

## **Appendix 2 .**

### Drivers of systemic change in North American water basins

1. Ecosystem Conditions and Processes Affecting Human Communities
  - 1.1. Hydrological Conditions and Processes
    - 1.1.a. General hydrological conditions and processes
    - 1.1.b. Drought (e.g., → water storage, irrigation)
    - 1.1.c. Flooding (e.g., → flood control projects)
    - 1.1.d. Groundwater levels and dynamics (e.g., → dependence & uncertainty)
  - 1.2. Geological or Topographical Conditions and Changes (e.g., → settlement patterns)
  - 1.3. Fire (e.g., → fire suppression)
  - 1.4. Extreme or Traumatic Events; Disasters
  - 1.5. Ecosystem Services and Feedbacks (e.g., → exploitation)
2. Human Communities' Alterations of Key Ecological Features and Processes
  - 2.1. Land Use Activities
    - 2.1.a. Agricultural activities
    - 2.1.b. Land use and development
  - 2.2. Alteration of Hydrologic Structure and Processes
    - 2.2.a. Engineered infrastructure and systems
    - 2.2.b. Altered stream and riparian structure(s)
    - 2.2.c. Altered stream flows
    - 2.2.d. Water demand and supply-demand mismatches
  - 2.3. Alteration of Land-Water Nexus
    - 2.3.a. Pollution
    - 2.3.b. Runoff
    - 2.3.c. Wetland alteration or loss
  - 2.4. Climate Change
  - 2.5. Conservation Practices
    - 2.5.a. Use or conservation of green infrastructure
    - 2.5.b. Land conservation practices
    - 2.5.c. Ecological restoration
3. Social-Political-Economic Forces
  - 3.1. Economic Valuation and Exploitation of Nature
    - 3.1.a. Treatment of environmental features and services as commodifiable resources for exploitation and consumption
    - 3.1.b. Forces of economic development and production
    - 3.1.c. Cross-scale economic forces
    - 3.1.d. Public values and norms
      - 3.1.d.i. Change in public values and norms over time
      - 3.1.d.ii. Psychology of human connection to place and framing/reframing of watersheds
    - 3.1.e. Technology and engineered infrastructure as tools for exploiting nature

- 3.1.f. Business organization behavior
- 3.2. Societal Growth and Development
  - 3.2.a. Settlement, resettlement, and migration
  - 3.2.b. Urbanization
  - 3.3.c. Population growth
  - 3.3.d. Land use and development
  - 3.4.e. Technology
- 3.3. Socio-Political Activity
  - 3.3.a. Power
    - 3.3.a.i. Interest group power and conflict
  - 3.3.b. Public values and norms
    - 3.3.b.i. Economic (consumption, commodification, exploitation)
    - 3.3.b.ii. Public health considerations
    - 3.3.b.iii. Environmentalism
    - 3.3.b.iv.. Framing & reframing (psychology)
    - 3.3.b.v. Change in public values and norms over time
  - 3.3.c. Social inequity
    - 3.3.c.i.. Oppression and marginalization
    - 3.3.c.ii. Indigenous peoples
    - 3.3.c.iii. Racial and ethnic minorities; structural racism
    - 3.3.c.iv. Socio-economic class
  - 3.3.d. Mobilization and activism
    - 3.3.d.i. Community-based mobilization and activism.
    - 3.3.d.ii. Political mobilization and activism.
    - 3.3.d.iii. Environmentalism.
  - 3.3.e. Socio-political change
- 3.4. Social-Interaction Dynamics
  - 3.4.a. Conflict and collaboration
  - 3.4.b. Trust and distrust
  - 3.4.c. Culture and spirituality
- 4. Institutions and Institutional Changes
  - 4.1. Institutionalization of Social-Political-Economic Forces
    - E.g., Economic goals and values
    - E.g., Oppression and marginalization (indigenous communities, racial and ethnic minorities)
    - E.g., Environmentalism
  - 4.2. Governance Structure
    - 4.2.a. Cross-Scale governance
    - 4.2.b. Fragmentation of governance
    - 4.2.c. Mixed and hybrid governance institutions (e.g., formal-informal)
    - 4.2.d. Federal resource ownership and management
    - 4.2.e. State and local governments (polycentric structure)
    - 4.2.f. Government-created infrastructure

- 4.2.g. Government-provided financial resources
- 4.2.h. Planning
- 4.2.i. Changes in governance agency mission
- 4.2.j. Emergence of adaptive methods and tools (e.g., adaptive management)
- 4.3. Legal Activity and Legal Institutions
  - 4.3.a. Legislation
  - 4.3.b. Regulation
  - 4.3.c. Enforcement
  - 4.3.d. Litigation
  - 4.3.e. Judicial decisions
  - 4.3.f. Law as disturbance (e.g., altering status quo)
  - 4.3.g. Law as facilitator (e.g., grant of authority)
  - 4.3.h. Law as resistance and entrenchment (e.g., rigid rules)
  - 4.3.i. Changes in legal institutions
- 4.4. Institutional Change
  - 4.4.a. Emergence: graduate & organic development of new regimes
  - 4.4.b. Evolution: incremental modifications to existing regimes
  - 4.4.c. Hybridization: new regimes from synthesis of 2+ existing regimes
  - 4.4.d. Transformation: complete shift from 1 regime to another regime
  - 4.4.e. Revolution: sudden, radical change in regimes
- 5. Ecosystem Changes Affecting Human Communities: Ecosystem Services Feedbacks
  - 5.1. Extreme or Traumatic Events or Disturbances
    - 5.1.a. Drought
    - 5.1.b. Flooding
    - 5.1.c. Fire
  - 5.2. Decline or Loss of Ecosystem Features on which Humans Depend
    - 5.2.a. Species decline or loss
    - 5.2.b. Alteration or loss of wetlands
    - 5.2.c. Alteration of stream flows and water flows
  - 5.3. Major Systemic Changes
    - 5.3.a. Altered hydrology
    - 5.3.b. Climate change
    - 5.3.c. Green infrastructure performance