Converting concrete channels to natural stream systems

The 50-Year Plan for Contra Costa County, California

Mitch Avalon
Deputy Public Works Director
Contra Costa County, California

Death, taxes, and flood protection infrastructure

Ben Franklin once said there are only two certainties in life: death and taxes. I would add the eventual failure of flood protection infrastructure to that short list. Aging infrastructure and how to replace it is a huge issue in our nation. Flood protection infrastructure, especially concrete channels and structures, are very costly to replace and we need all the time we can to plan for their replacement—even 50 years. And if we take a long-term view for the capital replacement of concrete channels and structures, we can reimagine the system to provide habitat value, recreational opportunities, and improved water quality. The eventual replacement of these facilities can be an opportunity and a catalyst for citizens, city planners, and city leaders to redesign their community to convert a concrete channel to a natural-looking engineered creek. The Contra Costa County Flood Control and Water Conservation District has adopted a policy to convert concrete channels to natural systems. This policy is referred to as our "50-Year Plan."

The end is coming

Service life is defined as the average length of time a facility will perform with a reasonable amount of routine maintenance to keep it operational. When maintenance becomes excessive and initial signs of decay appear, the normal service life is said to be reached. Service life is the length of time an agency can expect to receive "trouble-free" service with routine maintenance and the time a responsible agency has to plan for its replacement. The reasonable service life for a concrete channel is 75 years (see sidebar on p. 87).

In the decades that followed World War II a building boom blossomed in California and many parts of the nation. This development triggered the need for flood protection infrastructure. Flood control districts were asked to respond and often worked with the Army Corps of Engineers or the Soil Conservation Service (now the Natural Resources Conservation Service) to channelize creeks and rivers to provide 100-year level of protection. Given a typical expected service life of 75 years, concrete channels built between 1950 and 1990 will need to be replaced between 2025 and 2065. Of course, failure of a facility can occur before or after 75 years. We all hope our facilities perform beyond their service life, but that doesn't always happen. On the San Ramon Creek Channel in Contra Costa County, Calif., a drop structure constructed by the Soil Conservation Service in 1960 failed 35 years later in 1995 (see photo).

What have we inherited?

Local agencies, most notably flood control districts, were the local sponsor for Corps-built facilities, and upon completion the local agency assumed responsibility for maintaining them to a level of service specified in the project's maintenance manual. The requirements in the maintenance manual do not change with time

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to meet changing conditions or regulations. Maintenance costs for local agencies often increase in time due to the inflexible requirements in the maintenance manual. The Corps built flood protection facilities to the standards at the time they were built. Some of the standards are now considered antiquated and also create increased maintenance costs. For example, the Corps sometimes designed lower channel reaches with a steeper grade than the natural flowline and the channel outlet ended up below the receiving water body grade or flowline. Several channel outlets in Contra Costa County were designed and built two feet below the natural grade (marsh level). This practice required regular channel dredging to maintain flow capacity. Today, depending on the habitat and species present, dredging is very difficult or impossible to get permits to perform, yet the Corps still requires it to be done. Flood control district managers of today have inherited a flood protection system that is becoming more expensive to maintain and will need replacing at some point, yet often have insufficient funds to perform adequate maintenance let alone establish a capital replacement fund.

Is the glass half full or half empty?

We know a responsible agency has to plan for the capital replacement of its facilities, but how do we fund a capital replacement program? Our Flood Control District does not have the funds to rebuild its aging infrastructure now or at any time in the future as long as the taxing structure in California remains unchanged. Ideally, stormwater would have the same prominence and authority in California law as sewer and water, and would be able to establish a rate structure to fund operations and capital replacement. The only way we will be able to fund capital replacement is with financial investment from the federal and state government. The replacement costs are often too much for local agencies alone to bear. So we must be optimally positioned to attract state grants and federal funding. The best way to do that is to have community support, an environmentally sensitive project, and a system-wide approach. The eventual replacement of flood protection infrastructure can be the opportunity for a community to think about its future vision for economic development and an opportunity for the flood control district to gain public support and funding for a more sustainable natural flood protection system.

Three alternatives

There are three primary alternatives for capital replacement. **1. In-Kind Replacement:** Develop a plan to replace an old concrete channel with a new concrete channel, a "replace in-kind" strategy. **2. Patch-it:** The concrete channel can be patched and repaired as it begins to decay. This will extend the facility and service life but will only delay the inevitable replacement. Maintenance costs will increase as aging increases and there is greater risk of catastrophic failure. Most systems were built by channel reach and can be replaced channel reach by channel reach, but a "patch-it" strategy combined with deferred maintenance may result in much of the system failing over a short period of time, making the replacement much more difficult and expensive. **3. Natural System:** Replace the concrete channel with an engineered natural system, adding riparian vegetation, proper stream function, habitat, and recreation to the flood protection system.

Only alternatives one and three provide an agency with a replacement facility that will provide service over a long period of time. Alternative three should be strongly considered and discussed, as it will provide a sustainable system, be more acceptable by regulatory and granting agencies, and generate more public support. All things considered, alternative three will place a flood control district in the best position for state, federal, and local/community funding.

Definition/benefits of a natural system

In most situations a natural system in an urban area will be an engineered creek or river. In an ideal world the outside historical meander would be identified and adjusted to accommodate future hydrology. The anticipated outside limits of the meander would delineate an appropriate corridor needed to allow the creek's hydro-geomorphological processes to prosper unconstrained. However, there are tremendous demands for space in an urban environment and something less than ideal may be more realistic. Natural features can be part of a flood protection system but may need to be engineered to prevent erosion and change in meander. The more right away width that is available for the creek channel, the less drastic the engineering necessary to contain the natural processes. Alamo Creek in Contra Costa County was rebuilt by a large development project. It was engineered as a natural creek system but had bank armoring that was buried underneath the creek bank at curves and critical locations, then covered and heavily planted to provide riparian habitat. The creek bed was also controlled with rock grade-control structures that were fish friendly. This approach provides a stable creek bank that allows buildings to be built fairly close to the creek bank with a high degree of safety. The benefits of a natural systems approach is the environmental enhancement with vegetated creek banks, improved water quality through filtering and biological processes, habitat for aquatic and riparian species, recreational opportunities, and possibly improved public health as expressed in Richard Louv's book *Last Child in the Woods*. The other big benefit is the community's overall

improved image, and increased community engagement and vigor when it realizes implementing this vision can revitalize or enhance their economic development and improve their quality of life.

What's the process?

Developing a capital replacement program is hard enough, but to change your concrete channels to natural systems can seem even more daunting. A natural system alternative almost always requires increased right-of-way, usually a difficult proposition. But it is quite feasible if a long-term view is taken. The following are some of the key steps.

Talk about it. Changing a community's flood protection infrastructure to a natural system can seem like a radical change. You need to talk about your infrastructure, its economic importance to the community, the need for eventual replacement and the opportunities this represents. This outreach and awareness effort will be helpful when a community goes through a land use update. Cities must mentally take ownership of the creek in their community; they must see it as an amenity for the city rather than someone else's drainage channel. Increasing awareness of the creek channel and its opportunities helps change the city's perspective.

Community-based planning. This is the heart of the process. If there is to be support from a community to advocate for federal and state funding and to fund the local cost-share of a flood control district project, then the project must be a community's project. They will more likely support a project that meets their vision than one pushed on them by the flood control district. In the worst case scenario, where a community feels alienated by the flood control district, the community may oppose the flood control district project and may take the position that the flood protection system is the flood control district's and if it fails it is their problem. If property is damaged as a result of flooding then property owners will sue the flood control district. Nobody wins, everyone loses. In the context of this article "community" includes citizens, community-based organizations, creek groups, city staff, and elected officials.

Visioning. This is a community exercise to define the possible futures in the context of replacing flood protection infrastructure. They may choose to redesign their downtown to incorporate a natural creek into their central business district and make it an attraction. This was done, for example, in San Luis Obispo, California. The community may decide to include a natural creek in a linear park and plan to buy a row of houses to achieve it. Visioning allows the community to identify alternatives that can then be analyzed and evaluated for feasibility.

Land-use processes. Land-use authority is the purview of cities and counties, and cumulative land-use decisions can make a future channel replacement easier or more difficult. If a city supports a natural system as a future channel replacement, then it can preserve and widen the right-of-way corridor for the creek. The city can require a developer to dedicate additional right-of-way width for the creek corridor as mitigation or in exchange for higher density or for some other value. Cities and counties have a General Plan that establishes the goals and policies for development of the city. These are typically based on a 20-year planning horizon and are updated from time to time. Updating a General Plan, developing a Specific Plan, or reviewing ordinance codes are all good times for a flood control district to engage a community in discussions about what their creek should look like in the future. The creek (the flood control channel) going through the community is part of the community, it is part of the landscape that defines the community. The creek is a community design element and should be incorporated into their land-use planning documents and community designing processes.

Political processes. Politics are different in each community. It goes without saying that local political sensitivities must be understood and respected. Who to talk to first; who authorizes what; what are the lightning rod issues and sacred cows. Knowing this will help to navigate through a successful community-based planning process.

Partners. Partnering with local community groups and other agencies that would benefit from a natural creek system (e.g., a park district) will help in navigating through the political processes and working with the community. Having the support and interest of key engineering and planning staff and the city managers at the cities is also critical.

Demonstration projects. It is easier for a community to vote for a ballot measure to finance a project if they can visualize the project. Building a small demonstration project helps them see the benefits and helps build community support for the larger reconstruction and restoration project.

Incremental approach. Like a lot of large, complex initiatives, it is easier to complete a project one piece at a time rather than all at once.

The 50-Year Plan

The Contra Costa County Flood Control and Water Conservation District has been talking about converting concrete channels to natural systems for over 10 years. Our Flood Control District's governing board adopted the "50-Year Plan" as a conceptual policy in 2009. The policy is called the 50-Year Plan to recognize

the long time frame necessary to plan, acquire the right-of-way, and implement a channel conversion. We have been in discussions with several cities about the opportunities that a large development project on a creek channel offers, or discussions about restoration of the creek channel during a General Plan update.

Perhaps the best example of our planning efforts so far is Pinole Creek. In 1965 the Corps built a channel through the City of Pinole. They constructed a flat-bottom channel, two feet below natural grade at the channel mouth. After California Proposition 13 was passed in 1978, the Flood Control District tax rate in the Pinole Creek watershed was locked in at zero. Although the channel needed maintenance and dredging, our Flood Control District had no funds to do so. Each year the District would approach the City for maintenance funding, each year City staff included it as part of their budget hearings, and each year it was unfunded.

About 10 years ago City and flood control staff agreed to do a visioning effort for Pinole Creek. The visioning effort was to be the first step in eventually going to the voters with a ballot measure to fund maintenance and restoration of the creek. The Friends of Pinole Creek and Urban Creeks Council, a local nonprofit organization, received a grant and led the effort to develop a Pinole Creek Vision Plan after a host of community meetings. Seeing the public interest in the creek and having a vision, the City developed a Greenway Master Plan for the creek. This was subsequently adopted as part of the City's General Plan. The City and District agreed that having a portion of the creek restored as a demonstration project would help the community visualize what a restored channel would look like. The City received a $2.65 million state grant to restore the lower portion of the Pinole Creek. The first phase of the project was completed in 2010. Since 1965 the Corps channel silted in to approximate the original channel. The new low-flow channel was two feet higher than the Corps channel; it was back to the original creek flowline. The demonstration project left the low-flow channel in place and excavated out a broader marshplain and floodplain by narrowing the access roads on each side of the channel. The wider channel and short flood walls at the lower end provide the required flood capacity, tree planting provides habitat value, and a paved trail on one side provides recreational use. The Flood Control District wanted to restore flood capacity with a sustainable natural system and with community support. Community support translated into political support and successfully attracted funding.

We are currently working through the process detailed above on several of our concrete channels and, with a bit of luck, in another 40 years we should be celebrating the success of our 50-Year Plan!

Mitch Avalon can be reached at (925) 313-2203 or maval@pw.cccounty.us.

Service Life

A concrete flood control channel is a reinforced concrete structure and determination of its service life is the same as for other concrete structures. Bridge design specifications developed by the American Association of State Highway and Transportation Officials (AASHTO), define service life as the period of time that a structure is expected to be in operation. Design life is defined as the period of time that the structure can withstand the various and repetitive loading anticipated with a given set of design specifications. The AASHTO specifications require a design life of 75 years. In the 1950s and 1960s when the bulk of our flood control facilities were being planned, designed and built, the focus was on structure design life, which in those days was 50 years.

A structure's ability to meet its expected service life can be compromised in several ways. If the loading is increased over time during the service period, the expected design and service life will be decreased and structural failure will occur sooner than anticipated. Another problem is environmental conditions the structure is exposed to, such as chemical reaction with the concrete, extreme temperatures, freeze thaw cycles or excessive bed load. Certain chemicals, for example, can invade the concrete's pore structure and initiate physical or chemical reactions causing expansive by-products. These in turn cause cracks and access to the reinforcing steel, ultimately causing corrosion and spalling concrete. At that point if major maintenance and repairs aren't performed the structure will proceed towards failure.

AASHTO specifications require earth-retaining structures to be designed for a 75-year service life considering the potential long-term effects of materials deterioration, seepage and other potentially harmful environmental factors on each of the structure's material components. Although bridges, retaining walls and concrete channels are all reinforced concrete structures, more research could be done specifically on the service life expectations associated with flood control channels.