Proactive Risk Management: Federal Emergency Management Agency's Mitigation Support for Climate Resiliency

Lena River, Eric D. Kenney, and Nicole LaRosa

Lena Rivera, P.E., D.WRE, is principal water resources engineer with CDM Smith in Maitland, and Eric D. Kenney, P.E., CFM, is a project manager with CDM Smith in Fairfax, Va. Nicole LaRosa is a senior policy specialist with the Federal Emergency Management Agency in Washington, D.C.

Hazard Mitigation Assistance (HMA) provided by the Federal Emergency Management Agency (FEMA) is focused on funding projects that support risk reduction due to natural and man-made disasters. In response to *The President's Climate Action Plan* (2013), Executive Order 13653 (*Preparing the United States for the Impacts of Climate Change*), FEMA's Climate Change Adaptation Policy (2011-OPPA-01), and the 2014-2018 FEMA Strategic Plan, FEMA is taking steps to ensure its programs account for the impacts of climate change and include planning for mitigation actions in support of climate-resilient infrastructure and communities.

To explore how climate-resilient infrastructure may be incorporated into eligible HMA grants, CDM Smith supported FEMA to research climate-resilient project options and identify actions that provide risk-reduction benefits for flood and drought, and lend themselves to implementation using green infrastructure (GI) methods. Initially, over 70 climate-resilient project options were identified that may reduce the risk of impacts to people and infrastructure attributed to climate change weather extremes. Figure 1 summarizes the projected climate-change impacts and risk factors nationwide as summarized in the 2014 U.S. National Climate Assessment (Melillo et al., 2014).

The list of 70 project options was further screened and 14 project types were evaluated under various eligibility, technical, economic/financial, implementation, and environmental considerations. Of the 14 project types, four climate-resilient mitigation activities were ultimately selected, based on their high performance related to feasibility and cost-effectiveness, and their ability to meet programmatic funding requirements consistent with HMA guidance.

The four climate-resilient mitigation activities are:

1. *Aquifer Storage and Recovery (ASR)*: This involves injecting untreated surface water, untreated groundwater, potable water, or reclaimed water (when it is available) into an aquifer through a well, to be stored for a period of time until it is needed, and then recovered for use (referred to as a cycle) through the same well. Implementation of ASR increases climate resiliency for periods of low rainfall or extended periods of drought by taking advantage of seasonal variations in surface-water runoff or groundwater surpluses. The ASR does not typically provide flood-hazard reduction independently due to the relatively low injection volumes (compared to flood flows); however, it can be used to "free up" storage in regional stormwater management facilities and reservoirs if pumped at a constant maximum rate.
2. *Flood Diversion and Storage*: This includes the transfer of floodwater from a stream, river, or other body of water into a wetland, floodplain, canal/ditch, pipe, or other conduit (e.g., tunnels, wells). Storage of these floodwaters provides for a controlled baseflow release and reduces downstream peak flows, stages, and velocities. Water can be impounded in surface reservoirs, floodplains, and wetlands, along with retention and detention facilities. By actively managing floodwaters by diversion, storage, and infiltration, and allowing for a controlled baseflow release, the project would mitigate flooding impacts. In addition, floodwater diversion and storage can replenish water supply aquifers and enhance usable water supply to mitigate the effects of drought. Floodwater diversion can also help maintain healthy ecosystems.

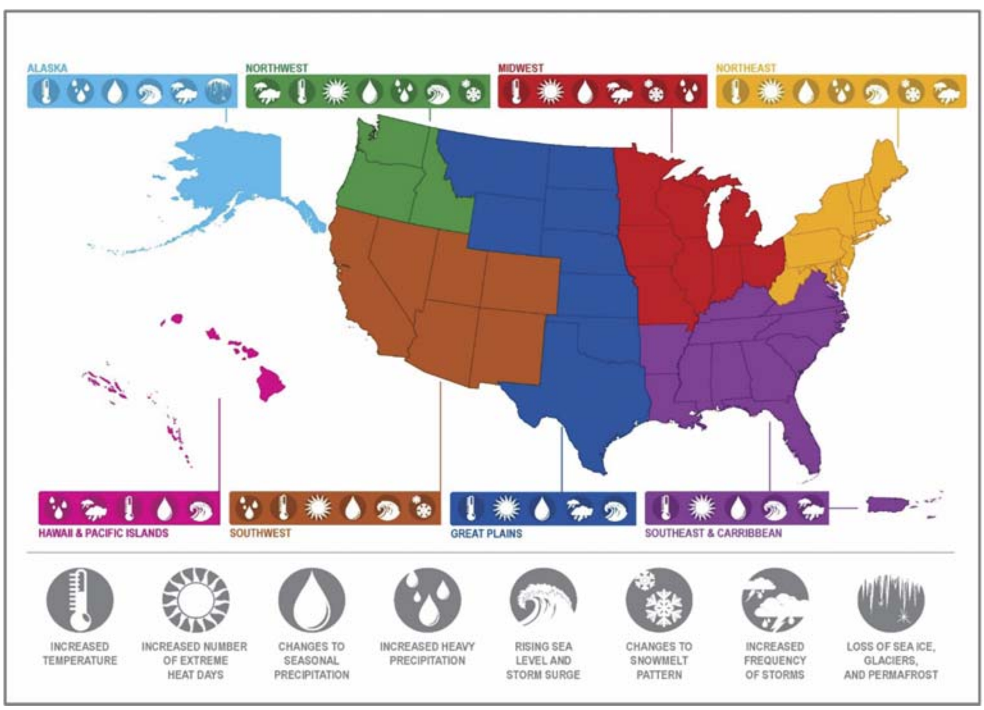

Figure 1. Summary of Regional Climate Change Impacts and Risk Factors in the United States

3. *Floodplain and Stream Restoration*: Natural events and human activities can change the dynamic equilibrium of stream and floodplain systems. Restoration is the re-establishment of the structure and function of floodplains, stream morphology, and ecosystems. Typical projects include improvements to floodplains and floodways, wetlands, streambeds, flow area, natural channel form, and sinuosity. When healthy, these systems can provide stream flood mitigation, mitigate bank erosion concerns, and provide ecological benefits. Additional benefits include habitat for fish and wildlife, improvement of water quality, water supply benefits, and recreation opportunities.
4. *Low-Impact Development (LID)/Green Infrastructure*: The LID is a sustainable development and redevelopment approach to natural landscape preservation and stormwater management. It emphasizes conservation and use of onsite natural features integrated with engineered, hydrologic controls to more closely mimic predevelopment hydrologic functions. The GI can be used at a wide range of scales in place of, or in addition to, more traditional stormwater control elements to support the principles of LID; these approaches are also termed best management practices (BMPs). Implementation of LID/GI practices can help mitigate flood events by increasing the ability of the landscape to store water onsite. Infiltration of these stored waters can also mitigate the effects of drought by replenishing water sup-

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Table 1. Climate Resiliency Snapshot Guide

CLIMATE RESILIENCY SNAPSHOT GUIDE		
Criteria	**Description**	**Features and Attributes**
Climate Change Risk Factor	Consequence of climate change impact	Flooding, Sea Level Rise, Storm Surge, Extreme Precipitation, Drought, Water Quality
Additional Benefits	Climate change risk factor that may be additionally addressed as a result of project implementation	Flooding, Sea Level Rise, Storm Surge, Extreme Precipitation, Drought, Water Quality
Project Type	Type of project proposed for implementation	Policy, Research/Study, Ordinance/Zoning, Program, Outreach/Education, Planning, Design, Construction, Operations
Project Timeframe	Timeframe for project implementation	Short-term *(within 3 years)* Mid-term *(3-5 years)* Long-term *(more than 5 years)*
Effectiveness Timeframe	Timeframe for project to start mitigating impacts once implemented	Short-term *(within 3 years)* Mid-term *(3-5 years)* Long-term *(more than 5 years)*
Technical Feasibility	Feasibility of project implementation and ability of project to independently mitigate identified risk	**Low:** Unproven implementation and only provides a partial solution to identified problem **Medium:** Proven implementation but only provides a partial solution to identified problem **High:** Proven implementation and provides significant solution to identified problem
Environmental Consistency	Level of consistency with existing and potential Federal, State, and local regulatory programs	**Low:** May not be consistent with regulatory programs or risky permit process **Medium:** May not be consistent with regulatory programs, but good case exists for update, and is otherwise a low-risk permit process **High:** Consistent with regulations and low-risk permit process
Economic Reasonability	Qualitative likelihood of project being considered cost effective	**Low:** Costs exceed benefits **Medium:** Costs equal benefits **High:** Benefits exceed costs
Social and Political Acceptability	Level of community and institutional understanding and acceptance of the project	**Low:** Not likely to be locally supported without focused public outreach and education **Medium:** Likely to be supported, but would benefit from public education component **High:** Generally understood and supported, but should include outreach component
Sustainability	Benefits to multiple infrastructure sectors and/or jurisdictions	**Low:** Project may only benefit one community or infrastructure sector **Medium:** Limited to one infrastructure sector but has potential to benefit multiple communities **High:** Benefits more than one sector and potentially more than one community
Financial Need	Ability of jurisdictions to fund projects without Federal assistance	**Low:** Funding mechanisms already in place among other grant programs or local revenue sources **Medium:** Need for Federal government to leverage other funding mechanisms **High:** Clear role for the Federal government to fill funding needs among jurisdictions

Figure 2. ASR Climate Resiliency Snapshot

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ply aquifers and enhancing usable water supply.

These four activities are now eligible under the HMA programs to support communities in reducing the risks associated with climate change. These activities address flooding and drought conditions, and may also provide benefits beyond hazard mitigation, including water quality and supply, as well as ecosystem services. Each of the four activities is summarized within the report in a climate resiliency snapshot (CRS) to provide an overview of the implementation considerations, costs, and benefits. Table 1 provides a guide to the CRS components.

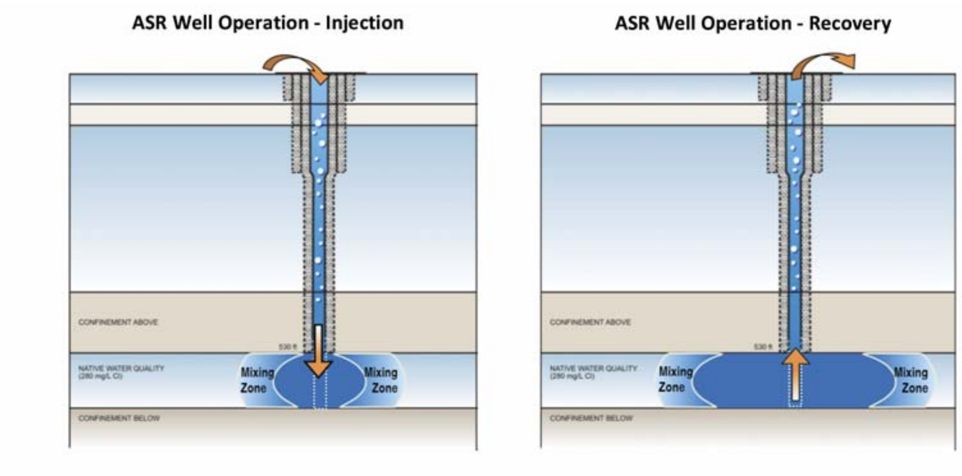

Figure 3. Typical Aquifer Storage and Recovery Well Operation

Aquifer Storage and Recovery

This activity captures water when it is abundant, storing the water in the subsurface in brackish aquifers and recovering the water when needed. It is a drought management tool that has all of the benefits of a surface reservoir, but does not have evaporative or seepage losses and provides better protection of the injected water quality. Once implemented, ASR systems help to supplement water supplies and mitigate the effects of drought. In addition, they can provide flood control and water quality benefits. A CRS for ASR is provided in Figure 2 and Figure 3 is a schematic of a single ASR well operation.

During times of abundant or excess water availability, fresh water is pumped (injected) into the aquifer storage zone, below the ground surface, to create a "bubble" of stored fresh water. Due to differences in water quality and, in particular, salinity (i.e., total dissolved solids), a "mixing zone" is created between the injected water and native groundwater. The salinity or density difference helps keep the injected water close to the ASR well for later recovery. During periods of drought, high demand, or when additional water supply is required, the stored water is pumped out of the aquifer (recovered), treated, and utilized as a freshwater supply. Typically, in ASR systems, water is pumped and recovered from the same ASR well.

The U.S. has been using ASR for more than 30 years (Muniz et al., 2003). According to a 2013 survey of the status of ASR in the country, over 50 sites in at least 26 states have either used or investigated the use of ASR, and worldwide, there are over 100 operational ASR facilities (U.S. Geological Survey, 2015). Source waters for injection into ASR wells range from potable water, reclaimed water, raw and partially treated surface water, and raw groundwater. Projects range in size from a single ASR well, storing relatively small volumes of water, to multiwell projects, storing billions of gallons of water in the ground. ASR systems can be operated such that the recovered water is used to satisfy seasonal demands, or water can be stored over several years, recovering only a portion of the water, but leaving a significant quantity of stored water to meet demands during drought conditions. Given the ability to utilize multiple types of source water for implementation, ASR systems can mitigate the effects of increased demand and drought in a variety of communities across the U.S., which all have different needs and constraints.

Feasibility and Effectiveness

Challenges for implementing ASR include reduced recovery efficiency due to improper selection of the storage zone, arsenic leaching from the storage zone materials, and elevated arsenic concentrations in the recovered water. An exploratory test well should be drilled to confirm that the hydrogeology is favorable for a successful ASR project. There have been advances in the last 10 years for minimizing arsenic leaching (pretreatment of the source water and conditioning) for the utility-scale ASR projects and regulatory relief mechanisms on larger projects, such as water quality criteria exemptions, mixing zones, and buffer zones. Technical considerations for successfully implementing ASR projects include clearly understanding the goals and objectives of the project, proper site selection, utilization of all available tools for appropriate storage zone selection, and hydrogeochemical characterization and modeling of interactions among the target storage zone aquifer matrix, native groundwater, and injected water.

Evaluation and Summary of Benefits and Costs

As a hazard mitigation project, ASR primarily enhances water supply resiliency during times of drought. If surface water is the source of supply to be redirected to the aquifer, the project may also mitigate impacts of flooding by reducing peak stormwater flows. The increased groundwater baseflow provided by ASR may also reduce subsidence and structural damage to facilities in the vicinity. To complete a benefit-cost analysis (BCA), an applicant would have to identify the quantity of additional water supply provided by the project (in millions of gallons) during drought conditions and a mitigation value associated with the additional water. Ideally, the applicant would also demonstrate the amount of water required for daily use versus the amount required for drought mitigation. According to rates developed by Pyne (2014) construction costs for ASR projects range from 50 cents to $2 per gal per day, or $0.5 to $2 million per mil gal per day (mgd) of total ASR system capacity, which is on the low end of the range for water supply projects and other surface storage technologies, such as reservoirs and ground storage tanks of comparable capacity. The implementation costs of an ASR project can vary based on existing conditions of the site and should be examined closely on a project-by-project basis.

Environmental and Historic Preservation (EHP) Requirements

All recharge or injection of fluids directly into aquifers in the U.S. are regulated by the U.S. Environmental Protection Agency (EPA) under 40 CFR Part 144, titled, Underground Injection Control (UIC) Program. As part of the EPA UIC

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permit process, an applicant must demonstrate that the activity does not impact other users of the aquifer.

An exploratory test well should be drilled to confirm that the hydrogeology is favorable for a successful ASR project. If there is evidence that the site is a historic or archaeologically significant site, then the location of the ASR site should be relocated. Similarly, facilities may be sited to avoid sensitive fish and wildlife and designated critical habitats, thereby reducing potential impacts and the necessary level of EHP review. The ASR facilities would not typically qualify for a categorical exclusion (CatEx) because they do not fit into the categories of actions described in 44 CFR 10.8. Most local-scale ASR facilities, and those closely associated with an existing municipal treatment facility, would likely be covered by an environmental assessment (EA). Early screening of the site is recommended to determine if an EA or and environmental impact statement (EIS) would be likely based on project complexity.

Figure 4. Flood Diversion and Storage Climate Resiliency Snapshot

Potential Coordination with Other Federal Agencies

Since ASR is often considered a sustainable and environmentally friendly alternative water supply option, there are currently several federal programs that have or could potentially fund ASR projects, such as U.S. Bureau of Reclamation (USBR), EPA, U.S. Army Corps of Engineers (USACE), U.S. Department of Agriculture (USDA), and U.S. Department of Housing and Urban Development (HUD).

Flood Diversion and Storage

Every year, communities face significant damages from flooding. Diverting floodwaters from a stream, river, or other body of water into a wetland, floodplain, canal/ditch, pipe, or other conduit (e.g., tunnels, wells) and storing them in reservoirs, floodplains, wetlands, or other storage facilities allows for a controlled baseflow release and attenuates peak flows, stages, and velocities to mitigate flooding. Actively managing floodwaters by diversion, storage, and infiltration can also replenish water supply aquifers and enhance usable water supply to mitigate the effects of drought. Floodwater diversion also can help maintain healthy ecosystems. A CRS for flood diversion and storage is provided in Figure 4.

Feasibility and Effectiveness

The concept of floodwater diversion and storage is applied nationwide at multiple scales: large, regional efforts, like the network of major flood control diversions along the Mississippi River; moderate-sized diversion and storage efforts that occur in relatively smaller rivers and tributaries; and at a site-specific or neighborhood scale that utilize stormwater infrastructure to divert flows and store water on a parcel-by-parcel basis.

Depending on the scope, scale, and location of potential sites, floodwater diversion and storage projects vary in complexity, and the scale of these projects must be considered when evaluating if the projects are consistent with HMA guidance regarding flood risk reduction projects. Proper planning, siting, sizing, and construction are required to implement successful floodwater diversion and storage systems. Types of flood storage (online, offline, dry, wet, or wet/dry), planning constraints, and design considerations (land acquisition, siting, and adaptability) are key elements of technical implementation.

Evaluation and Summary of Benefits and Costs

The primary benefit of floodwater diversion and storage projects is to reduce flooding by attenuating peak flows and velocities, allowing them to slowly be released or infiltrate into the ground; therefore, potentially reducing flood damages to infrastructure such as roads, residential and commercial structures, or other property downstream and upstream.

The reduction of flood impacts from peak stormwater flows can be quantified using traditional FEMA BCA methodologies in the current FEMA BCA tool. The applicant should provide hydrologic and hydraulic information to estimate the reduction in flood elevation pre- and post-project. If a floodwater diversion and storage project results in new or restored wetlands, estuaries, or riparian or green open space, the total annual benefits for these categories can be included in the BCA. The applicant would need to quantify the area of restored ecosystem and the land use type and may need to identify the quantity of additional water supply provided by the project (in millions of gallons) and demonstrate the amount of water required for daily use versus the amount required for drought mitigation.

Costs for floodwater diversion and storage projects are site-specific and vary, depending on the scope, scale, and location. Some costs that may be incurred include: land acquisition; feasibility analyses; environmental impact, habitat assessment, and cultural significance analyses; hydrologic and hydraulic analyses; subsurface and foundation investigations; consulting services for the design, permitting, project management, and supervision of the construction; demolition, construction, and mobilization costs (e.g., channels, pipes, detention basins, stormwater interventions, floodgates, levee realignment, and utility realignment); pre- and post-project monitoring; and operations and maintenance (O&M) costs.

EHP Requirements

There are numerous permits and supporting documentation that may be required as part of any floodwater diversion and storage project, and they may be required to show compliance with EHP requirements. Many of these permits relate to environmental habitat considerations, wetland delineation, water quality, and additionally, tribal community reviews. Neighborhood-scale projects that utilize stormwater infrastructure to divert flows and store water on a parcel-by-parcel basis would likely be eligible for a CatEx, but it would not apply if a project would change downstream flow patterns to the extent that land use, delineated special flood hazard areas, stream functions, stream habitat, erosion, or sedimentation rates are affected. Moderate-, large- or regional-scale projects would not be covered by a CatEx and would need to be reviewed under an EA or an EIS.

Potential Coordination with Other Federal Agencies

A critical piece of a floodwater diversion and storage project plan is to have a transparent and inclusive approach to outreach and collaboration. In addition to local stakeholders, there may be an opportunity to coordinate with other federal agencies, such as the USDA-Natural Resources Conservation Service (NRCS), USBR, EPA, National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (FWS), USACE, and HUD. In many of these cases, coordination is required for permitting, cost-sharing, and for multibenefit and multigoal objectives, such as using floodwater diversion and storage projects as a means for providing a wealth of ecosystem goods and services, recreational opportunities, and regional sediment management for beneficial reuse.

Floodplain and Stream Restoration

The U.S. has more than 3.5 million mi of rivers and streams that, along with closely associated floodplain and upland areas, comprise corridors of great economic, social, cultural, and environmental value (Federal Interagency Stream Restoration Working Group [FISRWG], 1998). When healthy, these systems can provide stream flood mitigation, mitigate bank erosion concerns, and provide ecological benefits.

Many natural events and human activities can contribute significantly to changes in the dynamic equilibrium of stream systems across the country. Stream degradation ultimately results in water quality issues, loss of water storage and conveyance capacity, loss of habitat for fish and wildlife, and decreased recreational and aesthetic values (National Research Council, 1992), while risks to flooding and erosion increase.

Restoration of disturbed river systems is accomplished by adjusting the physical stability and biological function of an impaired river to that of a natural stable river. Channel improvements generally involve alterations to degraded channel floodplain storage, side slopes, sinuosity (degree of meandering), vegetation, bed slope, and roughness. The floodplain of a riverine or stream system provides capacity for storing stormwater runoff, reducing the number and severity of floods, and minimizing nonpoint source pollution. Restoring floodplains and wetlands, and their native vegetation, are integral components of stream restoration efforts, as is the comprehensive consideration of the streams at a watershed scale. A CRS for floodplain and stream restoration is provided in Figure 5.

Feasibility and Effectiveness

A wide variety of techniques can be applied to stream restoration planning and channel design. There are no one-size-fits-all approaches, and stream restoration requires a site-specific approach based on sound stream restoration analysis and design. A successful stream restoration project must incorporate multidisciplinary techniques from hydrology and hydraulics, fluvial geomorphology, engineering, and stream ecology. Clearly defining the objectives of the stream restoration project reduces ambiguity for all parties involved. Objectives should not only be specific, but also realistic, achievable, and measurable.

Project scope and scale are major considerations for stakeholders and the design team in setting objectives, and both control the breadth of restoration options (Smith and Klingeman, 1998). Channel design is a critical portion of the overall stream restoration process and constructability and environmental impacts are two critical items to consider during the design phase. Flood damage reduction techniques should simultaneously provide flood protection benefits and restore natural environmental functions, while considering FEMA-authorized local and nonlocal flood risk reduction projects. Sedimentation analysis is a key aspect of design, since many projects fail due to excessive erosion or sediment deposition. Implementing a successful stream restoration solution requires detailed planning, analysis, and design phases. Once the restoration plan is designed, it is important to carefully execute the construction, maintenance, and monitoring phases.

Evaluation and Summary of Benefits and Costs

The primary benefit of floodplain and stream restoration is to reduce flood damages to structures and infrastructure, while restoring natural and beneficial function of the floodplain. The benefits due to a reduction of flood impacts from peak stormwater flows can be quantified using traditional FEMA BCA methodologies in the current FEMA BCA tool, and erosion control benefits can be similarly quantified. The applicant should provide hy-

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Figure 5. Floodplain and Stream Restoration Climate Resiliency Snapshot

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drologic and hydraulic information to estimate the reduction in flood elevation pre- and post-project. If a floodplain and stream restoration project results in new or restored wetlands, estuaries, or riparian or green open space, the total annual benefits for these land uses may be included in the BCA. The applicant would need to quantify the area of restored ecosystem and the land use type and may need to identify the quantity of additional water supply provided by the project and demonstrate the amount of water required for daily use versus the amount required for drought mitigation.

The costs of floodplain and stream restoration measures are very site-specific and depend on numerous factors, such as tributary area, size and condition of floodplain, depth, width, sinuosity, and flow of the stream. These factors, along with bank slopes, access, existing and proposed vegetation, extent of erosion, type of soil/rock comprising the streambed and stream bank, and the amount of land required for easement or acquisition, all result in a complex array of costs. Some costs that may be incurred include land acquisition; feasibility analyses; environmental impact, habitat assessment and cultural significance analyses; geotechnical investigations; hydrologic and hydraulic analyses; consulting services for the design, permitting, project management, and supervision of the construction; demolition, construction, and mobilization costs (e.g., erosion and sediment control, channel clearing and shaping, riprap, restoration structures, seeding and mulching, earthfill and drainfill, etc.); pre- and post-project monitoring; and O&M costs.

Figure 6. Low-Impact Development/Green Infrastructure Climate Resiliency Snapshot

EHP Requirements

Legal compliance, permits, and supporting documentation may be required as part of any floodplain and stream restoration project and may be required to show compliance with EHP requirements. Many of these permits relate to environmental habitat considerations, wetland delineation, water quality, and additionally, tribal community reviews. A simple floodplain restoration project that only involves land acquisition, removal of structures, and planting of indigenous vegetation might be covered under CatExs (d)(2)(vii), property acquisition and demolition, and (d)(2)(xi), planting of vegetation. A more complex project that involves construction activities, such as setback and reconstruction of levees, regrading stream beds and banks, or armoring countermeasures, would likely not be eligible for a CatEx and would need to be analyzed in an EA.

Potential Coordination with Other Federal Agencies

Several federal agencies are already engaged in floodplain and stream restoration activities, and many agencies help support and provide funding for these activities, including USDA-NRCS, FWS, USACE, and NOAA-National Marine Fisheries Service (NMFS).

Low-Impact Development/ Green Infrastructure

The LID is a sustainable approach to natural landscape preservation and stormwater management (EPA, 2013). This approach emphasizes conservation and the use of onsite natural features integrated with engineered, small-scale hydrologic controls to more closely mimic predevelopment hydrologic functions (Puget Sound Action Team [PSAT], 2005). Implementation of LID/GI practices can help mitigate flood events by increasing the ability of the landscape to store water onsite. Infiltration of these stored waters can also mitigate the effects of drought by replenishing water supply aquifers and enhancing usable water supply.

GI can be used at a wide range of landscape scales in place of, or in addition to, more traditional stormwater control elements to support the principles of LID (EPA, 2014). Both LID and GI utilize BMPs that can be combined in a BMP treatment train to enhance benefits and reduce costs. In the last decade, LID and GI often have been used interchangeably; however, LID focuses specifically on water management issues, while GI's scope can be broader and used to mitigate issues such as air pollution, urban heat island effects, wildlife conservation, and recreational needs (Chau, 2009). A CRS for LID/GI is provided in Figure 6.

Feasibility and Effectiveness

Instead of large, centralized treatment plants and water storage facilities, LID/GI emphasizes local, decentralized solutions that capitalize on the beneficial services that natural ecosystem functions can provide. The LID/GI is most effective when applied on a wide scale and encompasses much more than just water infiltration, as it can be used to mitigate floods downstream, filter pollutants, and capture and store water for use at a later time. Storing potential floodwaters onsite in LID/GI practices allows for a controlled baseflow release and attenuates peak flows, stages, and velocities to mitigate flooding. The diversion, storage, and infiltration of these waters also can replenish water supply aquifers and enhance usable water supply to mitigate the effects of drought.

One of the primary motivations for LID/GI for a number of communities in the U.S. is to reduce stormwater runoff, which may contribute to combined sewer overflow (CSO) events. Overflow occurs in cities with combined sewer systems (CSS) where wastewater (i.e., sanitary sewage), stormwater, and urban runoff water are collected in the same

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pipe network and routed to a treatment plant (Economides, 2014). If the capacity of the downstream treatment plants cannot handle the amount of water collected, excess flows, inclusive of sanitary sewage, are often routed directly to the nearest body of water. The LID/GI is an ecosystem-based approach that is used to replicate a site's predevelopment hydrologic function. The primary goal of LID/GI is to design each development site to protect, or restore, the natural hydrology of the site so that the overall integrity of the watershed is protected (Maimone et al., 2007). This is done by creating a "hydrologically" functional landscape.

In the face of a changing climate, LID/GI can potentially play an increasingly important role to reduce local impacts for community resources and waters. By reducing the volume of runoff entering sewer systems and increasing natural features that can reduce the effects of flooding, LID/GI can add resiliency to climate change adaptation planning (American Rivers et al., 2012). Scales of implementation, site design considerations, design guidance and technical manuals, and LID/GI practice selection are key considerations and guidance to be used in planning and design of any LID/GI project.

Evaluation and Summary of Benefits and Costs

The primary benefit for many LID/GI projects is the reduction of flood damages to structures and infrastructure through stormwater detention and infiltration. The reduction of flood impacts from peak stormwater flows can be quantified using traditional FEMA BCA methodologies in the current FEMA BCA tool. The applicant should provide hydrologic and hydraulic information to estimate the reduction in flood elevation pre- and post-project. If a LID/GI project results in new or restored wetlands, estuaries, riparian or green open space, the total annual benefits for these land uses could be included in the BCA. The applicant would need to quantify the area of restored ecosystem and the land-use type. If applicable, the applicant may need to identify the quantity of additional water supply provided by the project (in millions of gallons) and demonstrate the amount of water required for day-to-day use versus the amount required for drought mitigation.

There are some cases where LID project costs have been higher than those for conventional stormwater management projects, but in the majority of these cases, significant savings were realized due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping (EPA, 2007). On average, total capital cost savings ranged from 15 to 80 percent when LID methods were used (EPA, 2007). The O&M costs for LID/GI practices vary, depending on site-specific conditions; however, ongoing maintenance need diminishes as plant materials establish and the site stabilizes. Cost of LID/GI practices vary widely, depending on site-specific conditions and the type of GI techniques being used.

EHP Requirements

Water quality certification, hydraulic project approval, no-rise certification or a conditional letter of map revision, and a general construction permit may be required as part of any LID/GI project and may be required to show compliance with EHP requirements. Many types of LID/GI projects may be covered under existing CatExs when they are replacing existing structures resulting in the same developed footprint and similar form and function.

It is important, however, to note that while most LID/GI projects would be expected to meet the general criteria for a CatEx found in 40 CFR 1508.4, unless the activity would be covered under a specific CatEx in 44 CFR 10.8, it would require an EA.

Potential Coordination with Other Federal Agencies

Given the potential of GI to support a wide range of purposes, a number of agencies, including EPA, U.S. Department of Transportation (DOT), HUD, USDA, U.S. Department of the Interior (DOI), and U.S. Department of Energy (DOE) offer expertise and resources that can be used to help communities plan, design, and then implement GI practices.

Summary

To date, FEMA's mitigation funding efforts have been in response to natural and manmade disasters; however, FEMA's focus on risk management is expanding to include proactively anticipating climate changes and planning for additional new funding programs in support of climate-resilient infrastructure. It continues to integrate climate-change adaptation into programs, policies, and operations to strengthen the nation's resilience by addressing current needs, while planning for future risk.

All four climate-resilient mitigation activities presented here are consistent with FEMA's HMA programmatic requirements and guidelines. They are feasible and effective measures for independently addressing drought and flooding issues, can be shown to be cost-effective, and meet EHP requirements.

The funding of climate-resilient projects and enhanced land/floodplain development regulations are critical to building stronger, more resilient communities. Climate-resilient planning and infrastructure projects allow communities to be better prepared for disasters related to climate change in order to minimize, or avoid, damage. Climate-change mitigation planning results in less post-disaster damage and, therefore, reduced costs to rebuild communities post-disaster. Strategic funding by FEMA of climate-resilient projects will help communities proactively plan and be better prepared for impacts related to climate-change weather extremes.

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