent Failure notification of an actual or expected failure at the Bujagali Dam. This is not a drill. You must immediately implement the Emergency Preparedness and Response Plan on the assumption that there has been or will be a dam failure".

Repeat the statement.

The receiving party will be asked to acknowledge their understanding of the message.

The information requirements set out in Section 5.2.1 shall then be supplied.

5.2.5 Notification of Event Termination

Termination of the EPRP dam break response will depend on the most recent response level notified to other EPRP parties (refer Chart 5). Specifically:

Response Level 1 Internal Event — Where no formal notification of response level to parties external to BEL has been provided, then notification of event termination is not required. Communication via the usual coordination channels is sufficient in this instance (i.e. phone calls with UETGL NCC and UEGCL Generation Manager/Senior Shift Operator may be suitable).

Where formal notification to external parties has occurred, these same parties shall receive a follow up "all clear" / event over notification using the same information requirements outlined in Section 5.2.1. This should include positive confirmation that event termination has occurred and why.

Response Level 2 Potential Emergency – All external parties who have received notification of the response level, shall receive the event termination notification using the same information requirements outlined in Section 5.2.1. This should include positive confirmation that event termination has occurred and why. This outcome assumes the interventions were successful such that the dam safety threat has passed / been responded to and safe operation of the dam may continue with appropriate repair work (or otherwise recovery phase actions).

Response Level 3 Imminent failure — All external parties who have received notification of the response level, shall receive the event termination notification using the same information requirements outlined in Section 5.2.1. For Response Level 3, it is assumed that dam failure has occurred and post failure actions have been implemented to make the site safe prior to declaring the dam safety emergency response to be over, and moving into the recovery / rebuild phase. The decision to declare a Response Level 3 event as terminated would likely be made by NECOC and not BEL.

BUJAGALI HYDROPOWER DAM EMERGENCY ACTION PLAN

NOTIFICATION FORM – TO UGANDA POLICE FORCE

1.	NAME/ORGANISATION						
4.	EVACUATION REQUESTED? YES/NO (circle one)						
5.	DAM NAME AND LOCATION – Bujagali Hydropower Dam.						
6.	PROBLE	PROBLEM					
	6.1	Description					
	6.2	•	•	known features and wh face, toe, gated spillwa)	
7.	UNUSU	AL SEEPAGE FLOW	FROM DAM				
	7.1	Estimated Quanti	ty			•	
	7.2	Description of discolouration (e.g. clear, cloudy, muddy)					
8.	RESERV	OIR LEVEL					
	8.1	Estimated level (r	n)				
	8.2	Rising/Stable/fall	ing			··•	
9.	SITUAT	ON					
	9.1	Improving/stable	/worsening			•	
	9.2	Situation contains	able?				
10.	OTHER COMMENTS						
11.	NOTIFICATION CHECKLIST (tick when done, record time and name)						
	Bujagali Energy Limited		Time	Person Contacted			
	Uganda	a Police Force	Time	Person Contacted			
	UEGCL		Time	Person Contacted			
RECORDERS NAME, POSITION AND SIGNATURE							
Distribution: Bujagali Energy Limited, Uganda Police Force, UEGCL							

5.3 Preventative actions

Preventive actions are intended to stop and/or limit the potential for dam breach before a breach can occur (i.e. pre-emptive actions to prevent breach). The suitability of specific preventative actions requires assessment on site by informed and qualified BEL operations staff with support from the Technical Adviser(s) as required. The actions taken will be influenced by the extent of the issue identified and the available materials, equipment, personnel and time to respond.

Some examples of preventative actions include:

- Pre-emptive drawdown of the reservoir level using the gated spillways and/or power station.
 Refer to the emergency drawdown curves included in this section of the EPRP of the estimated drawdown timeframes.
- Laying sandbanks along pre-identified low points on the dam crest where overtopping is
 otherwise considered likely as the reservoir level rises. This may also occur as part of a postearthquake response where settlement/deformation of the dam crest is identified in advance
 of resumption of inflows.
- Stockpiling rock armour, cement, aggregate and/or bentonite pellets near site(s) of concern such that these are readily available should intervention be necessary (refer Section 5.4).
- Placing rock armour and/or mass concrete in areas of concern (for example, right embankment)
 prior or during a high inflow event before further scour can occur.

5.4 Emergency actions

5.4.1 Interventions

Interventions are actions taken to stop and/or reduce the extent of a dam breach <u>that has commenced</u> <u>or is about to commence</u>. The suitability of specific interventions requires assessment on site by informed and qualified BEL operations staff. The interventions made will be influenced by the extent of the issue identified and the available materials, equipment, personnel and time to respond.

Examples of interventions include:

- Commence emergency dewatering by opening both radial gates to fully open and locking them into this position, lowering the flap gates to fully down, and releasing flow through the turbines.
- Placement of fill, rock armour, large gravels, cement, concrete, bentonite pellets, filter cloth or similar into a void/crack/sinkhole in the embankment dams to attempt to limit enlargement, control seepage and otherwise prevent breach.
- Laying sandbags or granular fill on filter cloth over identified areas of foundation seepage on the downstream side of the embankment dams to try to reduce the potential for heave or continuing backwards erosion.
- Placing rockfill at the downstream toe/face of the dam to provide a buttress where slope instability is observed.
- Placing rock armour in areas below the spillway and downstream face of embankment dams that are scouring during a high flow event, which can be safely accessed, to limit further scour.

5.4.2 Cordons

Upon notification of a Response Level 2 Potential Emergency or Response Level 3 Imminent Failure scenario, the Uganda Police Force may implement and/or direct other emergency services to install cordons on the access roads in/out of an area that is/may become inundated due to dam breach. The purpose of these cordons is to prevent traffic and people from accessing the potentially affected areas.

5.4.3 Evacuation

In the event that dam breach is considered imminent (Response Level 3 Imminent Failure scenario), BEL should call the Uganda Police Force (DPCs as per communications chart) first and request evacuations. BEL will need to provide details of the dam breach location and the general area to be evacuated (using the flood hazard maps included in the Quick Reference Guide of this EPRP) for the Uganda Police Force to use.

Note: Self evacuation may be undertaken by potentially affected persons in advance of mandatory evacuation. For example, in a Response Level 2 Potential Emergency situation that appears to be slowly progressing to Response Level 3 Imminent Failure, BEL and/or the Uganda Police Force may recommend self-evacuation to potentially affected residents. This may apply to the Nile Bend Resorts and Wildwaters Lodge at Kalagala Island (Kalagala & Itanda Falls) and Whispers of the Nile.

5.5 Emergency response termination and documentation

A dam safety emergency, once declared, should not be terminated until the potential for breach has been addressed and/or the dam safety threat has passed. Termination of the response to Internal Events and Potential Emergency scenarios can be declared by the Dam Owner (BEL).

If the Ministry of Relief, Disaster Preparedness and Management (Office of Prime Minister) activate the NECOC as the result of a Potential Emergency or Imminent Failure scenario, the emergency response can only be terminated by the NECOC. Otherwise the Dam Owner (BEL) shall terminate the emergency response as appropriate.

Following a dam safety emergency, the Dam Owner (BEL) should fully document the emergency response in a report. The report should include discussion on:

- The event or condition that initiated the emergency.
- The response actions taken by the Dam Owner and all emergency responders.
- The extent of any damage to the dam(s).
- The extent and effect of any downstream inundation.
- The justification for terminating the dam safety emergency.
- Records of any modifications made to the dam or appurtenant structures during the response.
- The assessed strengths and weaknesses of the existing EPRP including the emergency management procedures, equipment, resources and leadership.
- Recommended actions to improve the EPRP.

The complete report should subsequently be circulated to all relevant parties to communicate any lessons learned and for continuous improvement.

BUJAGALI HYDROPOWER DAM DEWATERING PROCEDURES AND DRAWDOWN CURVES

PURPOSE:

The calculations in this spreadsheet set out estimates of drawdown rate for the Bujagali Reservoir under emergency conditions, such as immediately following an earthquake. The analysis is hypothetical and for use in the Emergency Preparedness and Response Plan only.

reparedness and response rian only.	
Reservoir characteristics	
Full Supply Level (FSL)	1111.5 m RL
Maximum Flood Level (MFL)	1112.0 m RL
Minimum Operating Level	1109.5 m RL
Reservoir area at FSL (up to Nalubaale Dam)	3.66 km²
Storage volume to FSL (see storage elevation curve)	12.8 million m³ live, 54.0 million m³ gross
Dam and embankment characteristics	
Dam crest level	1114.5 m RL
Tailwater level at maximum generation	1089.7 m RL
Overall length of dam crest	~ 870 m
Rockfill embankment	
Туре	Rockfill with clay core
Total length (in three sections)	~ 575 m
Maximum height	~ 35 m
Concrete structures	
Siphon spillway	~ 90 m long
Main spillway, powerhouse and adjacent concrete	~ 205 m long
gravity dam gravity dam	· ·
Spillways	
Gated spillway	
Nominal capacity at MFL (combined)	~3,300 m ³ /s*
Radial sluice gates (see discharge versus opening and	2 no. gates with top seal, 9.5 m wide x 10.5m high (height of
reservoir level curves)	opening), and invert level 1081.5 m RL
Radial gate capacity at MFL (both fully open)	2930 m3/s (1465 m3/s per gate)
Flap gate	1 no. high level gate, 12.0 m wide x 7 m high, with invert
Flap gate capacity at MFL (fully open at 15 deg)	(gate fully open) at 1105.45 m RL 355 to 423 m3/s
Siphon spillway	000 to 120 mo/3
Nominal capacity at MFL	1,200 m ³ /s
Arrangement	16 no. self-priming siphons, 5 m wide, which starting
Artungement	overflowing above 1111.5 m RL (ogee) with siphon
	activation at 1111.75 m RL
Total nominal capacity of both spillways at MFL	4500 m ³ /s
Power station	
Location and type	Surface type, left channel adjacent Dumbbell Island
Total installed capacity	250 MW
Maximum generation flow (at FSL)	1375 m ³ /s
Turbines	
Number and type	5 no. vertical axis, double regulated Kaplan
Discharge capacity	275 m³/s per turbine
*Conflicting estimates are presented for radial gate flow of	

^{*}Conflicting estimates are presented for radial gate flow capacity

The following graphs indicate the time of reservoir drawdown once the two radial gates and the flap gate have been activated fully open. The conditions of drawdown include:

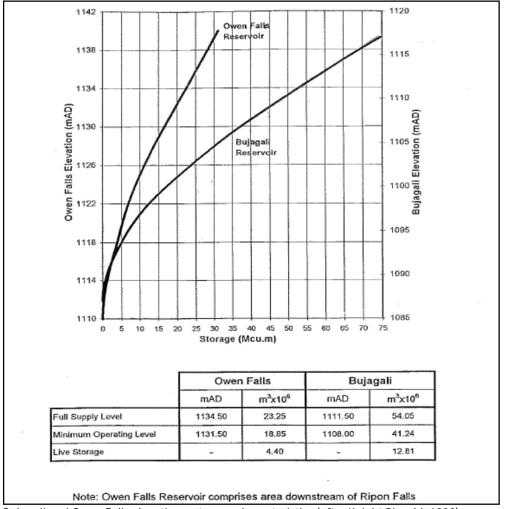
- 1) 870 cms inflow with gates full open and powerhouse operation until reservoir level reaches 1109.5 mASL, when
- 2) 0 cms inflow with gates full open and powerhouse operation until reservoir level reaches 1109.5 mASL, when the units are shut down
- 3) 870 cms inflow with only gates full open
- 4) 0 cms inflow with only gates open
- 5) 1700 cms inflow with gates full open and powerhouse operation until reservoir level reaches 1109.5 mASL, when the units are shut down

Data Sources:

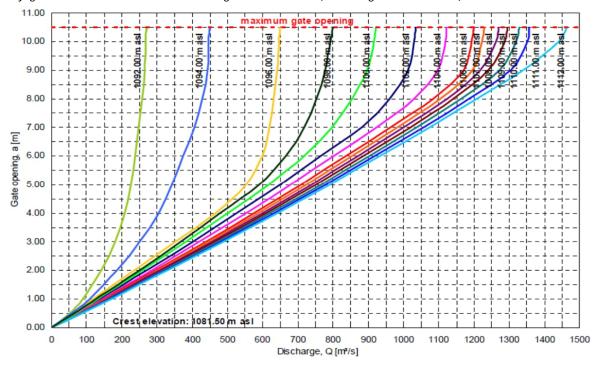
"Bujagali Hydropower Project Feasibility Study" by Knight Piesold for AES Nile Power, 1998 Spillway Gates Manual TI-0216

Design reports and drawings by Fichtner 2007

BHPP Final Design Report Rev 8

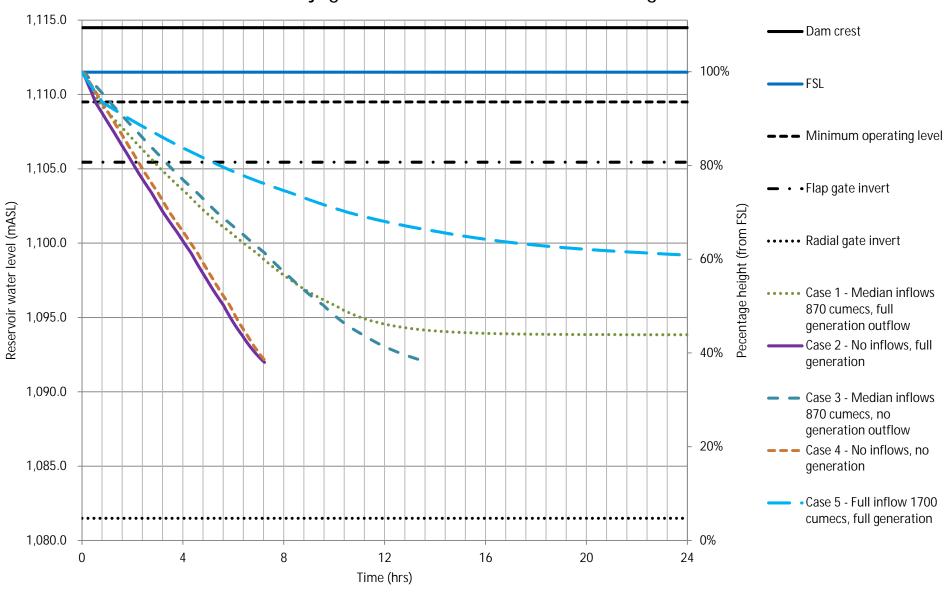


Bujagali and Owen Falls elevation – storage characteristics (after Knight Piesold, 1998)

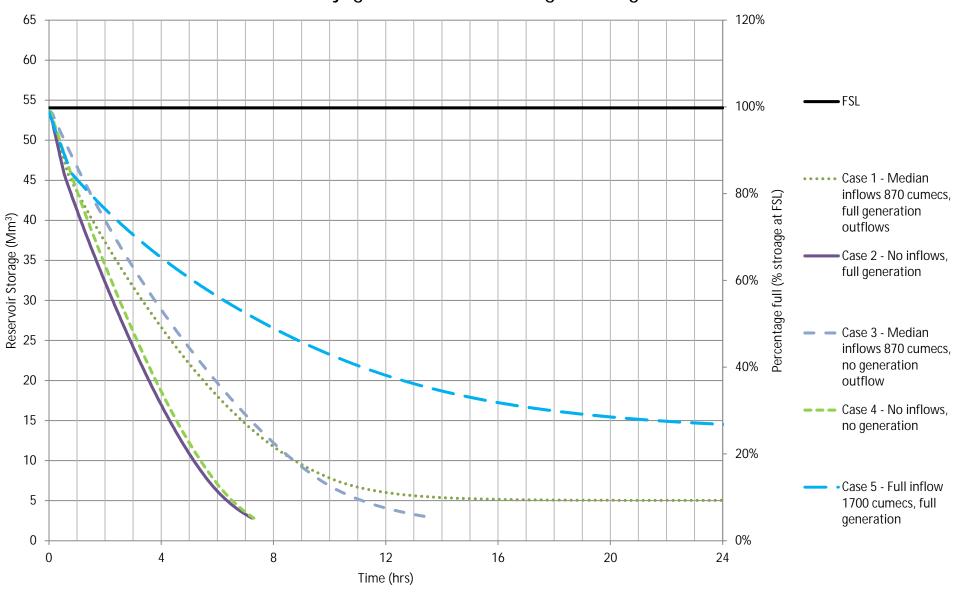


Radial sluice gate discharge through versus gate opening for range of reservoir levels for one gate (from Fichtner, 2007)

Calculated Bujagali Reservoir Water Level During Drawdown



Calculated Bujagali Reservoir Storage During Drawdown



EPRP maintenance and training

6 EPRP maintenance procedures

6.1 Training and testing

6.1.1 Summary

The Bujagali Asset Manager is in overall charge for implementing EPRP training for all BEL employees. The training of employees is dependent on their functions as well as current skills in relation to accidents and emergency situations. Based on these factors, the employees will be classified into groups. The intensity of training will depend on the characteristics of each group. Training for the security team shall be included.

The training program shall focus on the following:

- Roles and responsibilities of the employees.
- Plan procedures.
- Evacuation procedures.

The following training is recommended for personnel that have specified roles in this EPRP and/or could be reasonably expected to be involved in implementation of this EPRP:

- Personnel involved with the activation and implementation of the EPRP should attend internal training sessions specific to their organisation and role, so that they are familiar with the elements of this EPRP and their responsibilities.
- An internal test exercise involving Bujagali Energy Limited personnel, and a full communications test should be undertaken annually.
- A full-scale test exercise involving the Uganda Police, UPDF, and the other emergency services should be undertaken at no more than 2 year intervals.
- Additional tests should be conducted at the discretion of the Dam Owner (BEL) whenever justified by staff changes or for other reasons.
- The Dam Owner (BEL) should lead and participate in the planning and execution of these test
 exercises including development of the form or scenario for each test, providing information as
 required and sending out notification of the simulated breach.
- The Dam Owner (BEL) should maintain a record of each test, noting the relevant information e.g. date and time of the test and the person initiating it as well as the problems encountered and steps taken to eliminate similar problems in the future.

The Dam Owner should ensure that suitably trained staff are available and equipped to cope with all reasonable activities required under this EPRP and under foreseeable weather conditions. This is likely to require multiple staff trained and familiar with the dams and this EPRP so that cover is provide while people are on leave from work or otherwise unable to assist.

6.1.2 EPRP training frequency

All BEL operations employees undergo the basic training program that includes the EPRP upon joining the BEL. Refresher training is conducted quarterly during safety meetings. When employees change

areas or departments, the department managers provide appropriate training on their new responsibilities and procedures under this EPRP as appropriate. The Asset Manager determines the frequency of training for the managers and key emergency response personnel.

6.1.3 EPRP exercises/ drills

BEL should provide, maintain and regularly test the required materials, equipment and systems for emergency response under this EPRP. Essential information (including a copy of this Emergency Preparedness and Response Plan) and the routine test and inspection records should be made readily available to personnel with a role under this EPRP.

Emergency situations should be simulated regularly for all work shifts, to drill the employees and improve /maintain their emergency preparedness skills. The Asset Manager determines the frequency of these exercises. Specific areas to be monitored during these exercises are:

- Correct operation of alarm and other systems.
- Adherence to EPRP procedures.
- Response time of emergency contact personnel.
- Evacuation and accountability of personnel.

The exercises are documented in a report, which shall be completed by the Asset Manager. The reports should discuss the results of the exercise, problems encountered during the execution of the EPRP and any recommendations for improvements and modifications of the existing EPRP.

The Asset Manager will coordinate appropriate EPRP drills with external emergency response agencies.

6.2 Maintenance

6.2.1 Overview

Regular and systematic review of this EPRP is essential. Review and revision procedures and responsibilities are outlined below for the Dam Owner (BEL), who retains overall responsibility for the EPRP document, and other EPRP parties. The Dam Owner (BEL) is responsible for issuing, maintaining and updating all registered copies of the EPRP. The EPRP is a controlled document.

The Dam Owner (BEL) should review and update, as necessary but should not be less frequent than annually, the names and contact details of all personnel with emergency management responsibilities.

6.2.2 Dam Owner (BEL)

BEL should undertake the following:

On initial completion of EPRP revisions

The Asset Manager shall arrange for the relevant Uganda Police Force, UPDF, UEGCL, UETCL and DDMC personnel to receive a thorough briefing on major revisions to this EPRP. This is to encourage key personnel from these agencies to be familiar with the procedures for emergency reporting, notification, and action.

b Periodic review

The Dam Owner (BEL) should encourage the relevant staff from the Uganda Police Force, UPDF, UEGCL, UETCL and DDMC to maintain familiarity with the EPRP. Scheduling periodic reviews and briefings at a pre-agreed frequency may assist with this. An example EPRP review form for outside agencies is provided in this section.

c Revisions

The Dam Owner (BEL) is responsible for maintaining the currency of this EPRP and for arranging for the preparation of revisions and the distribution of controlled copies to all parties that have a role in the EPRP. A revision record should be maintained as part of the EPRP.

6.2.3 Other Parties/Agencies

Latest copies of the EPRP are to be sent to all parties/agencies that have a role in the EPRP whenever the EPRP is updated (refer to the Distribution List). Parties that have a role in the EPRP should be reviewing the EPRP for adequacy and forwarding any comment or suggested improvements to the Dam Owner (BEL). Proposed revisions should be addressed to BEL for consideration. An example revision form is provided in this section.

Agencies involved in the notification procedure for dam breach are expected to participate in the full scale exercises, complete and send the Test Report form/or other method of feedback to the Dam Owner (BEL) for consideration.

BEL will arrange for the revision of the EPRP as necessary. A record of review by outside agencies should be maintained by BEL. A review and revision record template form is provided in this section.

6.3 EPRP exercise review and revision record forms

Template forms for recording/documenting EPRP test exercises, reviews and revisions are provided below.

BUJAGALI HYDROPOWER DAM EMERGENCY PREPAREDNESS AND RESPONSE PLAN EXERCISE RECORD

TO:		DATE:		
		FILE:		
FROM:		TYPE OF TEST:		
		Limited Communicat	ions Test	
		Full Communications	Test	
		Operational Test		
		— (Please tick type of to	est)	
TIME AND DATE FIRST NOTIFIED:				
NOTIFIED BY:				
	-			
NOTIFICATIONS MADE				
NAME	AGENCY(IES)		TIME OF CALL	
MESSAGE RECEIVED/PASSED ON				
COMMENTS ON TEST:				
(If space is insufficient use addition	nal sheet(s))			

Name	Role	and	Signature
maine.	NOIC	anu	Jigilatuit

BUJAGALI HYDROPOWER DAM EMERGENCY PREPAREDNESS AND RESPONSE PLAN REVIEW RECORD

Agency	Date Reviewed	Remarks
		/
	,	

BUJAGALI HYDROPOWER DAM EMERGENCY PREPAREDNESS AND RESPONSE PLAN RECORD OF BRIEFING SESSIONS AND FULL COMMUNICATIONS AND OPERATIONAL TESTS

Date	Time	Initiated by	Description	Remarks
_				

BUJAGALI HYDROPOWER DAM EMERGENCY PREPAREDNESS AND RESPONSE PLAN REVISION FORM

To:	Dam Owner		. Date:
Fron	n:		File:
	Name	Signature	
Prop	oosed Revision:		
Othe	er EPRP's affected:		
(cc a	s applicable)		
For (Office Use Only:		
Appr	roved/Not Approved	d: /	Date:
Opei	rations Manager		
Actio	oned:		Date: