

USACE Flood Control Projects in Bay Area

Projets USACE de lutte contre les inondations dans la région de la baie de San Francisco

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RÉSUMÉ

Aux Etats-Unis, des agences locales œuvrent souvent en partenariat avec le Corps d'ingénieurs de l'armée américaine (USACE) sur des projets de lutte contre les inondations. L'USACE partage le coût des dépenses d'infrastructure et les agences locales supportent les frais d'exploitation et d'entretien. De nombreux projets de ce type construits avant les années 1970 souffrent de problèmes chroniques de sédimentation et de protection insuffisante contre les inondations. Si ces problèmes ont été traités séparément, il y a néanmoins de nombreux points en commun entre les projets. Nous avons examiné deux projets de la Région de la baie de San Francisco, situés à San Lorenzo Creek (comté d'Alameda) et à Corte Madera Creek (comté de Marin). Nous avons étudié leur historique, leurs performances de contrôle des inondations et les besoins en élimination de sédiments. Nous avons constaté que les plaines inondables sont remplacées par des canaux construits « en dur », que les projets n'offrent pas les niveaux de protection prévus lors de la conception et que les coûts d'exploitation et d'entretien ont été sous-estimés. Les résultats offrent un aperçu des problèmes les plus fréquents, dont (1) la détérioration de l'écosystème de la plaine inondable, générant des obstacles pour le projet ; (2) des systèmes d'analyse des coûts et des bénéfices et du financement fédéral privilégiant les coûts d'infrastructure au détriment des autres éléments ; (3) une conception des projets sans tenir compte des principes géomorphologiques, entraînant ainsi la sédimentation ; et (4) des coûts d'exploitation et d'entretien inattendus et inabornables, compromettant ainsi le niveau de service des projets en matière de protection contre les inondations. L'étude a montré que les projets de lutte contre les inondations menés avec l'USACE ont généré des coûts importants d'exploitation et d'entretien qui constituent un fardeau financier important pour les partenaires locaux, et que les projets analysés n'offrent pas les performances prévues lors de leur conception.

ABSTRACT

In the United States, local agencies commonly partner with the U.S. Army Corps of Engineers (USACE) on flood control projects. The USACE cost share the capital cost, and the local agencies are responsible for the operation and maintenances (O&M). Many of these projects constructed before 1970s are plagued by chronic problems on sedimentation and inadequate flood protection. These problems have been treated independently, but in reality there are commonalities to all projects. We examined two projects in San Francisco Bay Area, at San Lorenzo Creek (Alameda County) and Corte Madera Creek (Marin County). We examined their histories, flood control performance and sediment removal requirements. We found that the floodplain corridors are replaced with hard engineered channels, the projects cannot provide the design flood protection level, and the O&M costs were underestimated. The findings provided a snapshot of the common problems, including (1) degraded floodplain ecosystem and how it created project roadblocks; (2) cost benefit analysis and Federal appropriation bias on capital cost over other factors; (3) project design ignored geomorphic principles, resulted in sedimentation; and (4) unexpected and unaffordable O&M compromise the project's flood protection level of service. The study illustrated that the USACE flood control project created significant O&M burden to local sponsors, and the reviewed projects are not functioning as designed.

KEYWORDS

Flood control, Operation and maintenance, Sediment deposition, Urban creek, US Army Corps of Engineers.

1. INTRODUCTION

In the United States, the U.S. Army Corp of Engineers (USACE) is one of the leading Federal agencies on flood management. The 1936 Flood Control Act established the USACE's flood control mission. When a local community experiences flooding problems beyond its ability to solve, the local agencies could partner with USACE, to benefit from the agency's technical expertise and to receive a financial subsidy for most of the project cost. Most commonly, the USACE would design and build the project, then turn it over to the local sponsor, who is then responsible for operation and maintenances (O&M) (Carter & Stern 2010). The 1986 Water Resources Development Act revised the 'cost-sharing' policy, so that federal government covered a much smaller percentage of the total project cost.

Historically, USACE flood management has been heavily skewed towards conventional structural approaches. Most projects were designed to provide predictable flow conveyance capacity in the smallest possible footprint. Ecological values were mostly ignored. In addition, many of these project designs were based on clear water modeling and other unrealistic assumptions. They did not adequately account for sedimentation (Williams 1990).

As a result, many local agencies cannot afford the significant O&M requirements. Therefore, many of these projects are plagued by chronic problems on sedimentation and inadequate level of flood protection. It presents a challenge to the local agencies on how to provide adequate level of services for flood protection, while balancing project life cycle cost.

In the San Francisco Bay region, a number of flood control projects designed and built by the USACE during the 1960s and 1970s share common attributes of small concrete channels. Some of these projects now pose significant O&M problems. As these O&M problems emerged, they have been treated as independent problems unique to the projects. However, in reality these projects share commonalities in planning and design approaches, and the subsequent O&M problems (Samet 2007). To understand the general patterns of the problems, we examined two projects on their histories, flood control performance and sediment removal requirements, as illustration of the problems common in USACE projects, faced by local agencies as they attempt to maintain flood control function.

2. CASE STUDY – SAN LORENZO CREEK, ALAMEDA COUNTY

San Lorenzo Creek drains a 124 km² watershed, flowing westward from Cull Canyon, Crow Canyon, and Palomares sub-watersheds into San Francisco Bay. To alleviate recurring flooding at the downstream floodplain, the 1954 Flood Control Act authorized San Lorenzo Creek Flood Control Project. The project completed in 1962: 8.4 km of concrete channels and earthen trapezoidal channel flanked by levees. The construction cost was \$4.28 million (\$60 million in 2010), with 1.17 benefit cost ratio.

After the project was completed, urban development increased the 100-year peak flow from 227 cms to 468 cms. Since the project design flow is 275 cms, the project no longer has 100-year flow capacity.

Unrelated to the flood control project (funded by the Davis Grunsky Act), in 1960s the County constructed reservoirs on two tributaries, Cull Canyon and Palomares, to provide recreation and water supply benefits. The reservoirs also provided some ancillary flood storage, although their capacities declined rapidly from sedimentation, both down to only 20% of original capacities by 2003. Sedimentation in these reservoirs has reduced sediment delivery to the downstream flood control channel, although the third major fork of San Lorenzo Creek, Crow Canyon, still supplies sediment to the downstream channel without impairment.

The downstream reaches, within the engineered flood control channel, are natural sites for sedimentation, with their flat slopes. In the past, flood overflows would distribute the sediment load over the marsh plain, but with channel constriction and levees, the sediment is either carried into the bay or deposits in the channel. Since 1962, the County spent \$4.1 million (2010 dollars) on sediment removal from the flood control channel. If the total cost were to include the estimated cost to remove all sediment in both reservoirs, the total cost would increase to \$52 million (2010 dollars). It is an order of magnitude higher than the total O&M cost estimate in 1954, at \$3.5 million (2010 dollars).

3. CASE STUDY – CORTE MADERA CREEK, MARIN COUNTY

Corte Madera Creek drains a 73 km² watershed, flowing eastward from Ross Valley into Richardson Bay. Severe flooding occurred at least three times in the 1950s, prompting Marin County to initiate the

flood control project in partnership with USACE. The 1962 Flood Control Act authorized the Corte Madera Creek Flood Control Project, with four distinct project 'units', number from downstream to upstream. The first three of these authorized project units were constructed in 1971: 4.8 km of earthen trapezoidal channel and 2.4 km of rectangular concrete channel. The fourth (upstream-most) project unit was stopped due to local opposition to environmental impacts of the intended concrete channel. The construction cost was \$6.34 million (\$64 million in 2010), with 1.4 benefit cost ratio.

Although the project was designed to convey 212 cms flow, overbank flow resulted in extensive flooding of houses in 1982 from a peak flow of 204 cms. Without the fourth project unit completed, floodwaters left the channel at Lagunitas Road Bridge, whose conveyance capacity was only 100 cms. Another factor reducing the capacity of the designed channel was sediment, which increased the hydraulic friction above the clear water conditions assumed in design calculations. The estimated flood damages were \$2.25 million (\$4.87 million in 2010).

The O&M cost estimated in 1961 was \$25,000 per year, yielding a cumulative cost by 2010 of \$5.7 million (2010 dollars). Since 1971, Marin County dredged the project in 1987 and 1998, and Town of Ross has extracted sediment annually at Lagunitas Road Bridge, at a total cost of \$6.8 million (2010 dollars). A hydrographic survey in 2005 found that additional dredging is needed to restore the channel capacity. The additional dredging will increase the total cost to \$14.4 million (2010), significantly higher than the 1961 estimate of \$5.7 million (2010 dollars). Spending such amounts on a single stream is unrealistic for Marin County, whose the total flood control budget was only \$5.1 million in 2011.

4. FINDINGS

These case studies illustrate key attributes of USACE flood control projects in the region:

- *Ecological Values:* Increasing concern for ecological values resulted in opposition to the final phase of the Corte Madera Creek project. Therefore, failure to address the hydraulic constriction at the historical Lagunitas Road bridge contributed to extensive flooding and enormous losses in 1982.
- *Cost Benefit Analysis:* A key USACE project planning tool, the benefit cost ratio for a project must exceed unity or the project is rejected. This approach creates an incentive to select the lowest capital cost alternative to provide flood protection benefits, often at the expense of environmental and social values, as well as unrealistic and underestimated O&M requirements.
- *Project Design:* The clean water assumption implies sediment does not affect flow hydraulics. It is a fundamental design flaw in the studied flood control projects. The basic geomorphic principle that sediment deposition would be expected on distal alluvial fan was simply ignored. Thus, the sedimentation rate was underestimated and the creek capacity was overestimated, as shown in both case studies.
- *Operation and Maintenance:* Federal appropriation only covers the capital project cost. Local sponsors must fund the O&M, but many projects were not designed for efficient maintenance, nor were maintenance requirements properly projected for budget planning. Inadequate O&M reduces the project's flood protection level of service. It is a significant short fall that needs to be addressed.

5. CONCLUSION

Through the lens of the two case studies, we examined the ecological values, cost-benefit analysis, project design and O&M issues with USACE flood control projects. These systematic problems are not project specific. It illustrated a fundamental weakness in the USACE flood control project partnership process.

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