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MEMORANDUM

To: **CMAP Environment and Natural Resources Committee**

From: CMAP staff

Date: January 10, 2017

Re: Alternative Futures: What if climate change impacts intensified?

As part of ON TO 2050 development, CMAP is undertaking an "alternative futures" planning process focusing on exogenous factors that are largely beyond the control of any one entity, including CMAP and our regional partners. These factors include the environment, consumer preferences, technological advancements, and macroeconomic trends.

Based on research and feedback from stakeholders, CMAP envisions five different futures for the region, imagining life in 2050 where…

- Climate change impacts intensified
- More people chose mixed-use, higher density environments
- Economic restructuring continued
- Technology enabled smarter mobility
- Public resources continued to diminish

The Alternative Futures planning exercise, which draws upon ongoing CMAP work and ON TO 2050 products, will inform public engagement efforts to take place over the summer of 2017. CMAP will identify the key macro-level drivers shaping each future and their potential impacts. With written and interactive materials, staff will endeavor to illustrate life for residents and businesses in these imagined futures. With the assistance of committees, CMAP will also propose strategies that will help to mitigate potential negative outcomes and capitalize on opportunities that might arise. At the end of the project, staff will emphasize crosscutting strategies, that is, actions and policies that will help the region thrive across a wide range of possible outcomes.

This memo, the first in a series, will focus on a future in which climate change impacts have intensified greatly. CMAP developed this future based on the assumption that the status quo

will remain the same. Energy consumption levels, land use and development decisions, and other human activity that contributes to greenhouse gas emissions will continue at the same rate or higher between 2017 and 2050. This future also assumes that technological advances have not greatly reduced greenhouse gas emissions. The temperature, precipitation, and drought projections used throughout this memo, as well as the outcomes, are dependent upon the business-as-usual, high-emissions scenario.

In a future with intensified climate change impacts, high greenhouse gas emissions have led to more extreme temperatures, warmer winters, more intense and frequent storms, and drought. By 2050, these climate change impacts have strained the region's infrastructure and natural systems, disproportionately affecting the most vulnerable residents. Shifting habitats and agricultural zones, drought, and water quality issues also present economic and environmental challenges. Potential economic opportunities may arise from population growth and increased reinvestment, as residents and industries from other areas of the country that are more severely impacted by climate change impacts move to the region.

Primary driver: high greenhouse gas emissions

In 2050, decades of continued fossil fuel use has increased greenhouse gas emissions.

Greenhouse gasses contribute to climate change by trapping heat in the Earth's atmosphere. In large concentrations, these gasses – including carbon dioxide, methane, and nitrous oxide, among others – create a barrier that prevents heat from reflecting back into space, similar to the glass ceiling of a greenhouse. Human activity, such as the burning of fossil fuels, has increased the concentration of these gasses in the atmosphere, causing the climate to warm. If the status quo remains the same, emissions are expected to increase 28% by 2050.[1,2] As the primary driver of climate change, greenhouse gas emissions contribute to more extreme heat and more intense and frequent storms and drought.

[1] Chicago Metropolitan Agency for Planning. 2012. "Chicago 2010 Regional Greenhouse Gas Emissions Inventory." Accessed on Nov. 8, 2016.https://www.cityofchicago.org/content/dam/city/progs/env/CCAP/Chicago_2010_Regional_GHG_Inventory.pdf

[2] In 2010, the Chicago region produced an estimated 15 MTCO2e metric tons of carbon dioxide equivalent (MMTCO2e) per person, a per capita rate that is below the national average of 22.2 MMTCO2e and comparable to peer regions. Emissions in the Chicago region have remained fairly constant in recent years.

Intensified climate change impacts

In 2050, high levels of greenhouse gas emissions have exacerbated the impacts of climate change. Summer days are insufferably hot. Winters are warmer, but oddly, the few cold days are at historic lows. Storms are more severe, and rainy days last longer. Prolonged drought has increased hardship for communities without access to Lake Michigan water.

In the year 2050, average temperatures are expected to increase by 3-5°F.[3] Temperature increases at this scale would boost the number of days per year over 100°F from zero to two currently to fifteen days by 2050.[4] Nighttime temperatures are warmer, frequently reaching the high 70s and low 80s. Both of these trends contribute to more frequent and more powerful heat waves. By mid-century, the extreme heat events on par with the 1995 heat wave that killed more than 700 Chicago residents happen almost every other year.[5]

Winters in northeast Illinois are characterized by mild temperatures, heavy rains, and periodic deep freezes. By 2050, the region will have 22 fewer days below freezing than current rates.[6] The warmer temperatures cause more frequent freeze-thaw events[7] and more precipitation to fall as sleet and freezing rain.[8] At the same time, extremely cold days are colder and last longer due to fluctuations in the polar jet stream.[9]

A warming climate will trigger changes in the region's water cycle, specifically through stronger, more frequent storms and longer, more persistent droughts. The once-rare 100-year storm events, defined for northeastern Illinois as a 24-hour storm producing at least 7.58 inches

[3] National Oceanic and Atmospheric Administration. "Record of Climatological Observations – Chicago OHare International Airport, Jan. 01, 2016 – Dec. 31, 2016." https://www.ncei.noaa.gov/orders/cdo/866284.pdf

[4] Hayhoe, K., S. Sheridan, L. Kalkstein, and J. S. Greene. 2010. Climate Change, Heat Waves, and Mortality Projections for Chicago. Journal of Great Lakes Research, vol 36 (2) pp. 65-73, http://www.bioone.org/doi/abs/10.1016/j.jglr.2009.12.009

[5] Ibid.

[6] Kunkel, K.E., Steven, L.E., and Stevens, S.E., 2012. Climate of the Midwest. U.S. Guidance document prepared for the US National Climate Assessment.

[7] Henry, H.A.L., 2008. Climate change and soil freezing dynamics: historical trends and projected changes. Climate Change, Vol. 87: 421-434.

[8] Angel, Jim. Presentation on Climate Change in Northeastern Illinois, Oct. 27, 2016. Chicago Metropolitan Agency for Planning

[9] Sheffield, University of. "Extreme cold winters fuelled by jet stream and climate change." ScienceDaily. ScienceDaily, 26 October 2016. <www.sciencedaily.com/releases/2016/10/161026081551.htm>.

of rain, occur much more regularly.[10,11] Total annual precipitation in the Chicago region is expected to increase 20-30% by the end of the century, with virtually all of this increase occurring during these winter months.[12] Wetter winters will be offset by drier summers, with long periods of drought periodically interrupted by heavy, potentially damaging storms.[13] These dry periods may cause soils to become less porous, which increases the risk of flash flooding and erosion.[14]

Life in 2050 with intensified climate impacts

In 2050, Chicago residents will face a future with more extreme temperatures, severe storms, and persistent droughts. The outcomes described below assume that current trends and policies (e.g., land use trends, maintenance levels, public assistance programs, etc.) remain the same.

Property damage from flooding has increased.

More intense and frequent storms compromise quality of life, damage property, hinder economic activity, and endanger safety. In areas along rivers and streams, floodplains expand as waterways regularly overflow during heavy rains. Drainage systems in built out parts of the region are often overwhelmed, causing more basement backups and impairing access on roads. In 2015, the National Flood Insurance Program has provided the state of Illinois with approximately $7.6 million in claims, with much of the 6-county Chicago region accounting for the state payouts.[15][16] By mid-century, residents, businesses, and municipalities will pay significantly more to address property damage and accidents caused by flooding and rain.

Lakes and rivers are more polluted.

More rainy days leads to more polluted water bodies as stormwater travels over land and through storm drains, collecting sediment, garbage, and oils that eventually wash into lakes and

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[10] Since the 1980s, the Chicago region has experienced the 100-year storm three times.

[11] Chicago Metropolitan Agency for Planning. 2013. "Climate Adaptation Guidebook, Appendix A: Primary Impacts of Climate Change in the Chicago Region."

[12] Hayhoe, K., S. Sheridan, L. Kalkstein, and J. S. Greene. 2010. Climate Change, Heat Waves, and Mortality Projections for Chicago. Journal of Great Lakes Research, vol 36 (2) pp. 65-73, http://www.bioone.org/doi/abs/10.1016/j.jglr.2009.12.009

[13] Federal Highway Administration. Regional Climate Change Effects" Useful Information for Transportation Agencies. Accessed on Dec. 29, 2016. https://www.fhwa.dot.gov/environment/climate_change/adaptation/publications/climate_effects/effects03.cfm

[14] Huff, F. A., and J. R. Angel, 1989. Rainfall Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois (Bulletin 70), Illinois State Water Survey, http://www.isws.illinois.edu/atmos/statecli/PDF/b70-all.pdf.

[15] Federal Emergency Management Agency, "National Flood Insurance Program: Total claim payments", October 1, 2014 through September 30, 2015.

[16] Winters, Brad, et. al., "Report for the Flooding Awareness Act," Illinois Department of Natural Resources, 2015.

rivers. Combined sewer systems, found throughout the Chicago region, are not built to support the sustained heavy rains in 2050, especially 100-year storm events. Heavy rains overwhelm the sewer systems and lead to more combined sewer overflows, where untreated sewage is released into waterways.[17] [18] Federal regulations[19,20], longer droughts, and population growth in communities lake water access mean that communities in desaturated areas are not able to transition to lake water. Instead, municipalities need to dig deeper wells, switch to river water, build new, costly water purification plants, adopt strict water conservation policies, or explore other alternatives. Residents and businesses in these areas will also be paying more for water.

Habitats have shifted, bringing new species and requiring changes to agricultural practices.

Some native plant and animal species, including street trees, do not thrive in a warmer climate with more variable rainfall. These species gradually move to new habitats or become locally extinct. At the same time, some species not currently found in northeast Illinois, including invasive species such as the highly destructive kudzu vine, begin to establish themselves in the Chicago area.[21]

In the short term, the region's farms may benefit from warmer temperatures and higher concentrations of CO2, which plants need to grow. However, these benefits are gradually eliminated by more frequent crop failures due to heat stress, severe flooding, accelerated insect growth, and persistent drought.[22] Irrigation for farming will grow more quickly than any other water use, creating competition for increasingly scarce groundwater.[23] Large-scale droughts in other parts of the United States also disrupts agricultural markets. This will increase the value of agricultural land and crops in the region.

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[17] City of Chicago. "Combined Sewers." Accessed on Dec. 28, 2016. https://www.cityofchicago.org/city/en/depts/bldgs/supp_info/combined_sewers.html

[18] Mannix, Devin H., et al. "Groundwater Availability in Northeastern Illinois from Deep Sandstone Aquifers." Illinois State Water Survey. Fact Sheet 2 from Contract Report 2015-02.

[19] Federal regulations, which control the amount of water that may be diverted from the lake, limit Illinois' diversion to 3,200 cubic feet per second (CFS).

[20] Barker, Bruce, 1993. Lake Diversion at Chicago. Case Western Reserve Journal of International Law. Vol 18 (1). http://scholarlycommons.law.case.edu/cgi/viewcontent.cgi?article=1736&context=jil

[21] Hellmann, Jessica, J, Knute, J. Nadelhoffer, Louis R. Iverson, Lewis H. Ziska, Sephen N. Matthews, Philip Myers, Anantha M. Prasad, and Matthew P. Peters, 2010. Climate Change Impacts of Terrestrial Ecosystems in Metropolitan Chicago and its Surrounding, Multi-State Region. Journal of Great Lakes Research 36 (2010) 74–85, https://naldc.nal.usda.gov/download/49775/PDF

[22] National Climate Assessment: Midwest. Accessed on Dec. 28, 2016. http://nca2014.globalchange.gov/report/regions/midwest

[23] Chicago Metropolitan Agency for Planning, 2010. "Water 2050: Northeastern Illinois Regional Water Supply/Demand Plan," http://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757

Health and public safety problems increase.

Climate change impacts create or exacerbate multiple health issues.[24] Extreme heat causes higher rates of heat-related stress, strokes, and other health issues that can potentially lead to illnesses or death. The risk of vector-borne diseases, such as Lyme disease, will increase in warmer weather. Air pollution, especially ozone, gets worse because of higher temperatures, aggravating asthma, chronic bronchitis, and emphysema.[25] Impaired water quality leads to higher rates of water related illnesses such as cholera. More frequent and intense storms also increase the risk of accidents, particularly on roads.

Transportation is obstructed more frequently by weather related events.

Surface transportation – including cars, busses, trucks, and trains – are impaired more frequently due to road closures caused by flooding or weather related accidents, leading to time lost and increased costs due to repeated rerouting. During the summer months, extreme heat causes more pavement and railways to buckle, disrupting traffic and endangering commuters. More freeze-thaw cycles – a characteristic of warmer winters – will crack pavement and lead to pothole formation. Municipalities and transportation agencies will face higher maintenance and operation costs. Disruptions in rail and highway also pose challenges to the freight and logistics industries in the region. These disruptions are built into the cost of doing business, increasing costs and travel times for residents and businesses alike.

Energy and water infrastructure systems are more strained.

In addition to transportation, other infrastructure systems, including water and energy, are strained. More extreme cold increases the risk of water pipes bursting. More extreme heat increases demand for energy, leading to more blackouts and brownouts as demand surpasses capacity. Severe thunderstorms, ice storms, and strong winds damage overhead power lines, and cause power outages that disrupt business productivity and threaten public safety.

Population growth and new industries create new economic opportunities.

Many communities outside of the region face even greater impacts. Warmer waters create more powerful hurricanes and typhoons, threatening homes and businesses along coasts.[26] More arid regions such as the American Southwest that had extremely hot summers in 2016 will become even hotter and drier. These forces do not directly affect Lake Michigan, which sits 579 feet above sea level.[27] Manufacturing industries such as steel, petroleum, chemicals, and food processing have a high rate of water consumption as well as water-related energy requirements

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[24] Center for Disease Control and Prevention, "Climate effects on health," July 26, 2016.

[25] U.S. Environmental Protection Agency, "Ozone Pollution: Health effects of ozone pollution," 2016.

[26] Ibid.

[27] National Oceanic and Atmospheric Administration, 2016. Global Warming and Hurricanes. Accessed on Dec. 22, 2016. https://www.gfdl.noaa.gov/global-warming-and-hurricanes/

(i.e., process water, cooling, and boiler feed).[28] By 2050, these water-intensive industries have moved from drought-impacted areas in the United States to areas with dependable and bountiful water access, including the Chicago region. Similarly, population in the region has increased due to migration from regions facing even more severe distress by climate change impacts.

Disproportionately impacted communities

Lower income residents, the elderly, and populations of color, in particular, are at greater risk from the negative outcomes of climate impacts.

Some population groups will experience the impacts of climate change more acutely than others due to location (higher rate and/or intensity of exposure due to location), increased sensitivity, and lesser adaptive capacity (the ability to adapt to and cope with climate change).[29]

The effects of extreme heat will be most severe in urban centers where impervious surfaces, such as roadways, parking lots, and rooftops, will heat up during the day and remain hot well into the night. The phenomenon, known as the urban heat island effect, currently causes temperatures in the City of Chicago to be 2°F warmer than surrounding communities do. The temperature difference between urban and non-urban areas will grow as summers get hotter. Lower income residents and people of color are most often residents of urban heat islands[30,31]; furthermore, with fewer financial resources, lower income residents are less able to afford housing in areas with abundant green spaces or pay for amenities like air conditioning during the summer or heat during the winter.[32] Older adults, who are less physically able to respond to changes in temperature, will also face a greater risk of heat or cold related deaths and illnesses.[33] Older adults and persons of color will increase in population by 2050, underscoring the need to reduce and ameliorate the negative impacts of climate change.

Other population groups at risk during days of extreme heat or cold are people with existing medical conditions, those without health insurance coverage, infants and children who are more sensitive to extreme temperatures, people who live alone, and outdoor workers with

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[28] Ellis, Mark, et al. "Industrial water use and its energy implications," American Council for an Energy Efficient Economy, 2001.

[29] Füssel, Hans-Martin and Richard J.T. Klein, "Climate change vulnerability assessments: An evolution of conceptual thinking," *Climatic Change*, 2005.

[30] Wen, Ming, et. al., "Spatial disparities in the distribution of parks and green spaces in the USA," *Annals Behavioral Medicine*, 2013 (45) 18-27.

[31] Wolch, Jennifer R., Jason Byrne, Joshua P. Newell, "Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'", *Landscape and Urban Planning* 125 (2014) 234-244.

[32] Centers for Disease Control and Prevention, "Extreme Heat and Your Health: Heat and the Low Income," 2011.

[33] Centers for Disease Control and Prevention, "Extreme Heat and Your Health: Heat and the Elderly," 2011.

higher rates of exposure to high heat. Climate change impacts will also broadly impact populations that live in areas of the region more prone to droughts and flooding or are far away from services. Residents and businesses located in areas at risk of desaturated groundwater will likely have to pay more for water. Again, higher water rates will have a greater impact to lower income households. People and businesses along rivers will experience property damage and quality of life impairments due to floods. Residents in less dense suburban neighborhoods must often travel further, typically by car, to obtain goods and services. These households with limited transportation options or are socially isolated will have greater difficulty reaching people and critical services that could help them during storms, floods, or other emergencies.

Strategies to prepare for intensified climate change impacts

CMAP and partners can undertake a number of actions now to reduce greenhouse gas emissions and prepare for a future with more climate impacts. Below are the main strategies for CMAP and partners to mitigate climate change and its negative impacts. These strategies are described in more detail in related CMAP strategy papers and research (see Attachment A).

1. **Implement policies that effectively price use of energy, natural resources, and public infrastructure**

The full value of energy, water, and other natural resources include positive externalities like ecosystem services that mitigate the impacts of severe storms and heat. Ecosystem services already provide an estimated $4.2 billion in flood control benefits every year.[34] Consumption of these resources can have negative impacts, including increasing carbon emissions and reducing the capability of natural systems to function. Public infrastructure like the transportation system and water treatment have maintenance, operations, and delivery costs that are often not included in the price users pay, costs that are likely to increase as climate impacts become more severe. The region should use the many tools at its disposal to encourage conservation, reduce emissions, and provide a stable source of revenue for needed infrastructure maintenance. Pricing policies should take into consideration equity implications.

Main pricing policies:

- Mileage based fees for the transportation system
- Full-cost pricing for water
- Carbon trading
- Real-time pricing of energy, water, and transportation (i.e., tolling)
- Ecosystem service banking and trading

[34] http://www.cmap.illinois.gov/documents/10180/429845/2015-06-03-ENR-5.0-GIV+Ecosystem+Service+Valuation.pdf/f1306fa8-15d5-4a04-bad0-b18f52c18f7c

- Development impact fees

2. Integrate green infrastructure at all scales: site specific, community, and regional
Green infrastructure, including street trees, rain barrels, bioswales, and parks and open space, plays a critical role in reducing flooding, maintaining a high quality of life, and mitigating climate change. Green infrastructure interventions are highly regarded for their ability to provide "co-benefits," that is, they accomplish multiple goals simultaneously: retain stormwater, reduce air and noise pollution, sequester carbon, provide wildlife habitat, reduce the heat island effect, and create a more enjoyable streetscape. In addition, green infrastructure can reduce the cost of stormwater management than when traditional stormwater management systems are used alone.[35] As such, CMAP and partners should support efforts to complement traditional gray stormwater approaches by integrating green stormwater infrastructure at all scales.

Main strategies for implementing green stormwater infrastructure:

- Identify critical assets at regional and local scales through technical analysis and participatory processes
- Update design standards to incorporate green infrastructure, particularly with transportation infrastructure
- Assess incentives for private property owners to incorporate green infrastructure
- Create opportunities and reduce barriers to integrate green infrastructure into gray infrastructure such as roads and achieve other co-benefits
- Identify and protect wildlife corridors and conservation zones
- Encourage rain barrel, landscaping and tree planting programs, particularly in neighborhoods experiencing the urban heat island effect
- Support community based education and retrofit programs

3. Prioritize and protect critical physical assets for extreme weather events
CMAP and partners should identify and strengthen regional assets that mitigate the negative effects of extreme heat and storms. Vital regional assets are necessary for residents and communities to function safely, particularly in periods of stress. Some examples may include the following: the public transit system, which enables people without cars to get around; communications infrastructure that provides vital information in the case of emergencies; public institutions that can serve as community gathering centers or warming/cooling facilities in times of crisis; energy generation and distribution systems that power homes, businesses, and other resources; community assets, such as hospitals; natural assets that provide vital flood protection and other benefits; water treatment plants; and major routes on the highway and rail system. Critical assets should be protected throughout all stages of their lifecycle, from planning and design to operation and maintenance.

[35] U.S. Environmental Protection Agency, "Reducing stormwater costs through low impact development (LID) strategies and practices," December 2007.

Main strategies to protect critical assets:

- Identify critical assets at regional and local scales through a mix of technical analysis and participatory processes
- Update design standards and maintenance and operating procedures for physical infrastructure (communications, energy, transportation, water, green infrastructure) to account for intensified climate change impacts
- Invest in flexible, resilient communication systems to be responsive to the needs of residents and businesses during immediate shocks as well as long term stresses
- Encourage research, adoption, and coordination of decentralized energy systems and communication systems that will be more resilient to climate impacts
- Account for interdependency of critical systems in planning and design processes

4. Explicitly integrate climate change mitigation and resilience goals into planning and development

In undertaking community planning processes, such as comprehensive plans and capital improvement plans, municipalities should assess climate risks and impacts and incorporate those considerations into near- and long-term priorities. This planning may include identifying critical assets (see above) as well as resilient land use planning.

Main strategies to integrate climate goals into planning and development:

- Update floodplain and other place-based mapping based on new rainfall and climate impact information
- Direct development away from floodplains through conservation easements, zoning restrictions, and transfer of development rights (TDR) programs
- Encourage and incentivize infill development
- Update stormwater management ordinances and zoning codes to improve stormwater mitigation and reduce impervious surface creation

5. Provide people with multiple mobility options

Multiple transportation options can help to ensure that people are able to access jobs and services even during severe weather events. Clustering employment and higher-density residential development along existing transportation corridors, especially in areas with access to Metra and CTA rail and high quality bus service, will help to support transit and provide access to multiple modes of transportation. At the site scale, communities should be designed to promote non-auto oriented modes of travel (e.g., walking, biking, and transit). Using low- or no-emissions modes of transportation also helps to meet greenhouse gas emissions targets, critical to curbing climate change in the long run.

Main strategies to create more mobility options:

- Invest in public transit

- Implement complete streets and vision zero best practices when doing road construction and maintenance
- Invest in highway operations technologies like traffic control centers and dynamic message boards that can re-route travelers in case of sudden road closures
- Encourage transit-oriented-development

6. Enhance multi-sector, cross-jurisdictional planning to strengthen climate resiliency of communities and residents

Climate change impacts have wide-reaching effects that often do not conform to manmade jurisdictional boundaries. For example, flooding can impact multiple communities along a river, damaging public and private property and impeding transportation as well as local economies. Similarly, solutions for effective climate change mitigation and adaptation require multi-sector, multi-jurisdictional approaches to share resources, identify gaps, develop plans, and implement strategies. The Chicago region already possesses a number of cross-jurisdictional agencies responsible for promoting the efficient use of infrastructure and natural resources, including CMAP, Metropolitan Water Reclamation District, and the Regional Transportation Agency. Coordinated planning by key agencies can also help municipalities preserve critical natural resources, connect critical assets to underserved areas, incorporate stormwater detention facilities to prevent or mitigate flooding areas, and enhance local and regional economies. Improved coordination can also help to achieve co-benefits that leverage scarce resources. Cooperation is also necessary to leverage information resources, as discussed in the following strategy regarding data driven policy and programming. CMAP and partners should actively encourage cross-jurisdictional cooperation to promote climate change mitigation and adaptation in planning processes.

Main strategies for cross-jurisdictional coordination:

- Implement a groundwater monitoring and permitting system, requiring coordination with Illinois State Water Survey and municipalities
- Transportation, stormwater, energy, and development agencies incorporate green infrastructure at all scales
- Land use, economic development, and transportation agencies and private sector partners work to enable higher density, mixed-use developments
- Creating shared funding sources for cross-jurisdictional and cross-programmatic projects

7. Assume leadership role in data driven policy and programming analysis and implementation

Resilient infrastructure and systems can be bolstered by innovations in technology. The most recent National Oceanic Atmospheric Administration (NOAA) weather satellites can scan the Western Hemisphere every five minutes, and in areas of extreme weather

formations, every 30 seconds.[36] Satellite monitoring will become even more advanced by 2050, providing more real time information about weather, the environment, and land use. Other technological advances in GPS, sensors, and other tools will provide more accurate and up-to-date information on air and water quality, groundwater levels, land use change, transportation conditions, real estate trends, and consumer preferences.

The usefulness of improved information is dependent on our ability to collect, synthesize, analyze, and communicate this information. CMAP and partners should take a leadership role in leveraging data from advanced monitoring systems to guide policy, planning, and programming recommendations and assessments. CMAP should support partnerships for data sharing, coordinated management practices, and improved communications across jurisdictions, especially regarding transportation, land use, natural resources, and development data. CMAP should harness improved information not only to track regional and sub-regional trends but also to assess the outcomes of associated policies and programs. Partners should take the lead in establishing standards and guidelines for data collection and analysis and investing in research and development of technology.

Main examples of data driven policy and planning*:*

- Develop more accurate predictive modeling
- Improve aquifer monitoring
- Conduct outcome analysis of policies and investments
- Incentivize or mandate performance based management in all sectors
- Coordinating data sharing between organizations, agencies, and public

8. Protect agricultural assets

The region's fertile agricultural lands are an integral component of the open space system, tackling climate change impacts by helping to retain and recharge water, control floods, and manage soil. Activities related to the production, movement, and processing of agricultural products are also significant to the regional economy, particularly in rural communities.[37,38] CMAP and partners should continue to protect valuable farmland from development. Partners, with the assistance of CMAP, should also help to adapt agricultural practices to a future with more heat waves, drought, and more frequent and intense storms. As agricultural disruptions in drought-prone regions such as California and Florida lead to changes in global and national food supply, the region should support greater crop diversification, including production of more local foods for consumption.[39,40] Partners

[36] NOAA National Environmental Satellite, Data, and Information Service (NESDIS), "6 reasons why NOAA's GOES-R satellite matters," NESDIS News and Articles, October 11, 2016.

[37] In 2012, Illinois ranked 5th in the nation in food and agricultural export value.

[38] FARM Illinois, "A food and agricultural roadmap for Illinois," May 2015.

[39] Currently, nearly 80 percent of the state's agricultural production are beans and grains for export, ethanol, feed, and processed foods and additives.

[40] FARM Illinois, "A food and agricultural roadmap for Illinois," May 2015.

should take the lead in expanding food access to local communities and implementing more resilient farmland management practices.

Main strategies to increase resiliency of agricultural assets:

- Acquire land for preservation
- Enact conservation easements
- Adopt land use planning strategies (e.g., farmland preservation ordinances)
- Incentivize and/or mandate more resilient farmland management practices (e.g., cover cropping and no-till planting)
- Incentivize local food production and encourage demand for local food

9. Strengthen resiliency of residents disproportionately impacted by climate change

As discussed above, some population groups will experience climate change impacts at a greater intensity and/or frequency than others due to location, adaptive capacity, and characteristics such as age, income, or household composition. Several of the strategies addressed above will be particularly helpful for disproportionately impacted communities: land use planning and development activities that explicitly take into consideration climate change impacts can reduce the locational vulnerabilities associated with drought and floods. Expanding mobility options will ensure that residents can still access their homes, jobs, and other resources when either surface transportation or transit is impaired. Increasing coordination among jurisdictions will help to achieve co-benefits and increase opportunities for shared services, both of which will assist lower capacity communities with providing critical services. Capitalizing on new economic opportunities will help to create jobs so all households, including the lower income households, will increase the financial security of residents.

In addition to these strategies, CMAP and partners should make a more concerted effort to engage with historically hard to reach communities, such as the elderly, lower income households, immigrant groups, and residents with physical challenges. Resident participation at all levels of decision-making – from the development to implementation of policies, plans, and projects – will help to ensure that the needs of the most impacted populations are addressed. In addition to protecting physical assets, partners should take the lead in developing and fostering social networks to help people obtain assistance and goods, particularly during emergencies. At the regional scale, formulas to allocate funds and assessment projects should take into consideration climate change impacts, particularly impacts to low income or elderly residents and persons of color.

Main strategies to assist disproportionately impacted communities:

- Analyze potential climate change impacts to low income or elderly residents or persons of color when developing plans, analyzing policies, or allocating funds
- Strengthen ability of lower capacity communities to respond and adapt to climate change impacts through increased reinvestment

- Develop relationships and partnerships with local community partners representing hard to reach populations
- Implement best practices such as the use of translators or provision of child care and transportation services

10. Build climate literacy among decision makers and the public

Policymakers, planners, developers, and residents will require a higher level of climate literacy to prepare for and implement interventions for climate change impacts. At the local level, flooding and heat can be mitigated through low-investment, site-scale interventions initiated by residents and local communities. Other issues, such as energy and transportation resilience, may require large-scale, coordinated interventions led by municipalities and agencies. In order to support the development and implementation of these efforts, CMAP and partners should help to educate decision makers and residents of climate change impacts and solutions to prevent or mitigate negative outcomes. In addition to analyzing trends and tracking data, CMAP should take leadership in linking climate change impacts such as flooding and heat to land use and planning decisions and outcomes and communicating about these linkages with its partners. For example, the Climate Resilience strategy paper examined land surface temperatures, which are impacted by impervious cover, and social vulnerabilities to climate change.

Main strategies to build climate literacy:

- Develop and refine tools to assess climate vulnerability of community's roadways, land uses, and populations
- Continually update and improve data hub for ease of use
- Provide more educational materials linking data to impacts to communities, elected officials, and residents

11. Capitalize on new economic opportunities

Climate change will also provide new opportunities to the regional economy. In anticipation of water intensive industries relocating to the region, CMAP should explore sustainable land use, development, transportation and freight, and workforce strategies that meet the needs of new reinvestment. Supported by broad research conducted by CMAP on workforce needs, partners such as economic development agencies and community colleges should lead in workforce development initiatives to ensure that residents have the skillset to meet the demand for new technological advances, including in fields related to monitoring and data analysis and sustainable energy generation and distribution. CMAP and partners should also capitalize on population growth by supporting policies that create more jobs, provide housing options for all residents, and support a high quality of life.

Main strategies for new economic opportunities:

- Track indicators related to water consumption
- Conduct supply chain analysis of water intensive industries
- Create partnerships with multiple agencies

- Identify land use and development trends related to water intensive industries and intermodal facilities
- Provide workforce development training for green jobs
- Streamline existing policies and procedures
- Enact land use, development, and job creation policies to attract new residents

Next Steps

Following committee review and feedback, this memo will be finalized and used to inform the development of an online platform, MetroQuest, that will allow residents to learn about and select preferences for strategies to prepare for climate change impacts. In addition, CMAP is developing an interactive app illustrating the key features of a future with intensified climate change impacts. The app will be featured on digital kiosks hosted at various locations throughout the region and made available online. Both the app and the MetroQuest site will be utilized during an intensive public engagement period beginning in April 2017.

Four other potential futures for the region have also been selected for exploration. These futures will be oriented around what the region would be like if residents showed strong preferences for mixed-use, higher density environments; if the regional economy continued to become more service-oriented and automated; if significant technological advances improved mobility; and if federal and state public resources diminished significantly. These futures will also be accompanied by interactive apps and MetroQuest platforms. Staff will also develop a final memo highlighting cross-cutting solutions featured across each of the five futures. These solutions will inform strategies recommended in ON TO 2050, which will be completed in October of 2018.

Attachment 1: Related CMAP products by Strategy

Strategy	Related CMAP products
1. Integrate green infrastructure at all scales: site specific, community, and regional	ON TO 2050: Green infrastructure strategy paper, Climate resilience strategy paper, Stormwater strategy paper
2. Explore and implement innovative policies (including market-based and PPP) and technology to reduce emissions and mitigate impacts of climate change	ON TO 2050: Green infrastructure, transportation system funding concepts, Climate resilience strategy paper
3. Protect critical assets from climate-related disruption and sudden weather threats	ON TO 2050: Green infrastructure strategy paper, climate resilience strategy paper, Stormwater strategy paper
4. Ensure people have access to multiple mobility options	ON TO 2050: Green infrastructure strategy paper, climate resilience strategy paper, Inclusive growth strategy paper
5. Encourage development with the right standards in the right locations	ON TO 2050: Climate resilience strategy paper, lands in transition, water, reinvestment and infill, Inclusive growth strategy paper, Stormwater strategy paper
6. Enhance cross-jurisdictional planning and participatory processes	ON TO 2050: Community capacity, tax policy and land use, Climate resilience strategy paper
7. Invest in sensors and communications technology that allows better monitoring of natural systems and responsive infrastructure	ON TO 2050: Green infrastructure strategy paper, climate resilience strategy paper
8. Preserve and protect agricultural resources	ON TO 2050: Lands in transition
9. Educate public about climate change impacts and response strategies	ON TO 2050: Climate resilience strategy paper, Stormwater strategy paper