Small is Beautiful? State of the Dams & Management Implications for the Future

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Cornell University

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Water Resources Institute

Hudson River Estuary

Dam Inventory & Management


Gilboa Dam. Source: Wikimedia Commons

- US Army CoE & FEMA
  - National Inventory of Dams (NID)
  - 25 ft and 15 acre-ft, or 6 ft and 50 acre-ft
- U.S. Geological Survey
  - Major dams
  - 50 ft, or 5,000 acre-ft (normal), or 25,000 acre-ft (max)
- NYSDEC
  - Dam Safety Section
  - ‘Any artificial barrier, including any earthen barrier or other structure, together with its appurtenant works, which impounds or will impound waters.’

NID: 1,928

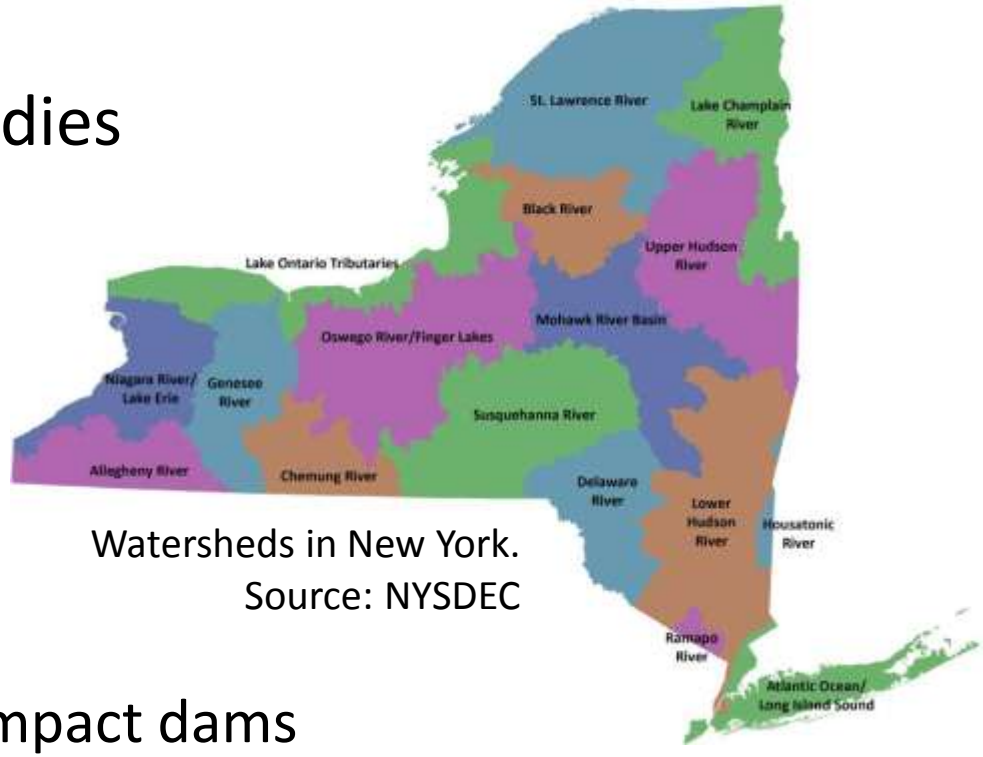
USGS: 241

DEC: 6,987

Active: 5,728

Dams in New York

- NID used in national- and regional-level studies
- Effects of small dams not accounted for
  - NY has the most number (ASDSO)
- Worked with DEC Dam Safety Section
- DEC uses 17 watersheds
- Characteristics
  - Age, concentration (density), storage, % high impact dams

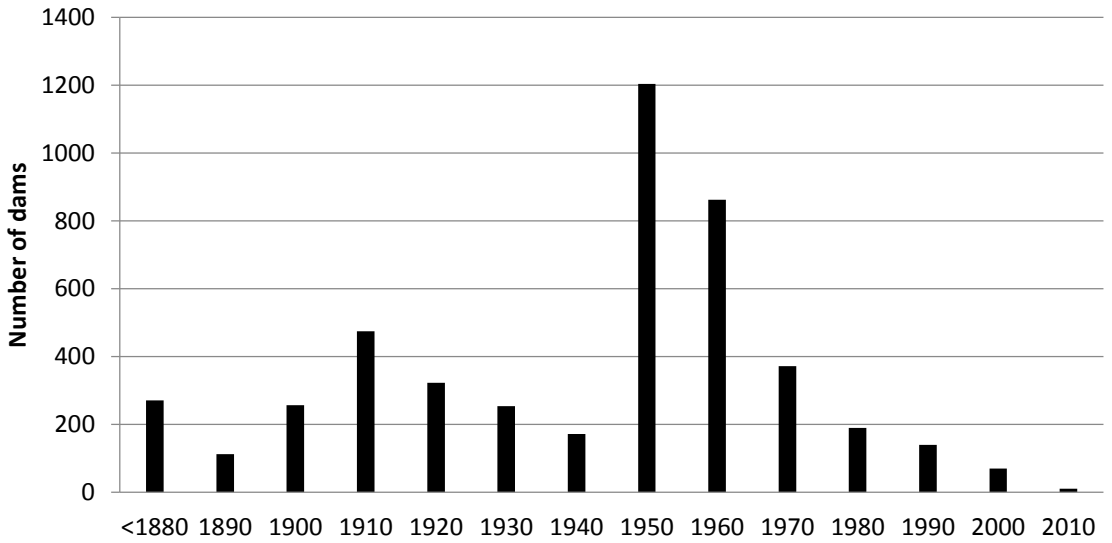


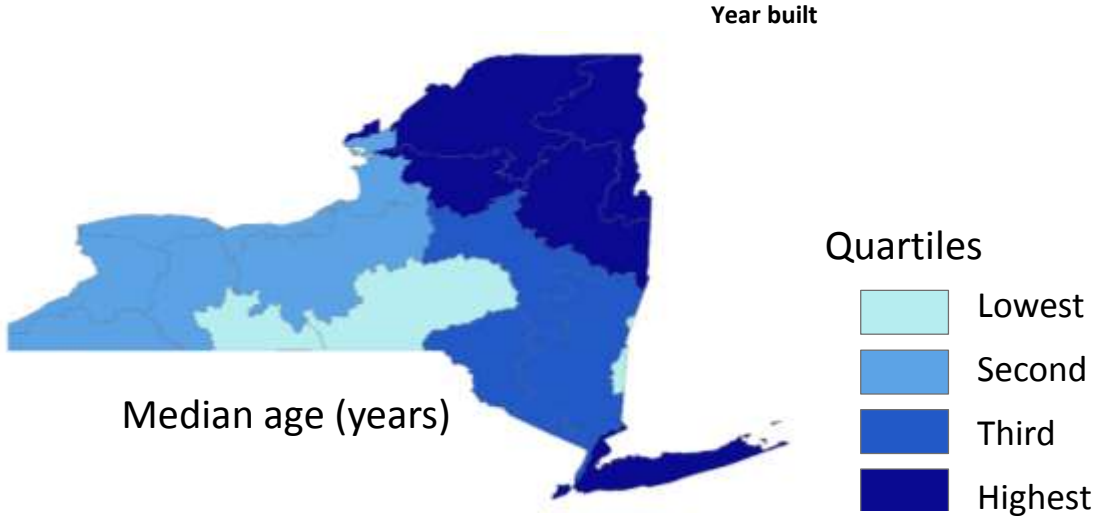
Watersheds in New York.
Source: NYSDEC

Age

- Median dam built in 1953
- LI watershed
  - Median dam is oldest
  - Also has the oldest dam (1699)
- Regions in the east
  - Dams are old, and numerous

Source: Family-images.com

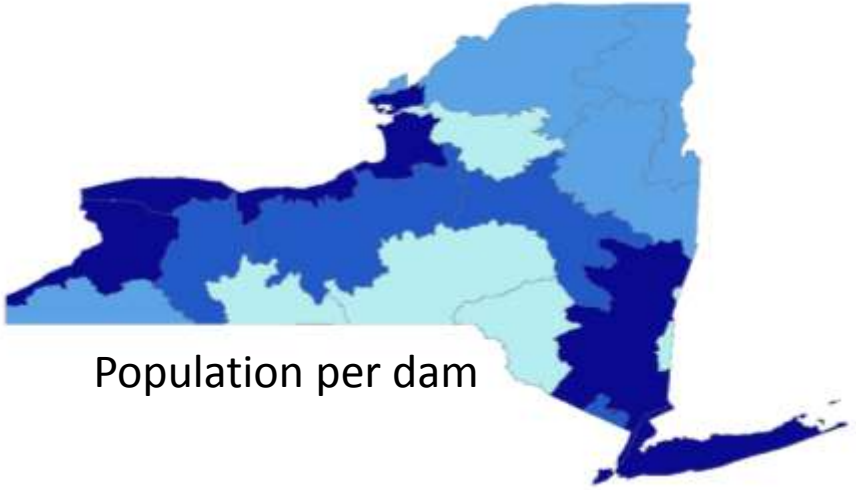




Density

- High population/dam ratio
  - Great Lakes, Atlantic Ocean
  - Dams are part of economic, social and recreational lives
  - Failure can be catastrophic
  - Long Island (57,000 persons/dam)

Flooding in the Mohawk River

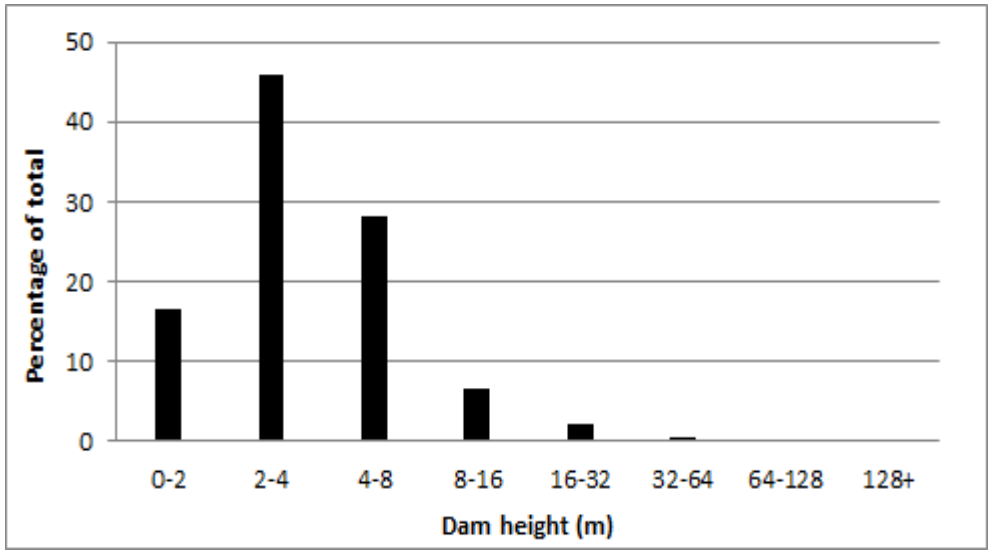


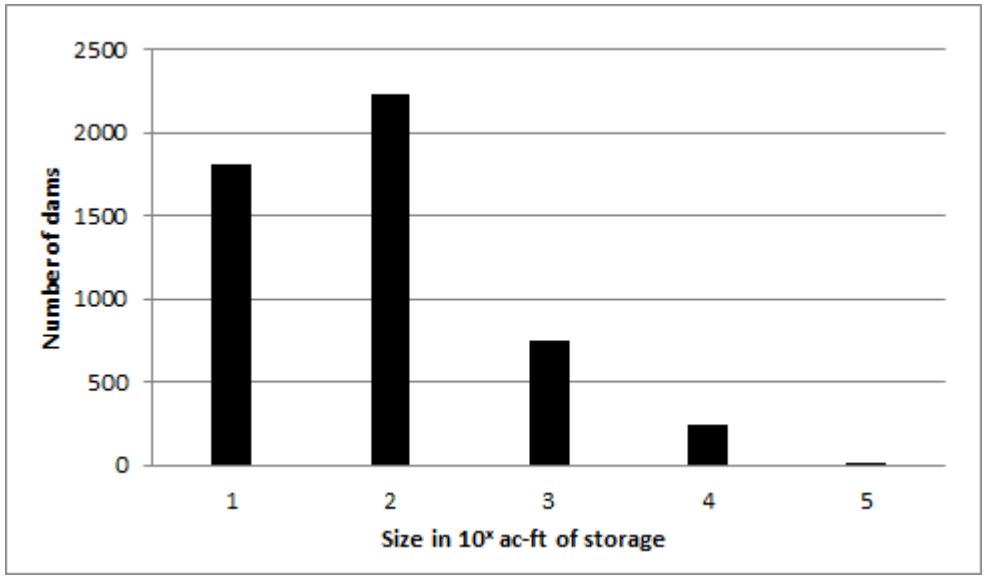
Population per dam

What is a small dam?

- NY has most ‘small dams’ in the US
- Small dams
  - Height: 2, 4, 5, 7.6, 10 & 15 m!
  - Storage: 20, 100 acre-ft
  - Low-head, run-of-river, ‘very small dam’
  - 63-80 %

Old Mill Dam on Tonawanda River in Batavia. Source Wikimedia Commons





Hazard classification

- Defined in 6NYCRR 673.5(b)
  - Class A – Low Hazard
  - Class B – Intermediate Hazard
  - Class C – High Hazard
  - Class D – Negligible or No Hazard
- Class C dams
  - 1/3 are older than 100 years
  - 1/3 are 75-100 years
  - Allegheny, Ramapo & STL have above avg.

Table II. Average age of the dams in New York

Hazard classification	Number of dams	Average year built
Class A	4093	1947
Class B	710	1934
Class C	396	1929
Class 0	529	1948
All dams	5728	1944

Table III. Number of Class B and Class C dams with Emergency Action Plans on file and exercised

Hazard classification	Number of dams	EAPs on file	EAPs exercised
Class B	710	237	14
Class C	396	360	42
Total	1106	597	56

EAPs, Emergency Action Plans.

Dam Safety & Ownership

- Dam safety budget: $1,386,500 (2011)
  - $242 per dam (vs. $510 nationally)
  - 1 FTE per 460 dams (vs. 1 FTE per 200 dams nationally)
  - Emergency response tested during Irene & Lee (2011)
- Ownership
  - Unclear ownership: 11% nationally, 3% in NYS
  - Example: New Rochelle Reservoir No. 1 Dam – Westchester Co.

Lake Innisfree. Source: Wikimapia

Dam Removal


Source: Lake Champlain International

- How does it impact local economy and community?
- Empirical studies
  - Lower Snake River, WA: Use value of river recreation = 6 * lake recreation
  - Ashuelot River, NH: Removal > dam with fish passage (using CVM)
  - WI: 14 sites with intact dams, dams removed and free-flowing rivers
    - No difference between river- and lake-side property values
    - Properties in the vicinity of rivers valued more than lakes
  - Kennebec River, ME: WTP to live farther from dam dropped after dam removal
    - $2,000 to be ½ mile away (pre-dam removal), $134 (post-dam removal)
  - Salmon River, NY: Benefits > Cost of dam removal by 4-1
    - Spatial differences; who pays?

Dam Removal (contd.)

- Since 1999
  - PA has removed 160+ dams
  - NY has removed 15 (avg. height 5m)
- Removal cost estimates hard to obtain
  - ~$216,000 for a small dam 4m high
- Repair ~= 3 * removal cost
- Benefits and liabilities over design life; stakeholder investment
- If stakeholders viewed dams not as individual structures, but rather as elements of a water development infrastructure, whose main purpose is to benefit society while causing minimal harm to the environment, the various ‘watershed interests’ could be more fully addressed.
- Cap-and-trade policy for dams

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SMALL IS BEAUTIFUL? STATE OF THE DAMS AND MANAGEMENT IMPLICATIONS FOR THE FUTURE

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ABSTRACT

Dams are a critical component of water infrastructure, providing services such as water supplies, recreational opportunities and flood control. At the same time, dams alter the flow regime of rivers and the biota that inhabit them. Large dams have been the subject of many studies because of their potentially significant impacts on stream hydrology and ecosystems. However, most dams are not large and consequently have received far less attention. Data for more than 5700 dams in New York State, USA located in 17 watersheds were used to develop watershed level metrics that relate the characteristics of the dams to the hydrology and demographics of each watershed. Metrics presented, stratified by watershed, include median structure age, density, dams per stream length, persons per dam, storage per drainage area, storage per person and percent high impact dams (high hazard and large). These metrics were used to perform a simple characterization of the 17 watersheds. Considerable regional differences in these parameters suggest varying management strategies in each watershed. A new era of river management has resulted in the removal of many dams, which is driven by the high cost of maintenance and state regulations. Copyright © 2013 John Wiley & Sons, Ltd.

Supporting information may be found in the online version of this article.

KEY WORDS: dams; dam removal; hazard; watershed characterization; infrastructure; management

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INTRODUCTION

All dams, including small dams, alter the natural hydrologic regimes of streams and rivers and impact the composition and dynamics of the biota that inhabit them, although large dams have a greater impact on riparian and aquatic environments. Not surprisingly, large dams have been the subject of numerous studies at the national and regional level investigating their impact (Graf, 1999; Poff and Hart, 2002; Magilligan and Nislow, 2005; Graf, 2006). Small dams, on the other hand, have more localized impacts. Literature on small dams is restricted to case studies or to investigations of their impacts on specific species of flora and fauna (Watters, 1996; Cortes *et al.*, 1998; Skalak *et al.*, 2009), but depending on the number of small dams within a watershed, their cumulative impacts and benefits could vary significantly. Because most states in the USA have at least a few thousand dams each, it is not feasible to conduct a national study of small dams. However, a statewide assessment of such dams is possible, especially when aggregated by watersheds. In this study, we conduct a comprehensive census of all dams in New York (NY) State, USA, which by one estimate contains the largest number of small dams in the USA. (Provencher *et al.*, 2008). We develop dam metrics for the 17 primary watersheds designated by NY, which are used to first characterize and then to contrast differences among watersheds. Within this context, implications for dam management, emergency preparedness and dam removal strategies are discussed.

METHODS/CRITERIA

In the USA, inventories of dams are maintained by both federal and state agencies depending on the structural characteristics of the dam. At the federal level, the US Army Corps of Engineers and the Federal Emergency Management Agency (FEMA) maintain a list of dams meeting specific criteria in the National Inventory of Dams (NID). The NID includes dams that satisfy one of the following conditions: (i) pose significant hazard to human life or property; (ii) exceed 25 ft in height and store 15 acre-ft or more of water[1] or (iii) exceed 6 ft in height and store 50 acre-ft or more of water (USACE, 2012). In addition, the United States Geological Survey (USGS) maintains a list of major dams that meet one of the following conditions: (i) exceed

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[1] 1 ft = 0.3048 m and 1 acre-ft = 1233.481 m^3