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Research Note

American Dams: Risk Analysis & Recommendations

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August 2016

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Keywords: Dams, Infrastructure, Critical Infrastructure, Homeland Security

Abstract: The author of this research notes examines dams across the U.S and the risks they impose on the American people. In particular, this paper focuses on the increasing threats to the sector from inconsistent governance, lacking emergency action plans, and growing concerns about the environmental and cultural impact of dams.

Executive Summary

American dams are a rich part of this country's history, and supply a renewable source of energy in many areas, particularly the Pacific Northwest. However, a lack of maintenance on dams and growing concern of dams' impact on our environmental health have brought public scrutiny and a demand for dams to be made safer and "greener" or, for some, to be removed all together. This paper examines some of the major risks that American dams impose upon individuals, businesses and different aspects of our government.

The 20th century saw incredible growth in the number of dams built in the U.S. as rivers across the country were dammed for irrigation, hydroelectric energy, inland navigation and water storage. While these dams were built with the best technology available at the time, many do not meet current regulations and in fact, pose a higher risk due to growing populations and widespread development than originally anticipated.

There are many challenges facing our dams today, and the risks within those challenges are worrisome. At an average age of 52 years old, American dams have seen great changes in their surroundings and in the weather conditions they must face. The mistake of planning for current conditions, 50 years ago, has led to peoples' lives being put in danger, as the conditions in those

exact locations are vastly different today.

Inconsistency in governance and Emergency Action Planning poses a significant risk to the safety of American citizens, but also to other aspects of our infrastructure, such as railways, roads and power lines. Resource shortages are an issue that many entities face, but given the dire situation of our dams, it is a risk that must be addressed.

Finally, public opinion of dams has soured in the last few decades, with demand for the removal of dams that are particularly harmful to the environment or simply no longer useful. These are expensive undertakings for an already resource starved sector, and action must be taken to appease the public and also ensure that every dollar spent repairing older dams and/or building new dams is well thought out and will survive the scrutiny of environmental groups and indigenous people.

Introduction

There are four key reasons that dams are built in the U.S.: to control flooding, to provide irrigation for farmland, municipal water supply, and hydroelectric power.¹ This last reason was a particularly influential driver behind the incredible pace at which dams have been built in our country. The first hydroelectric plants were built in the 1880's to power specific buildings or companies, with little to no regulation.² It would be less than 50 years and many dams later when construction would begin on the Hoover Dam – the largest dam in the world upon its completion, and what is still considered the second tallest dam in the U.S.³

Today, there are approximately 87,000 dams in the U.S., and they impound nearly 600,000 of the country's 3.5 million miles of river. Of these dams, two-thirds are privately owned and the remaining one-third is split between federal, local, state and "unknown" ownership.⁴ In this paper, we will look at assessments made by the American Society of Civil Engineers and the U.S. Army Corp of Engineers to identify the risks that American dams impose on both the government (financially, politically and related to infrastructure) and the private sector (loss of lives and businesses).

In the Homeland Security's, Dam Sector-Specific Plan, a classification system is presented for the dam system:

Hazard Potential Classification	Loss of Human Life	Economic, Environmental or Lifeline Losses
Low	None Expected	Low, Limited to owner
Significant	None Expected	Yes
High	Probable, one or more expected	Yes

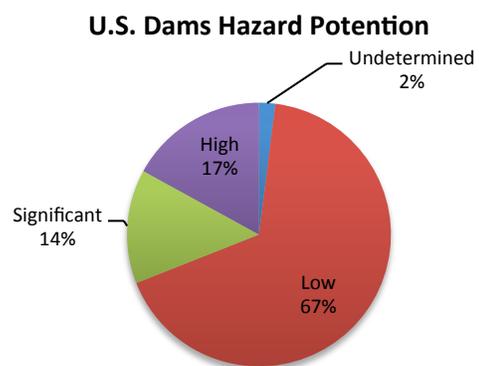
“The dam isn’t the problem, it’s the maintenance that’s the problem.” – Kim Kalama

There are many concerns today regarding the health of American dams, and the environmental impact that they are having on the planet. The average age of an American dam is 52 years old, and their structural integrity is being questioned – not necessarily because of age, but due to a lack of maintenance. In particular, dams that were previously classified as “Low Hazard Potential” or as “Significant Hazard Potential” are being reassessed due to the development of the land surrounding the dam and our ever-increasing population.⁵ These dams that once only risked flooding farmland, now risk taking lives, should they fail. According to the American Society of Civil Engineers (ASCE), there were 4,000 deficient dams in 2013, and half of those were “High Hazard Potential” – which means that human lives are at stake.

The ASCE gave American dams a D+ grade in their 2013 Infrastructure Report which, given our dependency on these dams for energy, water, food and personal safety, should be considered unacceptable.

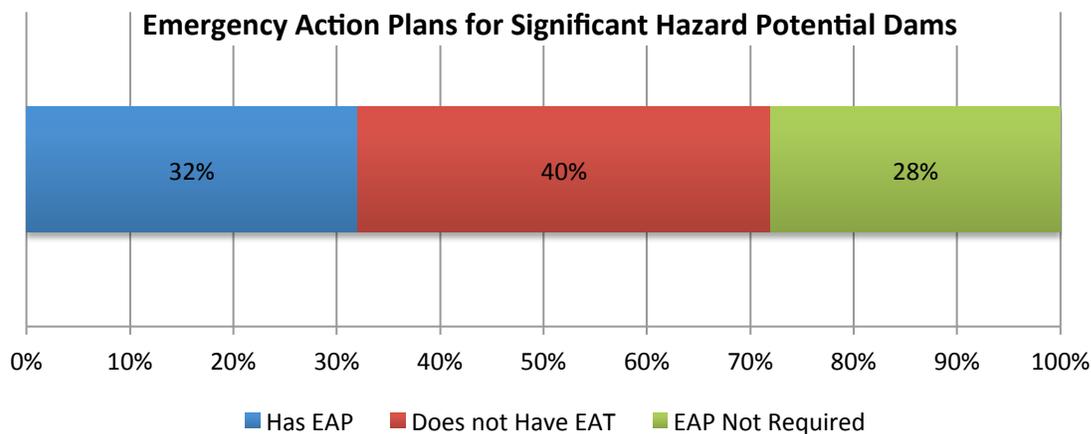
This unsettling fact begs the question: what is the plan, should one of these dams fail? What processes are set into place to reduce the loss of life and damages as much as possible? As with any system that carries risk, many dams have an Emergency Action Plan, or an EAP. “The purpose of an EAP is to facilitate and organize employer and employee actions during workplace emergencies.”⁶ This written document is meant to guide people during an emergency and, hopefully, save their lives and the lives of others. Naturally, you might assume that all dams would have an EAP in place. That assumption would be false.

The figure to the right shows the percentage of dams by Hazard Potential Classification. As you can see, 67 percent of dams in the U.S. are considered a low hazard potential,



and another 14 percent are considered a significant hazard potential. Only 17 percent of dams in this country risk human life, should they fail.⁷

So, can we assume that these 17 percent of dams have an EAP? Unfortunately, to assume that would also be wrong.



Only 32 percent (or roughly 4,000 of the 12,500 dams) that are considered a significant hazard potential have an Emergency Action Plan. The remaining 8,500 dams are not required to have an EAP, or they simply do not have one.

In this paper, we’re going to take a look at the risks that we face due to our aging dams and the seemingly flippant attitude towards preparing citizens, businesses and our government for their likely decline, both in usefulness and in structural integrity. But before that, let’s examine which other sectors rely upon our dams.

Dependencies

What other sectors of American infrastructure depend on our dams functioning properly?

Energy

Per the Department of Energy, hydropower is responsible for producing 7 percent of the U.S.’ electric generation in 2013.⁸ However, in the Pacific Northwest, that percentage is much higher. According to the Foundation for Water & Energy Education, the PNW has hydropower to thank for up to 80 percent of its electricity generation each year.⁹ Obviously, should our dams fails, we risk the loss of a major source of cleaner, renewable energy. It is worth noting here, however, that less than 3 percent of the 87,000 dams in our country generate hydroelectric power. And while the Pacific Northwest would certainly feel the impact of an electricity-generating dam failing, the

rest of the country would be far less affected.

Food and Agriculture

As mentioned earlier in this paper, another reason for building a dam is to provide irrigation for farmland that would otherwise be too dry to successfully yield crops. In fact, 48 percent of dams are built and used for the sole purpose of irrigation.¹⁰ Per the Association of State Dam Safety Officials, “Ten percent of American cropland is irrigated using water stored behind dams.”¹¹ In areas like California and Colorado, where drought can (and does) destroy entire crops, the water that dams store is incredibly important. Our ever changing climate and increasingly extreme seasons are an issue that we can assume to deal with for generations to come – having water stored in dams for irrigation will keep farms producing fruits, vegetables and grains and weather through periods of no rain.

Water

While it is unclear exactly how much of our drinking water comes from the reservoirs created by dams, it is well known that at least a portion of American’s clean, drinking water is a direct result of dams. With water already being a scarce resource in many parts of our country, the importance of this water supply has never been greater.

Transportation Systems

Dams help to make rivers more navigable for large barges that carry food, supplies, materials and more through our country. Through lock systems, otherwise treacherous river routes are tamed and large ships with heavy loads can enjoy a smooth ride. While this is an important aspect of dams, navigation and transportation account for less than 1 percent of their overall role.¹²

Operational Risks

James Lam defines operational risk as “...the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events.”¹³ He goes on to describe people risk, process risk, system risk and event risk. This is the framework that will be used to describe the operational risks of American dams as they stand today.

Planning for Current Conditions, not Future Conditions – Process Risk, System Risk and People Risk

It seems obvious that deficient dams are a risk – but why? How could so many dams (over 4,400) deteriorate to the point that the structural and hydraulic deficiencies make them so susceptible to failure?¹⁴

Dams were built with the most advanced technology and sophisticated engineering practices at the time – but that was, for the average dam, 50 years ago. Today’s standards are far stricter and

we have seen more extreme weather patterns that they must face. However, the process of updating a dam and incorporating new building standards is not as simple or financially realistic as updating a piece of software. The Association of Dam Safety Officials estimates that cost approximately \$21 billion to just repair the high hazard dams that have been declared deficient.¹⁵ This would be funded by both the public sector (tax payer money) and the private sector (the private owners of dams) and would span over the 15 years.

The number of deficient dams that could lead to a loss of life is startling – and part of this is due to a lack of thinking through the changes that a dam could bring to a region. Many dams were built for irrigation and, as such, were classified as low hazard potential. Low hazard dams adhered to less stringent requirements, as their failure would simply result in farmland flooding and not much else. However, as the land became usable and more people came to live and work in these areas, the hazard classification was upgraded and the standards to which the dam was built were no longer sufficient to adequately protect the people in its shadow.

Not only do the risks exist for human life, but also for businesses that are based in the areas near the dams. Dams, by nature, hold back a river and create a reservoir – these are typically referred to as lakes. These lakes are popular places to build homes, recreational businesses, restaurants, stores, etc. Upon failure, not only could people be injured or killed, the economy could take a hit as homes and businesses are washed away.

Recommendations

It is recommended for any new dams being built and existing dams that a projected lifespan of the dam be built out. This would essentially be a risk management exercise, where an external source would create a series of “what if” scenarios regarding the region in which the dam exists. What if oil is discovered 10 miles from here and the entire area booms with development of houses and business? Is the dam sturdy enough to protect those lives and businesses? What is the likelihood that the hazard potential classification changes to something more or less significant? With an exercise like this, hopefully the issue of building dams to existing conditions without considering how that dam would affect the area and its inhabitants would be eliminated.

Policies should be built around the kinds of analysis to be done for any future dam builds and for any repairs to be conducted on existing dams. The cost of repairing a dam is incredibly high – not only would thinking ahead save tax payers and dam owners’ money, it could also save lives.

Inconsistency in Dam Governance

As was mentioned earlier, no one entity owns the American dam system – there exist a wide variety, from private owners, to non-profits and the federal government. It takes a village to

operate these dams – but there is no standardization amongst these villages. The government and publically owned dams, in particular, lack the resources to staff their dams with enough qualified employees. As with any business, a lack of resources means that some things will be neglected – and for a 50-year-old dam, built according to 50-year-old science in the face of current environmental challenges, there is little room for error or neglect.

Individual states have dam safety programs that cover 77 percent of American dams that “...permit, inspect, and enforce regulations for about 77 percent of U.S. dams.”¹⁶ However, these are run by individual states, without an overarching governing body to enforce consistence regulations across the country.

Recommendation

Resources will likely be an issue for any sector, and the dam system is no different. Even if a dam location is short staffed or has a less tenured work force, there should be strict policies for monitoring, operating and maintaining the dams. These would likely vary slightly, as each dam is built for the river it is containing and the geography in which it is housed – but there should be a standard set of best practices from which all policies are derived to ensure that each and every dam is being operated at the highest level of excellence that it can. Private and public groups will need to work together, which they currently do on many issues, to create a persistent set of standards that they all agree to adhere to.

Lack of Emergency Action Planning

It was mentioned earlier that only 32 percent of the dams that, upon failure, would risk human life have an Emergency Action Plan. This is unacceptable. Dams contain rivers – they house massive bodies of water in, oftentimes, remote locations. This means that it may take a significant amount of time before an emergency response team is able to get to the dam location, should something go wrong. Without a required EAP, it is not guaranteed that documentation exists for an employee who needs to alert someone about a dam breach or failure. It is not a sure thing that documentation exists for a new or inexperienced employee that walks them through what to do in an emergency to prevent further damage to the dam or the surrounding area.

Recommendation

The recommendation is that every single dam in this country has some sort of documented Emergency Action Plan. Even the low hazard potential dams should have clear instructions for what to do during a dam breach or failure, written in a language that an inexperienced dam worker could comprehend in an emergency situation.

In particular, deficient dams should be required to have an EAP that is reviewed on an ongoing

basis to ensure that any new developments in the area, changes in geography or weather conditions are taken into account. Given the higher risk of failure, it is essential that the employees of this dam be well versed on what to do in an emergency and participate in practice drills.

Growing Concern over Environmental/Cultural Impact

Not only are dams receiving scrutiny due to their aging structures, lack of planning and high-risk profile, but also many of them are currently being assessed for future usefulness. If the 20th century was the “Era of the Dam”, the beginning of the 21st century most certainly marked the end of that era. If a dam has a reputation for being anything less than safe and useful and non-destructive to the environment, it is likely that someone will start pushing for its destruction.

When a portion of a river is dammed, the geology of that ecosystem is completely altered. In recent years, the Pacific Northwest has seen a 90 percent decrease in the number of salmon running up the rivers, as the dams block the route that these fish are genetically wired to take.¹⁷ Ladders and steps aren’t working and several salmon species have been placed on the endangered species list. Having barges transport spawning salmon to spawning pools, and then transporting the newly hatched fish back through the dam wastes resources. Hatcheries are able to harvest eggs and hatch new fish, but there is very little genetic diversity and, often, these hatchery fish die before every coming back to spawn.

Lastly, many of the populations that suffer the most when a river is dammed are indigenous people. In particular, a small fishing and trading village existed along the Columbia River, right on the border of Washington and Oregon for over 15,000 years. Up until 1957, it was the “oldest continuously inhabited community on the North American continent.”¹⁸ In order to harness the power of the Columbia, the government built The Dalles Dam, which flooded the falls and blocked the salmon from reaching the small village.

When a dam is built, the water must be stored somewhere...and typically, something is lost in the flooding, whether it is 15,000-year-old village or decades old artifacts left behind by a tribe long ago. With our ever-decreasing supply of national treasures, more and more people are looking at dams less as helpful feats of engineering, and more as environmentally and culturally destructive.

Recommendation

There is a strong push to dismantle dams in this country today. The era of the dam has passed and the rate at which new dams are being built is a mere fraction of what it was 40 years ago. Dams that no longer serve a purpose should be taken down and the river freed. This is done in a

controlled way today, and has been done upwards of 1,200 times since 1912, with approximately 850 removals occurring in the past 20 years.¹⁹ To remove a dam purposefully and intentionally is far better than the dam failing because it couldn't undergo repairs soon enough.

Any consideration for a new dam should heavily take into account the impact on the environment and any group of people. By ignoring these two important factors, the government or a private body could build something that creates such a controversy; it may not be long before millions of dollars are being spent taking the dam back down.

For those dams that are still necessary, it is pivotal that they be repaired as soon as possible, and any changes that can be made to lessen its impact on the environment should be considered. Environmental groups are gaining strength in their efforts to dismantle dams and if a dam isn't built well, and/or doesn't provide enough benefit to outweigh the consequences, odds are fairly good that it will be coming down in the next decade or so. If the government or a private owner doesn't want to pay for removing a dam, they need to make sure that any dollars put into it are making it better for this new, very environmentally aware generation.

Conclusion

As we can see, there is significant work to be done on both the private and public side when it comes to our nation's dams. Currently, the dams and their owners face every kind of operational risk that exists – resource shortages lead to people making mistakes or being improperly trained, insufficient systems and designs are leading to compromised structural integrity and an increased risk of dam failure, dams have lost that “golden” reputation and are under intense scrutiny by the public for their harm to salmon runs, indigenous people and national treasures.

With better-documented and more rigorously required Emergency Action Plans, as well as a transparent and thorough assessment of the best dams to repair and the best dams to dismantle, it is possible that the funds allocated to the Dam Sector could decrease the overall risks that it is currently bombarded with.

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