HUNTON
ANDREWS KURTH

Hydroelectric IPPs – addressing hydrological risks in a rapidly changing world

September 2021

Topics

1. **Overview**
2. Allocating hydrological risks
3. Climate change resilience – commercial and contractual implications

Overview

“Hydrology” – a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

Overview

Climate change is beginning to affect the hydrology of hydroelectric projects.

- **Examples**
  - Colorado River
    - Lake Mead (formed by the Hoover Dam) is at its lowest level since it was filled in the 1930s and is projected to end 2021 at 34% of its storage capacity
    - In August, federal officials declared a water shortage for the first time ever
  - Oroville dam (California)
    - Main and emergency spillways damaged in 2017 floods leading to evacuation of 188,000 people
    - Reservoir Regulation Manual not updated since 1970 and did not account for the effects of climate change or significant flooding events in 1986 and 1997

Overview

Considerable thought has gone into engineering hydroelectric projects for resilience to climate change.

- **Some risk mitigation measures are implemented during design; others may require adaptations over the life of a project.**
- **For hydroelectric IPPs, adaptations may lead to**
  - increased costs (including CapEx)
  - reduced revenues for the project company (depending on risk allocation)
  - financial strains on the offtaker (perhaps across multiple projects)
- **As new hydroelectric IPPs are structured, project participants would be well advised to consider the implications of adaptations that may be required during the life of the project.**

Topics

1. Overview
2. **Allocating hydrological risks**
3. Climate change resilience – commercial and contractual implications

Allocating hydrological risks

Background concepts

- **Distinguishing between large storage and run of river projects**
  - All hydro projects are unique, categorization is difficult
  - Run of river projects
    - Use a small dam or weir to ensure water enters the penstock
    - May have a small reservoir (pondage) to
      - increase head height
      - store water for same-day use
  - Large storage projects
    - Use a sizeable reservoir to store water for longer periods
    - Examples –
      - Many projects in Norway employ seasonal storage schemes
      - Nenskra (in the Republic of Georgia) will store water to meet winter demand peak

Allocating hydrological risks

Background concepts

- **Design parameters to consider**
  - Flood events
    - Design flood – the inflow to be discharged under normal conditions with a safety margin provided by the freeboard
    - Check flood – the inflow which must be bypassed safely without causing dam failure, although some damage to the dam may be acceptable
    - Glacial lake outburst flood – a sudden inflow of water and debris caused by the sudden collapse of a consolidated end moraine dam
  - Storage
    - Is storage necessary or desirable? How much?
    - Can top of cascade storage enhance the entire cascade?

Allocating hydrological risks

Background concepts

- **Design parameters to consider**
  - Capacity
    - How much generation capacity is feasible?
  - Load factor
    - Higher load factors decrease the levelized cost of electricity (LCOE)
    - For a given inflow and head height, increasing the capacity lowers the expected load factor and increases LCOE
  - Climate change
    - Design resilience to climate change
    - Economic resilience to climate change
    - Opportunities created by climate change

Allocating hydrological risks

- **Historic risk allocation in relation to hydro developed by state-owned enterprises (SOEs)**
  - SOE owns, operates project
  - SOE assumes risk of lower-than-expected load factors

- **Historic risk allocation in relation to hydro IPPs**
  - For hydro IPPs, allocating the risk of low load factors is a focal point
    - In other words, who takes the risk that water flows may be lower than expected?
  - This risk is mainly allocated by the tariff structure
  - Two main tariff structures:
    - Capacity-based tariffs
    - Energy-based tariffs

Allocating hydrological risks

- **Capacity-based tariffs generally**
  - Capacity (availability) charge
    - Payable for capacity made available, regardless of dispatch
    - Enables project company to recover fixed costs
      - Fixed operations and maintenance (O&M) costs
      - Debt service (principal and interest)
      - Return on (and of) equity
      - Taxes
  - Energy charge
    - Payable for energy dispatched and generated
    - Enables project company to recover fuel and variable O&M costs

Allocating hydrological risks

- **Energy-based tariffs generally**
  - Energy charge
    - Payable for energy generated
    - Enables project company to recover both fixed and variable costs
    - Spreads fixed costs over energy generated by assuming the primary energy source will be available at P90 exceedance probability level
  - Curtailment payments
    - Payable if offtaker cannot accept energy the plant could generate
    - Determined by reference to actual site conditions
      - Wind projects – wind speed and direction
      - PV solar projects – irradiation, ambient temperature

Allocating hydrological risks

Capacity-based tariffs tend to enhance the bankability of storage projects and run of river projects with significant pondage.

- **Adaptation (from thermal to hydro)**
  - Project company declares capacity available assuming nominal hydraulic conditions
  - Hydraulic conditions may be defined as head height or flow rate
  - Where hydraulic conditions are defined by head height:
    - Nominal hydraulic conditions = difference (in meters) between
      - top of the head pond at maximum fill; and
      - top of tailwater at maximum flow
    - Hydraulic adjusted capacity = nominal capacity *x* (actual hydraulic conditions/nominal hydraulic conditions)
- **Risk allocation**
  - The above structure allocates hydrology risk to the offtaker
  - Offtaker obligated to pay for electro-mechanical capacity regardless of head height or flow

Allocating hydrological risks

Energy-based tariffs can be combined with take or pay obligations to create a bankable energy-only tariff (with great difficulty).

- **Adaptation (from thermal to hydro)**
  - State take or pay quantities as monthly quantities (TOPQs) that reflect anticipated water flow
  - Credit the following against each monthly TOPQ:
    - Energy actually generated during the month
    - Energy not actually generated for technical reasons or any reason not attributable to offtaker or host government (other than lack of water flows)
  - If water flows are not sufficient to generate monthly TOPQ, carry the deficiency forward by adding it to subsequent TOPQs
  - If water flows for the entire year do not allow generation of sum of monthly TOPQs, either
    - Offtaker makes one-off payment; or
    - Energy charge adjusted for the following year (with interest on deferred revenues)
      - Continuing carry-forwards eventually lead to a one-off payment or project termination

Allocating hydrological risks

For smaller run of river projects, an energy-only tariff similar to those used for other variable renewable energy projects may be appropriate.

- Non-dispatchable – standing dispatch instruction to generate all energy that can be generated
- Curtailment payments payable if offtaker cannot accept energy (after an annual deductible)
- Consider an annual cap on energy the offtaker must purchase

Topics

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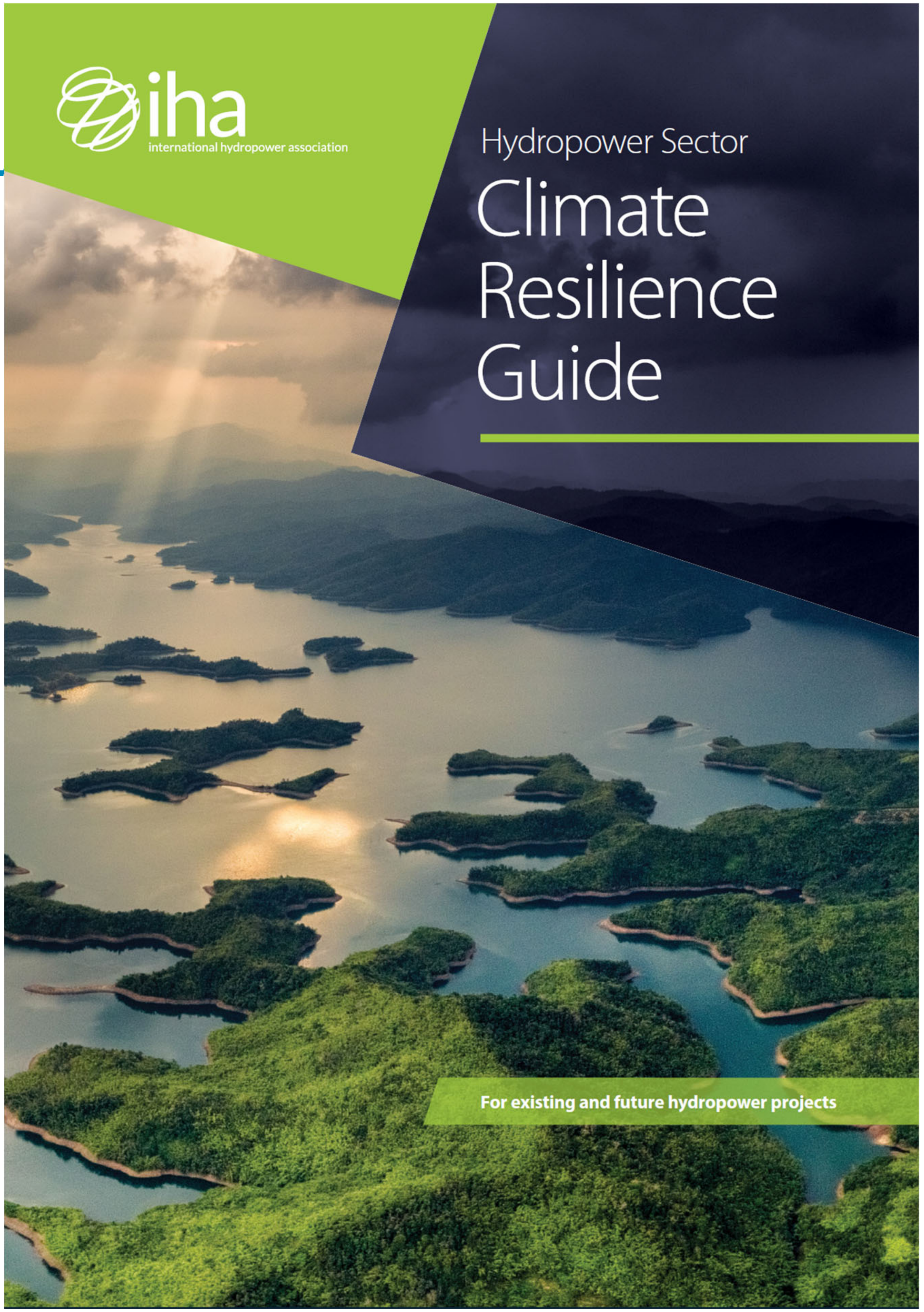
3. **Climate change resilience – commercial and contractual implications**

Climate change resilience

The International Hydropower Association (and others) have given considerable thought to engineering projects for resilience to climate change.



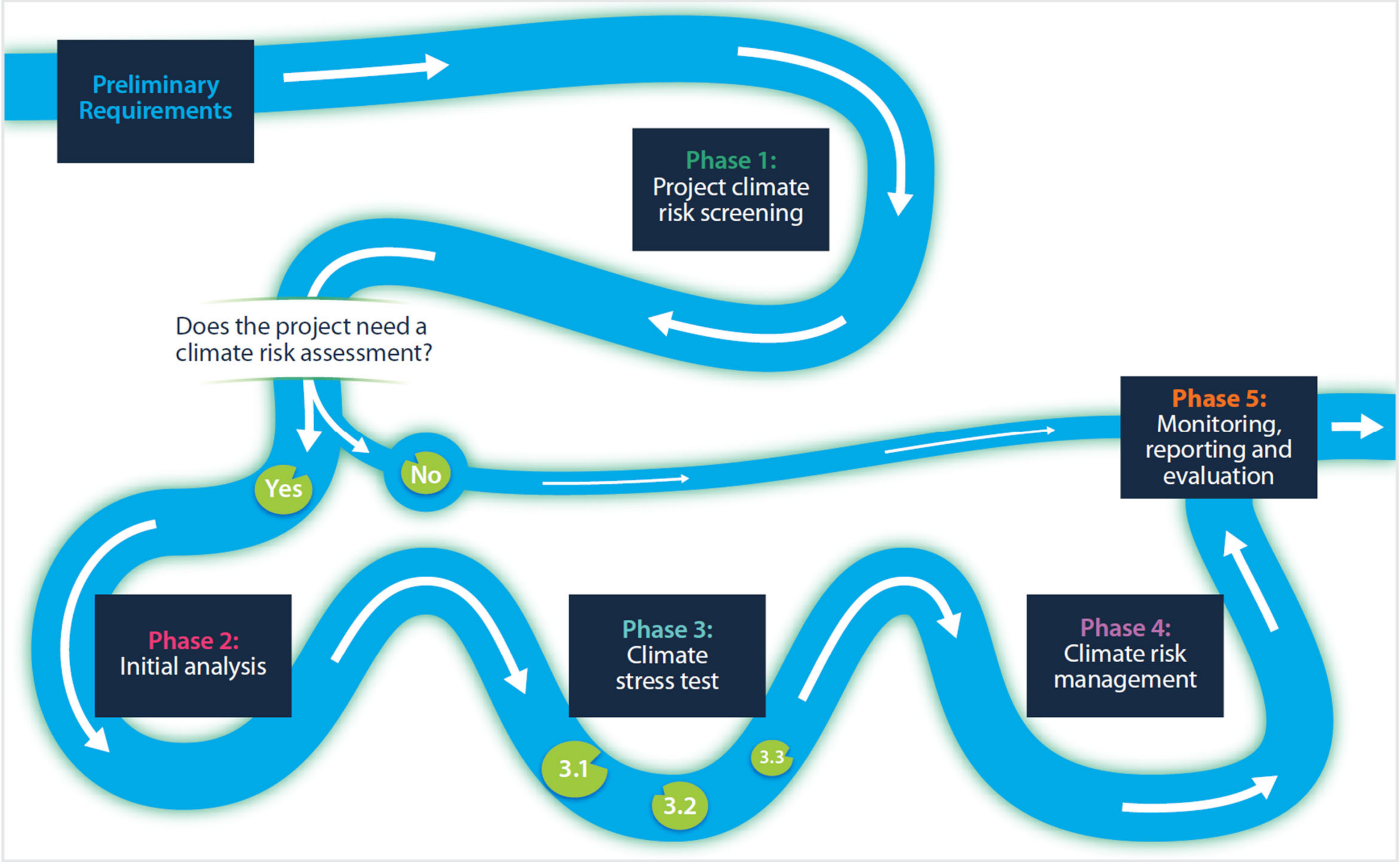
iha
international hydropower association

Hydropower Sector
Climate
Resilience
Guide

For existing and future hydropower projects

Climate change resilience – commercial and contractual implications

- **The IHA recommends a 5-step process that:**
  - Covers extreme weather events and changes to hydrological patterns
  - Evolves away from default use of historical data and assumption that the future will look like the past
  - Uses localized climate models, weather generators, and stochastic modeling techniques
  - Starts with a forward looking time horizon (recommendation = 30 years minimum)
    - 30 yrs. = typical term for project agreements (no safety margin at 30 yr. time horizon)



Preliminary Requirements

Phase 1: Project climate risk screening

Does the project need a climate risk assessment?

Yes

No

Phase 2: Initial analysis

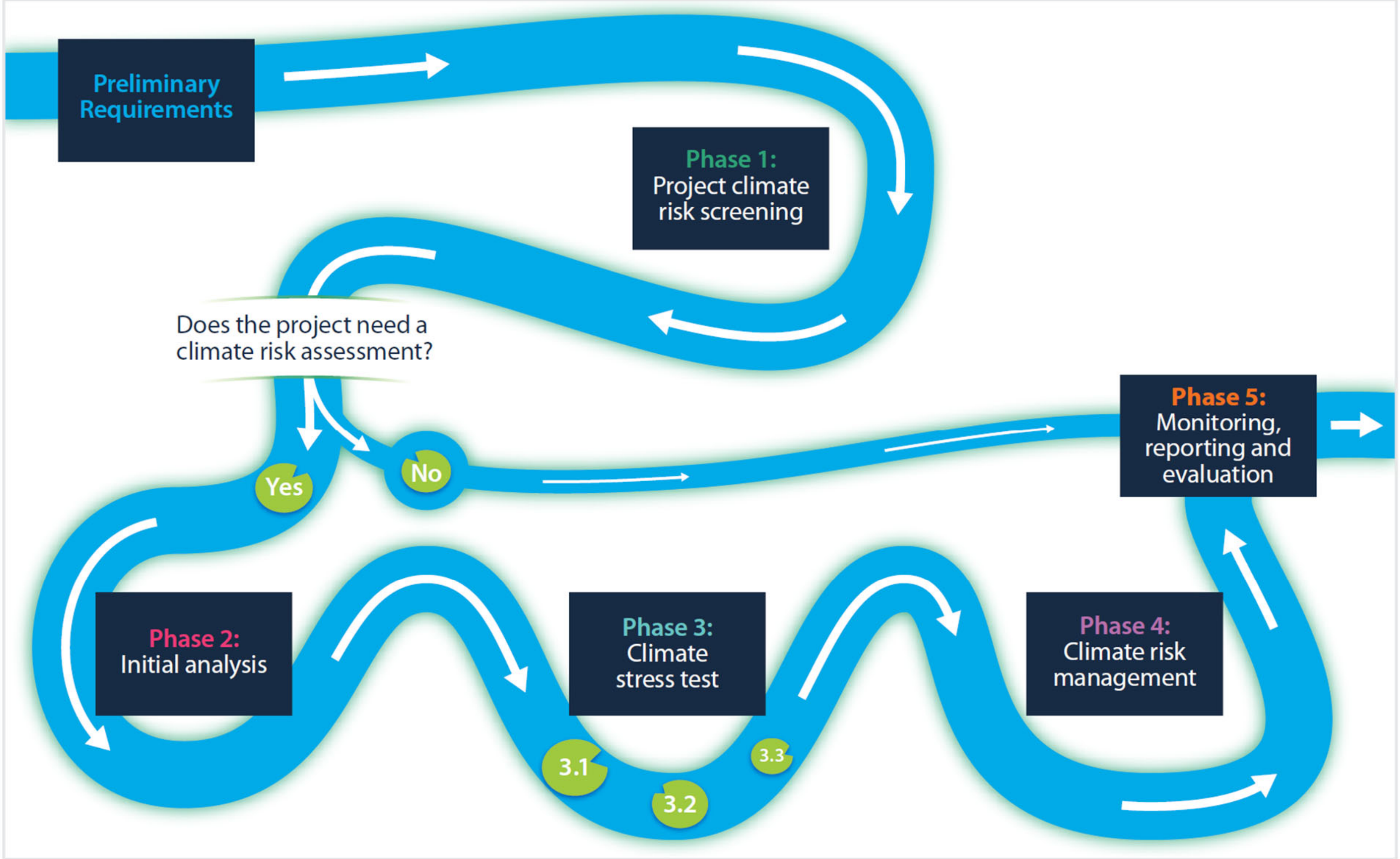
Phase 3: Climate stress test

Phase 4: Climate risk management

Phase 5: Monitoring, reporting and evaluation

Climate change resilience – commercial and contractual implications

- **Phases 4 and 5 could require adaptations during the life of a project!**
  - Structural adaptations – modifications to structures and scaling of project
  - Functional adaptations – modifications to operating policies
- **Impacts**
  - Adaptations may lead to
    - increased costs (including CapEx)
    - reduced revenues for project company (depending on risk allocation)
    - financial strains on offtaker (perhaps across multiple projects)
- **Takeaways**
  - Project agreements should contemplate adaptation strategies and provide a framework to address commercial implications
  - Additional focus on how to address commercial implications in project agreements is necessary when structuring projects



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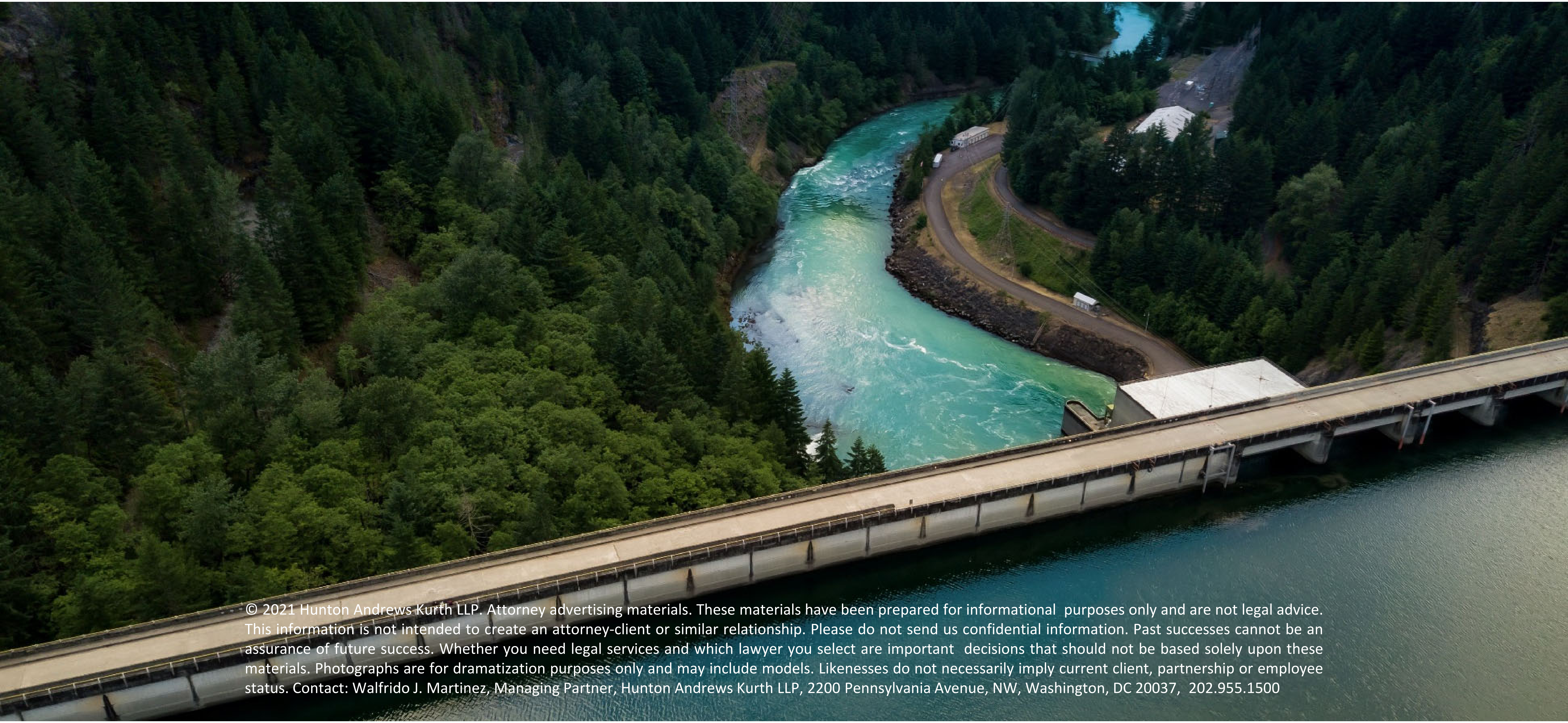

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