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Los Angeles County Metropolitan Transportation Authority Climate Change Adaptation Pilot Project Report

AUGUST 2013

FTA Report No. 0073
Federal Transit Administration

PREPARED BY
Los Angeles County Metropolitan
Transportation Authority

U.S. Department of Transportation
Federal Transit Administration

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Los Angeles, CA

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Federal Transit Administration
Office of Research, Demonstration and Innovation
U.S. Department of Transportation
1200 New Jersey Avenue, SE
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SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liter	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

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This Climate Change Adaptation Pilot Project Report details the project background of the recently-completed Los Angeles County Metropolitan Transportation Authority (Metro) Transit Climate Change Adaptation Pilot Project as well as the various work elements, the results and findings, and Metro's next steps in fulfilling its ongoing commitment to climate adaptation. The project capitalizes and uses Metro's existing Climate Action and Adaptation Plan (CAAP), Environmental Management System (EMS), and asset management system tools to integrate climate adaptation principles into ongoing conversations and implement best management practices in the areas of its operations and maintenance. The project also developed a comprehensive set of metrics that would enable Metro to gauge past progress while identifying new targets to guide the direction of future climate adaptation work. The project identified various messages and key points appropriate for targeted audiences, conducted a roundtable and a webinar, and produced a 100-second video to initiate a dialogue among stakeholders who are interested in and anticipated to work together with Metro in its climate adaptation efforts, with a special focus on the idea that Metro's patrons are part of the overall strategy to prepare Los Angeles for the impacts of climate change.

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This report draws heavily from work products completed by external consultants, with Metro staff responsible for the direction, assembly, implementation, and conclusions. Metro staff worked in tandem with consultants to develop these work products and invested significant effort and time in partnering with researchers at every stage of this project.

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ABSTRACT

This Climate Change Adaptation Pilot Project Report details the project background of the recently-completed Los Angeles County Metropolitan Transportation Authority (Metro) Transit Climate Change Adaptation Pilot Project as well as the various work elements, the results and findings, and Metro's next steps in fulfilling its ongoing commitment to climate adaptation. The project capitalizes and uses Metro's existing Climate Action and Adaptation Plan (CAAP), Environmental Management System (EMS), and asset management system tools to integrate climate adaptation principles into ongoing conversations and implement best management practices in the areas of its operations and maintenance. The project also developed a comprehensive set of metrics that would enable Metro to gauge past progress while identifying new targets to guide the direction of future climate adaptation work. The project identified various messages and key points appropriate for targeted audiences, conducted a roundtable and a webinar, and produced a 100-second video to initiate a dialogue among stakeholders who are interested in and anticipated to work together with Metro in its climate adaptation efforts, with a special focus on the idea that Metro's patrons are part of the overall strategy to prepare Los Angeles for the impacts of climate change.

EXECUTIVE SUMMARY

In December 2011, the Federal Transit Administration (FTA) awarded a $175,000 grant to the Los Angeles County Metropolitan Transportation Authority (Metro) for the implementation of a Transit Climate Change Adaptation Pilot Project. Metro committed to a 100 percent match of FTA grant, resulting in a total funding of $350,000. This report details the project background, the various work elements of the project, the results and findings of the project, and Metro's next steps in fulfilling its on-going commitment to climate adaptation. All documents produced by external parties as part of the project are included as appendices to this report for reference. While the accompanying reports include a series of comprehensive recommendations on possible next steps for Metro, it is important to note that not all recommendations will necessarily be implemented by the agency.

The Metro Climate Change Adaptation Pilot Project draws upon Metro's previous climate efforts and existing environmental and sustainability-related programs to develop a series of comprehensive implementation strategies that can serve both Metro and, in general, the transit industry. Metro has already completed an agency-wide vulnerability and criticality assessment, the results of which are outlined in the Climate Action and Adaptation Plan (CAAP). In anticipation of the project, Metro also developed and conducted several surveys, targeted at operations and maintenance staff, to assist in identifying key vulnerabilities from weather and the associated impacts at the Division level. Communications with staff at the Division level has helped to inform the direction of the project and will continue to play an important role in future efforts to ensure safe and reliable operations despite of extreme weather and climate events.

In light of the extensive work already conducted, the project goes beyond the issue of identifying risks and proposes viable implementation strategies to incorporate climate adaptation into established programs and initiatives within the agency. The project capitalizes on the agency's existing CAAP, Environmental Management System (EMS), and asset management systems—the Environmental Information Management System (EIMS) and the Maintenance and Materials Management (M3)—to integrate climate adaptation principles into ongoing conversations and implement best management practices in the areas of maintenance, preparation, scheduling, environmental compliance, and employee health and safety.

Metro identified the agency's EMS program as a viable route for implementing climate adaptation principles at the agency's maintenance facilities and sought to include the asset management databases and metrics development to support the EMS integration. As the EMS procedures and protocols are developed, enforced,

evaluated, and improved by Metro's own maintenance staff, the inclusion of additional procedures and protocols regarding adaptation and weather has been effectively embraced at all existing EMS facilities. As the EMS program expands agency-wide, all of Metro's maintenance facilities will incorporate these climate adaptation principles, using the program's continual cycle of improvement to monitor impacts and address them in a proactive manner.

The project also funded investigation into the adaptability of Metro's own asset management systems and the various possibilities for integrating climate assessment into the current technological framework. The results of the work are useful for both outside agencies and Metro staff in deciding how to proceed with asset evaluation and prioritization considering adaptation principles and severe weather risks.

Additionally, the project engaged in evaluating how climate adaptation principles align with overall agency goals and projects by developing a comprehensive set of metrics that would enable Metro to gauge past progress, while also identifying new targets and guide the direction of growth of climate adaptation work. Building off of best practices in adaptation in risk management from other industries, more than 100 metrics were developed for this project, which fall under the categories of Planning, Operations, Ridership, and Adaptation. As part of this project, Metro considered the adoption of seven metrics. These ranked highly in the metrics selection process and will provide valuable information and direction in tracking Metro's performance in the implementation of its climate adaptation strategies, developing action plans for continual improvement, and serving as a guide for further work and inclusion of the health and welfare of employees, constructors, and, most especially, vulnerable populations.

The project also synthesized the research and reporting that resulted from previous and current activities and developed various messages and key points appropriate for targeted audiences. One of the project's key objectives was to develop valuable messaging strategies for communicating to various audiences (i.e., internal staff, external agencies, private investors, elected officials, county residents, and riders) on how Metro is preparing for climate change and severe-weather impacts and how each of these stakeholders may help Metro to prepare for and mitigate these impacts.

The project culminated in the hosting of a Southern California Transit Climate Adaptation Roundtable and a webinar aimed at both sharing the results of Metro's pilot work and initiating a dialogue with other transportation agencies and interested parties who may be concerned with the same climate stressors as Metro. A 100-second video was also produced to highlight some of the agency's

key environmental initiatives as well as the idea that Metro's patrons are part of the overall strategy to prepare Los Angeles for the impacts of climate change.

All reports, materials, and presentations from the project are now available on Metro's website at http://www.metro.net/ecsd. These resources intend to further enhance public awareness of the evolving issues of climate change but, most importantly, to begin empowering audiences to take action and collectively (with Metro) act to reduce the growing impacts related to more severe and more frequent extreme weather events.

While the project contains specific recommendations and next steps for Metro, the results, findings, and tools identified and developed within this project can also be applied to other transit agencies, regardless of their size, and can be adapted to consider their unique geographic and climate considerations.

Examining Metro's experiences and lessons learned in climate adaptation integration into its operations serve as an example for others seeking a calculated segue from identifying vulnerabilities and associated risks to implementing viable adaptation strategies.

SECTION
1

Metro Background

Metro is the state-chartered Regional Transportation Planning Agency (RTPA) and public transportation agency for Los Angeles County (California). Metro serves as the transportation planner and coordinator, designer, builder, and operator for Los Angeles County. The county has the largest population among all counties in the United States (about 9.8 million people, which represents about 26% of the total population of California).

Los Angeles County's population would make it equivalent to the ninth largest state in the country, just behind Michigan. It includes people from 140 countries that live and work in 88 cities and unincorporated areas. Metro's service is essential for meeting the travel needs of people with very diverse socio-economic and demographic backgrounds. According to the 2010 U.S. Census, the demographic profile of Los Angeles County consists of 47.7 percent Hispanic, 27.8 percent White, 13.7 percent Asian-Pacific Islander, 8.3 percent African-American, and 2.5 percent people from other ethnic groups.

Metro's service area is currently 1,433 square-miles (35% of the area of Los Angeles County) and is located within the Los Angeles-Long Beach-Santa Ana Urbanized Area (UZA). The services that Metro provides include heavy rail (Red Line and Purple Line), light rail (Blue Line, Gold Line, Green Line, Expo Line), and bus service (local, limited, express, shuttles and circulators). Metro also operates Bus Rapid Transit (BRT) service (Metro Rapid, Orange Line, Silver Line) and a vanpool program. It also provides funding for local and highway improvement projects as well as subsidy for commuter rail and other municipal transit service. A map showing Metro's rail and transit service area is shown in Figure 1-1. Additional maps can also be accessed at www.metro.net/maps.

Figure 1-1 *Los Angeles County Current and Future Fixed Guideways*

In the last 25 years, Metro has developed an extensive mass rapid transit system consisting of almost 88,105 miles of urban rail, two very successful BRT routes, and the nation's largest fleet of very low emissions buses. Metro currently operates more than 2,220 buses that comprise a 100 percent compressed natural gas (CNG) fleet, with Metro's last diesel bus retired in February 2011. Metro operates 183 bus routes, servicing almost 16,000 bus stops to accommodate approximately 1.1 million average weekday boardings, for a total of 359 million annual boardings.

Metro also operates the region's fixed guideway system, which includes a heavy rail subway (Red/Purple Line) and four light rail lines (Blue, Gold, Green, Expo Lines). The first segment of the Metro Red Line was opened in 1993, and the final segment to North Hollywood was opened in 2000. The Red/Purple line averages 148,000 weekday boardings for a 2011 total of 47.2 million boardings. Combined, the four light rail lines (Metro Blue Line, completed in 1990; Metro Gold Line and its extension to East Los Angeles, completed in 2003 and 2009; Metro Green Line, completed in1995; and Metro Expo Line, completed in 2012) are 87.7 miles long, include 80 stations, and average 364,000 weekday boardings as of July 2013. Total rail boardings in calendar year 2012 were estimated at more than 101 million boardings.

Metro has a very ambitious expansion program planned for the next 30 years, courtesy of a voter initiative called Measure R. Measure R is a half-cent sales tax for Los Angeles County to finance new transportation projects and programs, and accelerate those already in the pipeline. The voters of Los Angeles County approved the measure in 2008 and the tax took effect July 2009. Over 30 years, it is projected to generate $40 billion for congestion relief projects. Measure R alone does not fully fund all projects. Measure R funded transit projects are shown in Figure 1-1.

The Measure contains an Expenditure Plan that identifies the projects to be funded and additional fund sources that will be used to complete the projects. The Measure R Expenditure Plan devotes its funds to seven transportation categories as follows: 35 percent to new rail and BRT projects; 3 percent to Metrolink projects; 2 percent to Metro Rail system improvement projects; 20 percent to carpool lanes, highways, and other highway related improvements; 5 percent to rail operations; 20 percent to bus operations; and 15 percent for local city sponsored improvements. Specifically, these would include:

- Synchronizing traffic signals
- Repairing potholes
- Extending light rail with airport connections
- Improving freeway traffic flow
- Keeping senior/student/disabled fares low

- Providing clean-fuel buses
- Expanding subway/Metrolink/bus service
- Dedicating millions for community traffic relief

Additional information on Measure R and LA Metro's future expansion can be obtained from http://www.metro.net/projects/measurer/.

The rapid expansion of Metro's system is already underway. The Exposition Light Rail Line Phase 1 and the Metro Orange Line Extension (busway) opened in 2012. The Exposition Light Rail Line Phase 2 and the Gold Line Foothill Extension are currently being built, and the Crenshaw Light Rail Transit Project will soon commence. In light of these new projects that are impacting infrastructure and land-use planning throughout the country for the decades to come, climate stressors and impacts become increasingly more important as Metro's current and planned service double over the next 30 years. In addition, the expanding transportation system may also result in increased operational costs while simultaneously challenging existing assets and infrastructure. Such considerations have framed the context of the project and are being seriously considered by various facets of the agency as the planning, construction, operations, and maintenance of new and existing systems continues.

SECTION 2

FTA Pilot Program Background and Objectives

In 2011, the Federal Transit Administration (FTA) announced its Climate Change Adaptation Initiative. As part of the program, FTA distributed just over $1 million of research funding to seven pilot projects completed by transit agencies across the nation to conduct climate change adaptation assessments. Intended to "advance the state of practice for adapting transit systems to the impacts of climate change" the effort is in keeping with broader long-term FTA goals to address state-of-good repair needs and enhance transit safety.

Upon completion of the grant projects in August 2013, lessons learned will be shared with the public and transit agencies across the nation to help ensure that mobility will be protected for transit users in the face of sea-level rise, extreme heat, flooding, and winter storms.

Extreme weather events across the country have already had significant impacts on public transit. When Hurricane Sandy hit the East Coast in 2012, flooding greatly impacted subway and bus service in New York City and other major urbanized areas. As transit was seen as a crucial component to ensure individuals could return to work and back home, FTA's streamlining of the environmental review process was prioritized in order to expedite emergency relief funds to get transit back online in a timely manner (Bernstein, 2013). While it is too early to report back on lessons learned from this streamlining, there is great interest in the ability of FTA to streamline transit processes to move projects forward more efficiently and effectively adapt to changing conditions in the future.

Worldwide, climate is changing and shifts in regional climate patterns are now considered highly likely. Climate scientists are already observing changes in the United States and anticipate increased variance in the future. Regionally, Los Angeles risks include increases in heavy downpours, rising temperature, sea-level rise, increased likelihood of drought, and unpredictable storm conditions. While immediately addressing greenhouse gas (GHG) emissions may reduce the severity of these impacts, past and present GHG emissions have already impacted the atmosphere to such a degree that they will have continuous and long-term effects. Therefore, in addition to GHG mitigation, it is essential that adaptive actions be evaluated and implemented. The FTA Pilot Program focuses on adaptation.

Climate change has particular impacts on public transportation. Subway tunnels, busways, tracks, and maintenance facilities are vulnerable to an increase in flooding from more intense rain storms, sea-level rise, and storm surge. Extreme heat can cause deformities in rail tracks, at minimum resulting in speed restrictions and, at worst, causing derailments. Public transportation is also called upon to provide evacuation services during the type of extreme weather emergencies that are projected to become more common with climate change. Transit dependent populations are particularly vulnerable. Adapting transit assets to climate change impacts is critical to maintaining a state of good repair, protecting the safety of travelers, and ensuring mobility.

In recent years, multiple state and local governments have developed climate adaptation plans. Partnerships between academic institutions, non-profits, and state and local governments have been some of the most successful efforts. In the transportation sector, researchers and practitioners have begun to consider the impacts of climate change on transportation infrastructure, most notably in Transportation Research Board Special Report 290 and in the U.S. Department of Transportation's Gulf Coast Study. However, to date, little work except for FTA's publication "Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation" (FTA 2011) has focused on public transportation assets and operations.

FTA seeks to increase knowledge of how transit agencies can adapt to climate change. FTA's objectives are to advance the state of the practice in adapting transit assets and operations to the impacts of climate change, to assess lessons learned for application to other transit providers, and to build strategic partnerships between transit agencies and climate adaptation experts.

SECTION 3

Metro Pilot Project Summary

Background

Metro has been a leader in pursuing a variety of sustainability strategies to maximize transportation efficiency, access, safety, and performance while minimizing energy use, consumption, pollution, and the generation of waste. These efforts support environmental stewardship and have resulted in long-term cost savings for Metro while maintaining the agency's environmental and sustainability leadership in the transportation and transit industry. Sustainability strategies will also become increasingly important to comply with regulatory processes related to California Assembly Bill 32, California Senate Bill 375, and related regulations under CEQA, the Federal surface transportation re-authorization process, and potential federal, state, and local climate change legislation.

Metro has already identified a variety of opportunities to reduce greenhouse gas (GHG) emissions from its own operations, as well as emissions from motor vehicles traveling throughout Metro's service area. Metro's GHG Emissions Cost Effectiveness Study (LACMTA 2010a) provides estimates of emissions impacts and costs for 17 strategies in the areas of alternative travel modes, transit service expansion, vehicle technology, and facility energy use. Metro's Sustainability Report (LACMTA 2010b, 2011b, 2012b) and Water Action Plan (LACMTA 2010c) also identify energy saving and GHG reduction opportunities. Forthcoming efforts by Metro will likely identify additional opportunities in areas such as energy efficiency, demand management, and renewable energy generation (LACMTA 2011a).

Metro previously completed a Climate Action and Adaptation Plan (CAAP) (LACMTA 2012a) that provides a unified framework to assess the benefits of these strategies and barriers to implementation, and to make recommendations for an actionable approach to achieve Metro's GHG reduction and climate goals and objectives. There were several steps involved in the development of the CAAP: Identifying Critical Assets, Analyzing Climate Data, Assessing the Risk, and Evaluating Adaptation Options.

Identify Critical Assets

Metro developed an inventory of infrastructure and services critical to accomplishing the agency's missions and objectives. The agency has drawn on existing inventories that identify rail lines and associated infrastructure (tunnels,

structures, etc.), buildings, other facilities (yards, etc.), and supporting systems (electrical, water, gas, etc.). As necessary, Metro supplemented its inventories with data from other local or national sources. Using Metro's 2009 Long Range Transportation Plan (http://www.metro.net/projects/reports/) and other planning and programming documents, the agency augmented its inventory to include facilities that will be funded with revenue from Measure R. Metro then developed a matrix of factors and identified critical assets along its rail and bus network.

Analyze Climate Data

Metro gathered and evaluated climate data to identify potentially significant climate change impacts for Los Angeles County. This effort allowed the agency to identify the impacts with a high likelihood and/or magnitude on which to focus its selection of adaptation strategies, and more so, the development of Metro's Climate Action and Adaptation Plan. The identification of potentially significant climate impacts was based on state-of-the-art climate observations, modeling results, and scenarios, including:

- Comprehensive historical weather and climate data from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center;
- Statistically and dynamically downscaled data models (e.g., CMIP3, NARCCAP);
- Scenarios commissioned by the California Energy Commission Public Interest Energy Research Program's (PIER) Climate Change Research Center; and
- Sources of local or regional data.

Assess Risk

Using the information produced in the two previous CAAP tasks, Metro screened current assets and identified those that are particularly vulnerable to climate change. The agency has considered the following factors to identify the assets with highest integrated risk:

- High likelihood of climate impact occurring;
- High vulnerability of the asset to projected climate change; and
- High impact on society of expected consequence.

Evaluate Adaptation Options

Metro then developed an initial list of options for adaptation, drawing on historical precedents from ongoing experience in Southern California and other major metropolitan areas. Metro analyzed the available options, based on cost, effectiveness, timing issues, and indirect effects. The agency has evaluated and refined the potential approaches to pinpoint the most effective and cost-efficient strategies.

Table 3-1 is a summary of the adaptation analysis effort provided within the CAAP.

Table 3-1
CAAP Adaptation Analysis Effort

Service/Asset	Climate Impact	Potential Adaptation Option
Rail Operations	Equipment malfunction (electrical systems; air conditioning systems) during periods of extreme heat	• Pre-emptive maintenance or inspection; weather/climate-related monitoring
	Railway buckling during periods of extreme heat	• More heat-resistant materials or designs, if available • Increased shading of railways
	Flooding of underground stations and tracks during heavy rainfall events	• Improved stormwater management systems • Infrastructure upgrades in stations (ventilation grates, entrances, seals) • Increased pumping capacity
	Flooding of at-grade railways and (Bus Rapid Transit right-of-ways[1]) during heavy rainfall events	• Upgraded stormwater management systems
Bus Operations	Fleet breakdowns and maintenance during periods of extreme heat	• Pre-emptive maintenance or inspection; weather/climate-related monitoring
New Construction/ Measure R Projects	Exposing new infrastructure to episodes of extreme heat and heavy rainfall events	• Integration of climate considerations in siting and alternatives decisions
	Labor interruptions or delays during periods of extreme heat	• Modification of construction schedules, especially during summer months

[1] Although BRTs are part of Bus Operations, the right-of-ways are functionally more similar to a railway.

In Metro's current work, staff has learned the importance of fitting climate change adaptation plans into existing decision-making frameworks. Therefore, a key part of the current work is how to better understand the opportunities to integrate adaptation options into the agency's planning and programming, construction, operations, and procurement activities.

Specifically, the CAAP identified the changing climate conditions that are to impact Metro's service area, which consist primarily of an increase in frequency of extreme heat events and an increase in the frequency of events of heavy precipitation. In light of these conditions, the CAAP assessed the vulnerability of Metro's rolling assets (rail operations, bus operations, and projects under construction) and provided a series of adaptation options for the agency to consider. The CAAP also identified a series of greenhouse gas (GHG) reduction strategies and their subsequent cost-effectiveness. Figure 3-1 shows the critical and vulnerable assets within Metro's area of service. The full CAAP is available for download at www.metro.net/ecsd.

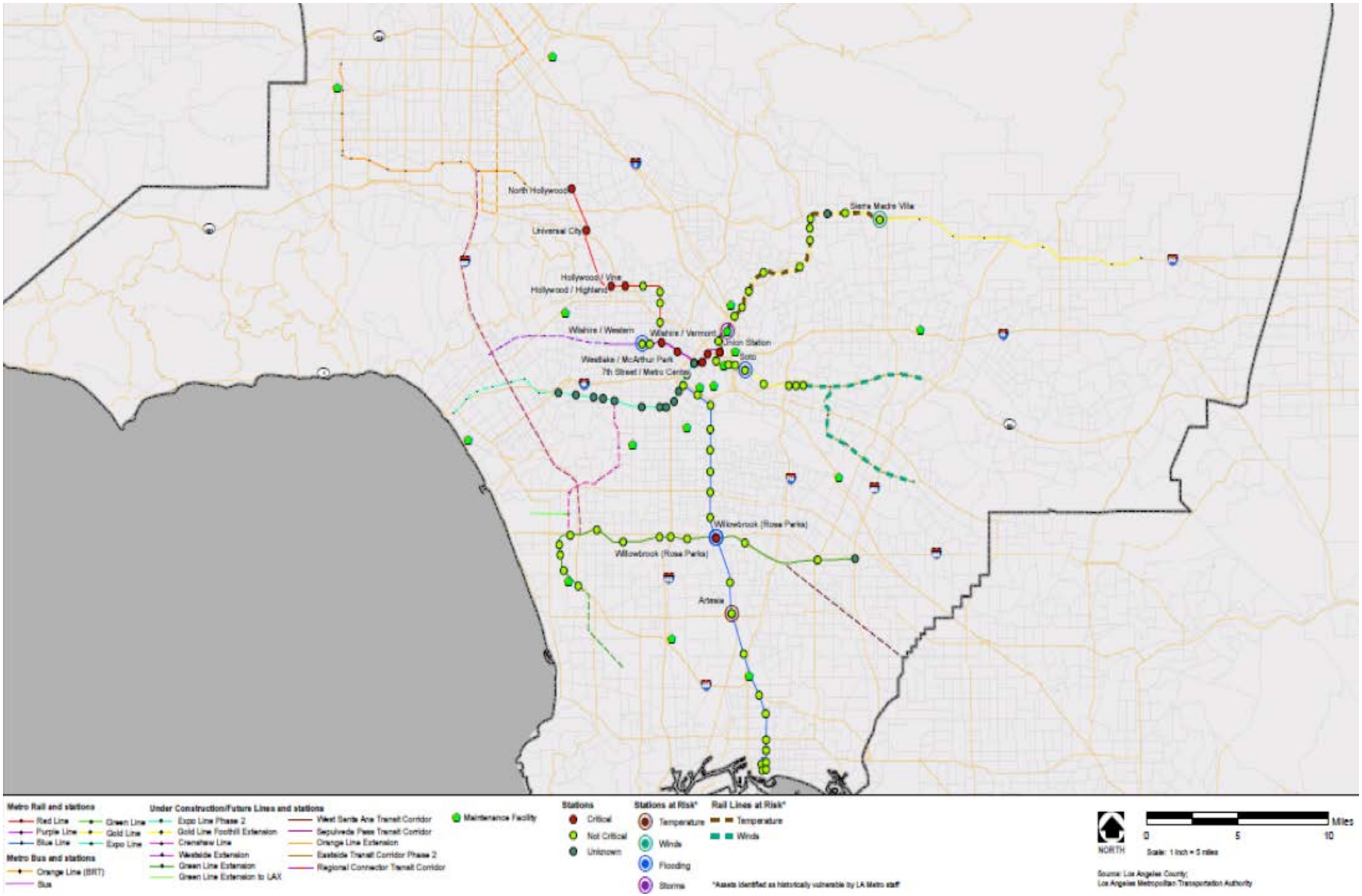

Figure 3-1 *Critical and At-Risk Metro Assets and Facilities*

In conjunction with (but independent of) this project, Metro had also previously developed and conducted several surveys, targeted at operations and maintenance staff, to assist in identifying key vulnerabilities from weather and the associated impacts at the division level. A summary of the survey results is included in Appendix A.

The surveys analyzed extreme weather events, including heavy rain, high temperatures, blackouts, and windstorms. Additionally, survey participants were asked to identify the events they observed that had the greatest impact on operations. With approximately 40 staff from various divisions contributing to these responses, the issues of equipment overheating in high temperatures, power outages, and roof leaks from heavy rain, and damage to facility awnings, roofs and landscaping from windstorms were just a few of the impacts reported.

To mitigate these issues, Metro staff at the division level and within some individual business units adopted specific strategies to mitigate these issues, but these strategies are not specifically correlating the strategies or the root causes to issues of climate change. The best practices associated with these strategies have resulted in reduced extreme weather related impacts, but were developed primarily not to adapt to the changing effects of climate but to ensure the continuous and maintained level of service.

The engagement with staff at the Divisions at this level of detail has helped to inform the direction of the project, helped staff understand how to approach this gap at the frontline, and directed efforts to better practically implement climate adaptation. Such an effort will continue to play an important role in future work to ensure safe and reliable operations despite the increasing frequency of extreme weather and climate events.

It is evident from these activities that Metro has the tools in place to effectively introduce climate adaptation strategies into its agency-wide activities. There are also existing best practices observed and documented by staff that are currently being implemented to reduce operational impacts but are currently not being directly correlated with extreme weather events or the increasing frequency of extreme weather impacts. The challenge Metro faces is therefore two-fold:

- How can Metro capture the best practices currently being implemented by frontline personnel and assist them in preparing for anticipated more frequent extreme weather incidents in the future?
- How can the principles of climate adaptation be embraced without impeding operational efficiencies or impacting the level of service?

In 2008, Metro decided to implement an Environmental Management System (EMS) as the tool to comply with the Metro Environmental Policy. Since then, Metro's ISO 14001:2004-certified EMS has become the overarching framework,

not only to ensure environmental compliance but also to serve as an effective tool in the roll-out and implementation of a comprehensive energy program (http://media.metro.net/projects_studies/sustainability/images/Sustainability_Report_Energy_Conservation_Plan.pdf). Additionally, EMS was cited by Metro as a possible climate change tool as early as 2009.

This pilot is unique in that Metro goes beyond the identification of the criticality and vulnerability of assets and development of strategies. In this project, Metro leverages existing procedural infrastructure in the EMS to integrate Climate Adaptation principles into regularly reviewed and monitored activities.

Metro's Climate Change Adaptation Pilot Overview

An FTA grant application for $175,000 in federal Public Transportation Research Funds was submitted by Metro for the implementation of a Transit Climate Change Adaptation Pilot Project. The grant application was in response to the notice of Request for Applications (RFA) published by FTA on June 1, 2011. Although the RFA allows for a 100 percent federal participation, Metro committed to provide 50 percent of the total cost of $350,000 that was needed to implement the Pilot Project. The grant application and proposed local match supported Metro's recognition of the need to develop an integrated, efficient, and adaptable approach to ensure that transit infrastructures are resilient to changing climatic impacts. The key components of the project include the following:

- Task 1: Development and implementation of a plan for the integration of adaptation principles into Metro's Environmental Management System (EMS) that can be applied agency-wide.
- Task 2: Development of a tool or modification of an existing software application to evaluate and track climate risks associated with Metro's fixed and rolling assets.
- Task 3: Development of adaptation set of metrics to measure and assess Metro's progress in addressing adaptation.
- Task 4: Development of an outreach plan to create internal and external stakeholder awareness of Metro's adaptation efforts.

The following sections outline the pilot tasks in detail and provide the major conclusions and next steps for Metro. These results can be used by other agencies as deemed appropriate.

EMS Integration/Asset Management

Overview

First Environment, Inc., was awarded the contract to work with Metro on Tasks 1 and 2 of this project. The final First Environment report also refers to Tasks 3 and 4, where applicable. The report, included herein as Appendix B, consists of two parts: 1) a plan for integrating climate adaptation principles into the existing Metro EMS, and 2) a report on guidelines to develop a tool to assess climate risks to assets.

The plan developed under Task 1 documents the framework and elements of an EMS and specifically uses Metro as a case study to demonstrate how a transit agency can integrate adaptation to climate change into its EMS. It examines the 17 elements of an ISO 14001:2004 EMS that fall under the areas of Policy; Planning, Implementation, and Operation; Checking and Corrective Action; and Management Review. The plan describes how adaptation to climate change can be integrated into and addressed within Metro's existing ISO 14001:2004-certified EMS. Metro's EMS was developed under a separate pilot collaborative with FTA and has now evolved into an agency-wide program. Metro's report on its initial EMS efforts is available at http://www.cota.vt.edu/ems/clients/case_studies/LosAngeles.pdf.

The work product resulting from Task 1 is a Plan and establishes that the Metro EMS provides an excellent structure in which to manage adaptation and, more broadly, that it would provide an excellent structure for other transit agencies to mimic and use. The EMS, which is structured around the Plan-Do-Check-Act (PDCA) cycle, facilitates ongoing integration of climate change risks into operations and planning. Specifically, the methodology in the EMS was used to identify and prioritize environmental impacts and provides a process that can be modified to address risk to assets from severe weather. As a result, the prioritized risks can then be managed within the other component of the EMS.

Improvements to harden assets to climate risks can be integrated into the process for setting improvement objectives in the EMS. Operational changes to protect assets can be identified and integrated into the procedures, inspections, training, and emergency planning already addressed within the EMS. The effectiveness of adaptation efforts can be tracked and evaluated using the existing EMS processes, and, finally, management review can provide a process to keep management apprised of the progress in managing this risk.

To help insulate Metro's operations and services from extreme weather-related impacts, the case study for Metro was developed for three scenarios: augmenting Metro's existing EMS, expanding Metro's EMS operations-wide, and expanding

Metro's EMS to the entire agency. First Environment's Task 2 addresses the Metro FTA Pilot's Task 2 and provides guidelines to develop a tool to assess climate risks to assets addressing: Criticality, Vulnerability, and Rate of Change.

The case study provides a methodology for Metro, as well as guidance to other transit agencies, to assess risk to its assets over time using Indicators of Risk. Building on Metro's CAAP, the methodology identifies assets at risk to climate change impacts over time that can effect reliability, service, maintenance, planning, and state of good repair (SGR)—when assets are functioning reliably and within their useful life.

It is necessary to consider how the impacts of climate are changing over time. The climate is in flux, and the conditions that agencies experienced in the past and are experiencing today are changing. Under Task 2, it was determined that Metro's existing material management system could provide a platform to evaluate and track evaluation and tracking of climate risks associated with Metro's fixed and rolling assets. Using the climate risk evaluation methodology identified in Task 1 that builds on Metro's CAAP, a sample analysis was undertaken to demonstrate the use of the methodology. The sample analysis was undertaken with Metro personnel, who evaluated selected assets for criticality and vulnerability to precipitation, heat, and wind.

To determine the rate of change, default indicators for risk over time were used. Developing indicators for Southern California is one of the next steps recommended by First Environment to be done by Metro, in coordination with other entities.

The application of the methodology resulted in a prioritization of the risk to the selected assets to various climate impacts, which could be included in Metro's maintenance and material management system with minor modifications to the system.

Environmental Management System and ISO 14001

Metro committed in its Board adopted 2009 Environmental Policy to establish and use an Environmental Management System (EMS) as its primary tool in applying sustainable principles and practices in its planning, construction, operations, and procurement to protect the environment for present and future generations. The EMS provides the structure for managing all environmental issues initially for Metro at two facilities; Red Line Maintenance of Way Yard and Division 10 Bus Yard. The Red Line Yard's EMS is third-party certified to meet the requirements of international standard ISO 14001:2004, Environmental Management Systems—Requirements with Guidance For Use (ISO 14001 Standard). Metro has just been awarded agency-wide certification for its EMS, with Division 10 and the Administration Team residing at Metro's Gateway Headquarters as the initial facility enrollees. All Metro facilities are scheduled to be ISO 14001:2004-certified

by 2016. The ISO 14001 Standard is considered an international best practice for EMSs and is a management system standard that focuses on compliance with environmental regulations and improved environmental performance.

Since 2008, Metro has been working with FTA to build its EMS. Metro was one of eight transit agencies that participated in FTA's EMS training and assistance project to implement an ISO 14001:2004-certified EMS. FTA offered this training in support of President's Executive Order 13148—Greening the Government Initiative and Executive Order 13274—Environmental Stewardship and Transportation Infrastructure Project Reviews, which directed federal agencies to promote environmental stewardship in the nation's transportation system while streamlining the environmental review and development of proposed transportation projects. Integrating Adaptation into Metro's EMS builds on the efforts of the June 2012 CAAP and current EMS efforts.

An effective EMS is typically structured around a PDCA cycle. The PDCA cycle is critical to developing a system that can lead to continual improvement. The system engenders a continual cycle of setting relevant objectives and targets, planning and implementing to meet these targets, checking the progress, and reviewing the results in anticipation of setting new objectives and targets. An EMS is designed to encourage an organization to develop a better understanding of its existing and potential interactions with the environment—positive as well as negative—and to use this knowledge to improve performance.

Figure 3-2

EMS Plan, Do, Check, Act (PDCA) Framework

An EMS provides systemized knowledge and control of environmental impacts and risks from ongoing operations. It also provides a framework to reduce these impacts on an ongoing and rational basis. The EMS can include an organization's operations as well as those of its contractors, service providers, and suppliers, to the extent that the organization exerts control or influence over these other entities. It provides the organization with the ability to identify and manage environmental interactions while providing an overarching management structure that communicates requirements and supports compliance and performance.

An EMS organizes existing environmental programs and streamlines management of them. Further, the results of these programs feed into the EMS and support such EMS functions as change management and performance reporting. The EMS interacts with existing functions including the contracting, budgeting, purchasing (including the proposal and solicitation process), and information technology (IT) processes so as to simplify both the operation of the EMS and the performance of these functions.

An EMS structured around the requirement of ISO 14001:2004 can be expanded to accommodate adaptation and response to climate change as well as broader sustainability issues such as climate mitigation. The same elements that are used to manage traditional environmental performance can be augmented to manage these additional concerns. The advantage of this approach is that it includes adaptation challenges within the continual improvement cycle and integrates it into an existing structure that is already used to manage related issues—a structure with which the organization is already familiar. Metro introduced the possibility of using the EMS principles as a climate change management tool as early as 2009 and more formally in 2010 (http://www.metro.net/about_us/sustainability/images/2010/D3-Cris-Liban-Summit-Presentation.pdf).

LA Metro capitalized on the existing EMS framework to integrate principles of climate adaptation into regular planning, operations, and maintenance. Since the EMS framework was already in place, the pilot was able to provide recommended revisions to the existing elements of the Metro EMS, which were then adopted by EMS Core Team members for formal incorporation.

Metro EMS Elements and Adaptation Integration

The ISO 14001:2004 Standard is a flexible management system based in a PDCA framework. It includes various elements that have broad purposes: General Requirements; Planning, Implementation, and Operation; Checking and Corrective Action; and Management Review. Within each of these are specific reference sections: Scope, Environmental Policy, Environmental Aspects, Legal and Other Requirements, Objectives Targets and Programs, Resources Roles Responsibility and Authority, Competence Training and Awareness, Communication, Documentation, Control of Documents, Operational Control, Emergency Preparedness, Monitoring and Measurement, Evaluation of Compliance, Nonconformity Corrective Action and Preventative Action, Control of Records, Internal Audit, and Management Review.

Metro evaluated in detail each of these sections to determine the optimal strategy for integrating Climate Adaptation Principles. Using the existing framework within its EMS in these sections, Metro ensured that established processes could simply be expanded to cover a new concept: Climate Adaptation. Following is a listing summary of various recommendations for each EMS section.

- **Scope** – The scope defines what agency activities fall under the EMS. The scope is currently under modification, as the agency is in the process of rolling EMS out to cover all agency activities. Climate Adaptation is implicitly included within the scope as it is included as a consideration within many agency activities (i.e., Planning or Construction).
- **Environmental Policy** – The EMS contains a preamble to the agency-wide Environmental Policy that outlines specific ISO 14001:2004 commitments. The recommendation is that the preamble be modified to include specific direction to reduce the risk of weather related impacts and adopted.
- **Environmental Aspects** – The existing EMS will transition and augment the information in the CAAP on risk from climate change. Metro will add an Extreme Weather Risk Assessment for each type of weather impact associated with climate change to assess the risk to the EMS facility assets from severe weather.
- **Legal and Other Requirements** – The purpose in the procedure will be augmented to include the identification of all legal and other requirements associated with severe weather risks. Additional revisions to the procedure will be made to include severe weather risks with environmental aspects, such that both are addressed.
- **Objectives, Targets, and Programs** – The existing EMS will augment the existing Objectives and Targets Procedure to include evaluating assets at significant risk from severe weather impacts when setting objectives and targets. The EMS Administrative Team will then set objectives and targets and develop programs to reduce or eliminate the risk using the existing templates in the EMS, just as they currently do in the EMS.
- **Resources, Roles, Responsibility, and Authority** – The roles and responsibilities to address climate change risks will rely on the existing procedure and matrix. The procedure's purpose will be augmented to include adaptation to severe weather events. The Emergency and Homeland Security Preparedness Manager, who is responsible for planning for and responding to all hazards including severe weather events, will be added to the matrix. The EMS Administrative Team, with assistance from Environmental and Compliance Services (ECSD), will be identified as responsible for assessing severe weather risks and determining adaption objectives and targets. The matrix establishing existing roles in the EMS will be reviewed to ensure that any responsibilities specific to adaptation to climate change are identified.
- **Competence, Training, and Awareness** – To address severe climate impacts the EMS facilities, the existing procedure will be relied on. The EMS awareness training will be augmented with information regarding:
  - The addition to the policy regarding adaptation
  - The significant climate risks identified for the EMS facility
  - Objectives and targets related to adaptation
- **Communication** – The EMS will rely on the existing processes for communication within the EMS. The communication procedure's purpose will

be revised to include adaptation to severe weather. The EMS Administrative Team will work with the Communication Department on adaptation messaging.

- **Documentation** – The documentation procedure will not require revision and will be used as-is. Climate risks and other related terminology will be included in the Definitions.
- **Control of Documents** – The existing EMS will use the current procedure to control climate related documentation. Documents will be added to the Document Matrix.
- **Operational Control** – The methodology for development of work instructions described in the operational control procedure will be used by the existing EMS to address adaptation to climate change. The existing EMS will review the significant extreme weather impacts and the assets with which they are associated. Appropriate controls to minimize the impacts will be identified, and these will be added to existing work instructions. Where it is identified that new work instructions are required to control these impacts, they will be developed as defined under the operational control procedure. New procedures will be added to the list of work instructions. Any required training will be included in the Job -Specific EMS Training. Additional requirements identified for contractors can be addressed by the current Contractor Management Procedure.
- **Emergency Preparedness and Response** – The existing EMS will use the existing procedure for emergency preparedness and response to address severe weather emergencies at the EMS facilities. The responsibilities for weather-related emergencies, which lies with the Emergency and Homeland Security Preparedness Manager, will be added as will reference to any relevant plans. The existing EMS will use the processes in the existing procedure to ensure that they are prepared to respond to severe weather events and that appropriate follow-up occurs.
- **Monitoring and Measurement** – The existing EMS will modify the procedure on monitoring and measurement to include the collection and monitoring of any adaptation metrics adopted by Metro that are appropriate to their operations including any in the CAAP deemed relevant and those identified under Task 3 of FTA pilot. Maintenance and Materials Management (M3) will be explored for its capability to ensure the necessary monitoring occurs and will also be referenced in the procedure. Relevant metrics will also be added to the Monitoring and Measurement Evaluation Form and be included in the annual review. If the monitoring involves any monitoring equipment, it will be added to the monitoring and measurement calibration log and will be maintained and calibrated or verified, as necessary.
- **Evaluation of Compliance** – Adaptation is not a subject of legal requirements at this time. However, other requirements will be assessed as part of the evaluation. As Adaptation falls under Other Requirements, Evaluation of Compliance for Adaptation commitments to Internal Audit procedure is recommended.

- **Nonconformity, Corrective Action, and Preventative Action** – No change to the procedure is required. Any nonconformance associated with adaptation will be addressed within the existing procedure.
- **Control of Records** – The existing EMS will use existing records procedures. The records associated with adaptation will be added to the records matrix.
- **Internal Audit** – The existing procedure will be used, and adaptation, as addressed within the EMS, will be audited to ensure that adaptation efforts have been implemented as part of the EMS internal audit. The Auditor Training will be evaluated to determine if additional training on adaptation should be developed and implemented. The EMS Audit Checklist will be augmented to include an assessment of adaptation policy commitments; the climate risk analysis for assets; adaptation objectives targets and program; adaptation related training, communication, and work instructions; adaptation monitoring and measurement; and any other adaptation-related audit questions.
- **Management Review** – The existing EMS will use the existing management review procedure and will include in management review adaptation performance the extent to which objectives and targets address adaptation are achieved, changing circumstances related to adaptation, and recommendations for improvement that include adaptation.

The project has resulted in the adoption of several recommendations for incorporating various procedural elements of climate adaptation into Metro's EMS. The EMS Integration report includes a menu of various recommendations for methods to incorporate climate adaptation principles into the Metro EMS. Metro staff reviewed these recommendations and identified them as "Green Light" or "Yellow Light."

Green Light recommendations will be integrated into the EMS as they are aligned with Metro's priorities for the maintenance divisions and fit within Metro's EMS management structure. Yellow Light recommendations, on the other hand, will not be immediately integrated into the agency's EMS, but will be regularly revisited as time and resources become available and the agency-wide roll-out of the EMS comes to a close.

The Green Light recommendations include:

- **Legal and Other Requirements** – Integrating climate adaptation standards into Other Requirements, showing Metro's consideration of adaptation within the larger context of environmental impacts.
- **Objectives and Targets** – Metro's CAAP and other major policies will be added to this record to serve as overarching drivers for projects pertaining to sustainability.

- Inclusion of new **Significant Aspects** related to monitoring and measuring of climate change and extreme weather-related impacts.
- Re-evaluation of existing **Roles and Responsibilities** within EMS in context of climate adaptation to verify that all relevant Metro departments are included based on area of need in the future.
- Some Metrics developed in Task 3 of the project will be used in **Monitoring and Measuring** any Objectives and Targets related to climate and extreme weather-related Significant Aspects.

Metro has formally adopted and began the incorporation of the above recommendations into the agency's EMS through an EMS Adaptation Plan. As EMS Core Teams at Metro facilities go through the PDCA framework of the EMS, they will be required to touch on the elements of Climate Adaptation. This process is self-sustaining, as the circular management nature of the EMS directs management to continually re-evaluate and review specific elements. This systematized and regular review of Climate Adaptation in every element ensures that Metro takes it into consideration at every level and for every action.

Asset Management Tool Development

Metro currently employs several electronic tracking systems, including the Environmental Information Management System (EIMS) and the Maintenance and Materials Management (M3) System. For Task 2 of the FTA Pilot, Metro evaluated the incorporation of Climate Adaptation into these asset management systems. During evaluation, it became clear that Metro's M3 system was better suited than the EIMS to handle the demands and requirements of evaluating assets in the context of adaptation because 1) it was already fully populated with all existing Metro assets, 2) its functionality already allows for flexible data and information input fields, and 3) it will soon be upgraded with additional capacity, functionality, and streamlining. ECSD is a stakeholder in identifying new functionality needs and requirements, which presents an excellent opportunity for Metro to employ an asset management system with explicit capacity to include climate risk.

Metro's EMS Adaptation Plan provides a methodology for Metro, as well as guidance to other transit agencies, to assess risk to its assets over time using Indicators of Risk. The methodology builds on Metro's completed CAAP and provides a methodology to identify assets at risk to climate change impacts over time that can affect reliability, service, maintenance, planning, and SGR. Identifying the assets at risk and incorporating adaptation strategies requires the development of a tool or modification of an existing software application to evaluate and track climate risks associated with Metro's fixed and rolling assets.

Guidelines were developed as part of this work to create a tool for Metro, and for transit agencies more generally, that address asset risk from climate change.

The M3 is a product used by Metro and other transit agencies across the country that includes MTA New York City Transit, Dallas Area Rapid Transit, and the Utah Transit Authority, among others. Building on the EMS Adaptation Plan that addresses activities, products, and services, the guidelines provide a methodology to identify the criticality and vulnerability of fixed and rolling assets so that Metro can take appropriate measures to reduce vulnerability to extreme weather. Outlined below is a demonstration of an example of how to use M3 so an agency can systematically review its assets in their entirety, prioritize the criticality of its at-risk assets over time, and, ultimately, identify viable strategies to consider when developing capital and operating budget actions to avoid current and future risks and impacts.

Metro's M3, is a commercial-off-the-shelf (COTS), fully-integrated public transit Enterprise Asset Management software suite. It is designed to integrate with commonly-used transit systems such as fuel and fluids management, automated vehicle location (AVL), human resources, finance, and procurement. The technical design is multi-tier client/server that allows access from all Metro locations to a central data system. Its reporting capabilities track Metro's key performance indicators, and the system includes a search engine for ease of use, searching, and printing reports.

M3 supports asset management, inventory, and warehouse management, as well as bus, rail and facilities maintenance. It is integrated with Metro's purchasing and financial systems to create a seamless environment and eliminate duplication of data. The system uses and resides on computer hardware accessible at all Metro locations.

Historically, the M3 contract developed the system requirements for M3 as a singular, integrated system that would meet the comprehensive needs of the MTA's operations function. Metro eventually expanded the project scope beyond solely bus maintenance to incorporate rail maintenance and facilities maintenance, as well as asset, inventory, warranty, fuel, and fluid management. Metro is currently planning the next generation of M3 and is expected to be fully deployed by 2016.

Metro's case study through this project shows how Metro and any transit agency can address asset risk from climate change by identifying the criticality and vulnerability of assets over time, using Metro's EMS Adaptation Plan and Metro's M3 as a template. Building on Metro's ISO 14001:2004-certified EMS and CAAP at the Red Line Yard (RLY), First Environment developed a methodology to screen for the assets at risk. In particular the methodology provides a tool for a transit agency to:

- Identify assets
- Screen assets for criticality

- Screen assets for vulnerability to precipitation, heat, and wind
- Screen for indicator of risk over time – rate of change
- Assess the risk on the asset

Identification of Assets

M3 is a database of all Metro's assets and provides a database of assets within its ISO 14001:2004-certified facility in the RLY. They are broken down by vehicles, equipment, and buildings by location. Metro's M3 readily provides a listing of all of Metro's assets by class and location.

To identify the assets specific to the RLY, Metro prepared a report of all assets associated with it. Assets include vehicles, equipment, and buildings (see Figure 3-3). From that, First Environment worked with its local subcontractor Beacon Management Group and operations staff at RLY to identify those assets that were actually assigned to RLY and within the scope of the RLY EMS. Only assets within the RLY scope were considered.

Figure 3-3

Red Line Yard Assets: Partial Snapshot of M3 Report

Red Line Yard Equipment

Equipment	Equipment Code	Equip Class	Equip Type	Current Facility
Air Compressor	070820	SHOP EQ (ELEC-MECH)	AIR COMPRESSOR	20
Projector	155140	OFFICE EQUIPMENT	PROJECTOR	20
Diagnostic Analyzer	156084	DIAGNOSTIC	ANALYZER	20
Portable Steamer	156744	SHOP EQUIPMENT	PORTABLE	20
Generator	156945	SHOP EQ (ELEC-MECH)	GENERATOR	20
Computer Switch	158492	COMPUTER	SWITCH	20
Diagnostic Analyzer	173001	DIAGNOSTIC	ANALYZER	20
Laptop Computer	177611	COMPUTER	LAPTOP	20
Railbound Equipment	19-0006	NON REV RAILBOUND EQUIPMENT	Railbound Equipment	20
Centrifugal Pump	197855	PUMP	CENTRIFUGAL PUMP	20
Diagnostic Meter	197952	DIAGNOSTIC	METER	20
Shop Eq	203014	SHOP EQ (ELEC-MECH)	MACHINE	20
Lift	203019	LIFT	LIFT	20
Rail Organization Equipment	203022	Rail Organization Equipment	Rail Org Equip	20
SHOP EQ (ELEC-MECH)	203185	SHOP EQ (ELEC-MECH)	MACHINE	20
Monitor	203679	COMPUTER	MONITOR	20
Jib Crane	203681	SHOP EQ (MECHANICAL)	JIB CRANE	20
Server	203682	COMPUTER	SERVER	20
Property Equipment	203673	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203680	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203691	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203692	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203706	PROPERTY EQUIPMENT	PROPERTY	20

First Environment worked with Beacon Management and the RLY operations staff to verify that the assets listed in Metro's M3 are currently located at the RLY. It is necessary to note that while equipment may be assigned to the RLY, the equipment may not be actually located there from day to day. Equipment that is not at the RLY is not within the scope of Metro's RLY EMS. For example, non-revenue passenger vehicles may be assigned to RLY for administrative purposes within M3; however, these vehicles are not actually located at the RLY on a regular basis.

For the purpose of testing the methodology, First Environment and Beacon identified 12 classes of assets within the RLY to screen for criticality and vulnerability that represented the operations of RLY in different locations throughout the yard. The sample assets focused primarily on stationary assets at the RLY. Rolling stock included truck assemblies that are on rail cars. The assets include:

- Stormwater collection system
- Outdoor waste accumulation area
- Underground car hoist
- Truck assembly – on train
- Truck assembly – spare
- Wheel truing machine
- Bridge crane
- Portable steamer
- Power substation
- Third rail
- Trainway feeder
- Signals

Screening Assets for Criticality

The next step was to screen assets for criticality. In relation to the asset assessment, criticality is defined as something that is essential to operations without service disruption. Essentially, the question is, "If this service or asset were removed from the transit system, would the transit system be fundamentally different?" A critical service or asset would be extremely difficult or costly to replace or to substitute. As the EMS Adaptation Plan draws from Metro's CAAP, this definition of criticality is consistent with Metro's CAAP.

As a group, the RLY EMS Core Team assessed each asset for criticality based on the following criteria: most critical, somewhat critical, and not critical.

Infrastructure such as the third rail and a power substation are "critical" and, therefore, necessary to provide service; without them, there is no rail service. If they were removed from the transit system, the system would be fundamentally different. An example of critical rolling stock is the truck assembly on the subway cars. Without the truck, the train does not move—hence, no train service.

A "somewhat critical asset" example is the signal in the train yard. Service can be provided without a signal; it can be replaced by human flaggers. Another example is the wheel truer. The wheel truing machine sharpens the steel wheels that are placed on trucks. A train can still run with flat wheels, although it is not desirable; the spare wheels may be adequate in the event the wheel truing machine is not available for a short period of time.

A portable steamer is an example of an asset that is "not critical" for operations. The steamer assists with maintenance on the trucks; however, service does not depend on it. Furthermore, it is relatively easy to replace.

To test this methodology, First Environment prepared Beacon Management to work with the EMS Facility Core Team at the RLY. Beacon met with the EMS Facility Core Team and presented a sample of assets that would represent all levels of criticality. At this meeting, Beacon and the RLY EMS Core Team also assessed the assets for vulnerability.

Screening Assets for Vulnerability

As a group, the RLY EMS Core Team assessed each asset for degree of vulnerability, which is defined by the level of exposure an asset has to extreme weather impacts. Metro's extreme weather impacts identified in the EMS Adaptation Plan are heavy precipitation, high heat, and wind. They were scored as most vulnerable, somewhat vulnerable, and not vulnerable.

This assessment was also qualitative and was consistent with Metro's CAAP. The vulnerability of a service or asset is a function of its exposure, sensitivity, and adaptive capacity with respect to a particular impact of climate variability or change. Each of these three concepts from the CAAP is described below, focusing on examples of periods of extreme heat and episodes of heavy precipitation:

- **Exposure** – Is the service or asset exposed or protected from extreme heat or heavy precipitation? (e.g., assets located underground are not as exposed to high temperatures as assets located aboveground)
- **Sensitivity** – If exposed, does extreme heat or heavy rain cause damage or negatively affect the service or asset? Are there thresholds at which impacts occur? (e.g., air conditioning units start to break down and cause damage around 100°F; rail buckling can begin around 110°F)

- **Adaptive Capacity** – Which assets are most easily replaced? Which can be moved or changed to reduce exposure or sensitivity? (e.g., subway trucks are mobile and can be moved in response to or anticipation of flooding)

Table 3-2 presents the results of the RLY EMS Core Team's assessment for assets and their criticality and vulnerability to each weather impact.

Table 3-2 *Preliminary Assessment Results*

Asset	Criticality	Vulnerability		
		Extreme Heat	*Heavy Precipitation*	*Wind*
1. Stormwater collection system	3	1	3	1
2. Outdoor waste accumulation area	2	1	2	3
3. Underground car hoist	2	1	1	1
4. Truck assembly – on train	3	1	1	1
5. Truck assembly – off of train (spare)	3	1	1	1
6. Wheel truer	2	1	2	1
7. Bridge crane	1	1	1	1
8. Portable steamer	1	1	1	1
9. Power substation	3	2	2	2
10. Third rail	3	1	2	1
11. Trainway feeder	2	2	2	2
12. Signals	2	3	2	1

Screening for Indicator Rate of Change

The impact of extreme weather on the assets changes over time, and it is no longer possible to rely on institutional knowledge and history at transit agencies to plan for and address climate change. As indicated in Metro's CAAP and FTA's "Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation," weather patterns are shifting, and the models in the CAAP show average rates of increase in high heat days and extreme precipitation for periods 25 years from now until the end of the century. Climate change also affects wind patterns. Current models of climate change indicate high winds associated with the Santa Ana phenomenon are expected to decrease and shift in seasonality toward drier periods, resulting in greater dust. Wind and other regional and local impacts associated in climate change also need to be researched for inclusion as an impact.

While there are no short-term (5–30 year climate) models readily available to show the average changes over planning periods for Metro's extreme weather events, it is necessary to develop Indicators of Risk to plan for both short-term operations and long-term capital improvements. Without them, it is not possible to identify costs and develop specific resilience strategies by asset class and/or individually or identify the time frames when action is necessary.

First Environment recommended developing Indicators of Risk that quantify, on average, the increase in extreme weather events that will affect Metro over the next 20 years and beyond, as shown in the Aspects section of the EMS Adaptation Plan. The time periods are:

- 0–5 years
- 5–10 years
- 10–20 years
- 20–50 years

These time periods are provided to support shorter-term operations needs and longer-term capital planning requirements. It is necessary for operations personnel to understand the impact of weather on their operations for 0–5 years, as they plan and allocate staff and materiel on an annual basis and project budgets for five years. It is also necessary to examine the mid- and long-term time periods for trends and identify when risks will change so that the transit agency can prepare accordingly. This allows for capital planners to revisit their capital plans and provides insight to the potential impact on the operations budget. Furthermore, it provides capital planners a mechanism to assess their assets in advance for impacts on SGR.

Indicators of Risk identify the scale of the risk associated with these impacts during the planning horizons. They include Days Over 90˚F (Extreme Heat), Heavy Precipitation, and Wind.

Using the Indicators of Risk, Metro can perform a Rate of Change assessment that takes into account the various impact scenarios from regional climate models.

An example of using Indicators of Risk is available from New Jersey Transit (NJ TRANSIT), the largest statewide transit agency in the country. NJ TRANSIT prepared a report, "Resilience of NJ TRANSIT Assets to Climate Impacts" (First Environment 2012) to determine the potential risks of weather-related events on its stationary assets. As there were no short-term (5–20 year climate) models available to predict NJ TRANSIT's extreme weather events, they developed Indicators of Risk that quantify, on average, the increase in extreme weather events that will affect NJ TRANSIT over the next 20 years and beyond. These Indicators identify the scale of the risk associated with these impacts. For NJ TRANSIT in the northeast section of the country, they include Days Over 90˚F, Sea Level Rise, and Storm/Flood Frequency.

Default Rate of Change factors for Metro are assigned for each climate impact as follows:

- 3= significant
- 2 = somewhat significant
- 1 = not significant

For illustrative purposes, First Environment provided sample Rates of Change for each asset and weather impact: extreme heat, heavy precipitation, and wind. There are models in the CAAP for long-term change such as 2010–2039 and 2040–2079; however, they do not quantify, by average, the increase in extreme weather events that will affect Metro within the operational planning horizons. Table 3-3 provides an example for extreme heat.

Table 3-3 *Heat Asset Analysis*

Sample Assets	Criticality	Vulnerability	Rate of Change *(Illustrative)*			
			Yr 0–5	*Yr 5–10*	*Yr 10–20*	*Yr 20–50*
1. Stormwater collection system	3	1	*1*	*1*	*1*	*2*
2. Outdoor waste accumulation area	2	1	*1*	*1*	*1*	*2*
3. Underground car hoist	2	1	*1*	*1*	*1*	*2*
4. Truck assembly- on train	3	1	*1*	*1*	*1*	*2*
5. Truck assembly- off of train (spare)	3	1	*1*	*1*	*1*	*2*
6. Wheel truer	2	1	*1*	*1*	*1*	*2*
7. Bridge crane	1	1	*1*	*1*	*1*	*2*
8. Portable steamer	1	1	*1*	*1*	*1*	*2*
9. Power Substation	3	2	*1*	*1*	*1*	*2*
10. Third Rail	3	1	*1*	*1*	*1*	*2*
11. Trainway Feeder	2	2	*1*	*1*	*1*	*2*
12. Signals	2	3	*1*	*1*	*1*	*2*

While the actual models have not been developed yet, this illustrative assessment shows that there is not an impact on the assets in the short term or medium term. The impact is scored as not significant, 1, for the 0–5-year, 5–10-year, and 10–20-year periods. However, there is a somewhat significant impact in 20–50 years; and the impact is scored as 2. The Indicator of Risk is the same for each asset, but can differ for time periods.

Assess Asset Risk

Using this methodology, Metro or any transit agency can identify its specific critical assets and take appropriate measures to reduce its vulnerability to extreme weather as it changes over time. This risk can then be incorporated into any asset management system to appropriately quantify the risk. The risk associated with each asset and weather impact is determined by multiplying the criticality by the vulnerability by the rate of change for each weather impact (criticality × vulnerability × rate of change = asset risk level). The assets with the highest scores are at immediate risk to climate change impacts that can effect reliability, service, maintenance, planning, and SGR. The risk will then be managed though adaptation actions, just as significant aspects and their associated activities are managed within the EMS.

The purpose for determining the risk to climate change impacts is to provide a methodology to prioritize Metro's assets and rank them. The weighting is based on a combination of Metro's professional knowledge and climate models. The purpose of this exercise is not to apply a formula to establish exact risk; rather, it is to aid in prioritization so that adaptation measures can be addressed.

Once this information is put into an asset management system such as M3, it will be identified as requiring attention and Metro maintenance or operations personnel may use the information to make informed decisions on how to protect and preserve assets from weather impacts. For example, one appropriate course of action would be to establish that the Outdoor Waste Accumulation Area may require construction of a permanent cover. Actions may include planning, construction, and inspection of the cover. A procedure for the inspection may be required, and its creation and implementation can be tracked using M3. In this way, Metro will be able to systematize the climate risk assessment of all assets through the EMS procedure and then input this information into the agency's asset management database for prioritization and recording.

Metrics Development

Overview

To move forward with climate adaptation within the agency, Metro worked alongside the Urban & Environmental Policy Institute (UEPI) at Occidental College to determine key metrics that the agency could use to track its progress of implementing any adaptation strategies. Metrics can generate a feedback loop between actions and data that can help Metro plan for its continuous operation in a changing climate. The result will be a resilient transit system that continues to serve and link Los Angeles County's diverse communities. While targeted specifically to Metro's organizational and operational structure, UEPI's efforts are also intended to provide a context for other transit agencies to benchmark their current progress on climate adaptation efforts and prepare for their future related initiatives.

A literature review on metrics and indicators for climate change adaptation by transit operators was initially conducted, which is detailed in a summary metrics report in Appendix C. As climate adaptation by transit agencies is a new and evolving field, the scan of the literature provided examples of metrics that transit agencies are exploring but that are not yet standardized across the industry. The scan subsequently translated common adaptation actions found in the literature into potential metrics. Additional metrics were identified through surveys and discussions with Metro frontline staff and employees, who shared their knowledge about the agency's maintenance and operations.

There were 109 possible metrics generated through the literature review, related research, and discussions with various Metro departments and staff. The metrics fall into four categories: Planning, Operations, Adaptation, and Riders. Some of the metrics are binary, providing "yes or no" answers as to whether a transit agency is taking an action related to climate adaptation. Other metrics require gathering and comparing numerical data.

Since this number of indicators would likely be unwieldy to track, criteria to rank the metrics were developed to identify a smaller set of priority metrics that Metro and other transit agencies could gather and analyze. Each metric was rated None, Low, Medium, or High for each of the "core criteria" and six "multiple co-benefit criteria." The six core criteria are Criticality, Severity, Equity, Feasibility, Cost, and Best Practice. The multiple-benefit criteria (so called because they measure whether a metric provides information that would help an agency address other elements of their climate change agenda) are Climate, Visibility, Participation and Governance, Design, and Mitigation.

Points were summed to provide a score for each metric. Core criteria granted twice the points of multiple-benefit criteria. Ratings of High, Medium, and Low in a core criteria earned 6, 4, and 2 points, respectively, and in a multiple-benefit criteria earned 3, 2, and 1 points, respectively. Each metric could, therefore, receive up to 54 points.

The 20 highest-ranked metrics were those that rated 35 or above. UEPI's report provides a summary, a description of what data need to be collected, and a justification and recommendations for each of these 20 top priority metrics. An additional 19 metrics were rated 34 or 33, which are classified as "Recommended Metrics" within the report. These top-ranked metrics consider impacts on riders, vulnerability assessments, vulnerable populations, and operations failures. The UEPI's Recommended Metrics are the following:

1. Have impacts on riders been analyzed?
2. Has a vulnerability assessment been conducted?
3. Assess Mean Distance Between Failure (MDBF) for buses by temperature and geography
4. Have adaptation actions been prioritized?
5. Have vulnerable assets been mapped with transit-dependent and low-income populations?
6. Assess number of injuries/medical emergencies to workers and riders by temperature and rainfall.
7. Does agency have overheating standards for public transport facilities and rolling stock?

8. Does the agency have an ongoing and regularly-convening team tasked with implementing climate adaptation plans?
9. Percent of climate adaptation recommendations/actions from adopted plans implemented.
10. Evaluate capacity to monitor weather and temperature conditions in real time at key locations in service area.
11. Assess extreme weather impacts on service delays and cancellations.
12. Percent of agency facilities and vehicles with cool roofs.
13. Does the agency conduct regular climate planning updates?
14. Are climate adaptation indicators tracked in agency's asset management system?
15. Assess number of rail kinks/buckling by temperature and by heat island areas.
16. Number of technical advisors and members of the broader community included in climate adaptation team.
17. Do agency design standards consider climate adaptation?
18. Does the agency have designated evacuation routes?
19. Progress in reducing vulnerabilities based on meta-analysis of climate adaptation indicators.
20. Funding needed and provided to implement climate adaptation.

The complete list and description of the metrics are provided in Appendix C.

UEPI recommends that transit agencies across the region consider these metrics as they begin to consider climate adaptation management and planning. Agencies can track metrics that make the most sense for their operations, and their overall organizational structure.

Metro Metric Selection and Adoption

Metro has considered the Recommended Metrics in the context of existing agency resources, adaptation progress, and agency goals. Metro examined metrics from the UEPI's report and identified seven that are currently feasible in regard to resource constraints and labor, that will advance Metro's adaptation work, and that are aligned with the agency's stated goals and policies.

Staff drew from the top 20 Recommended Metrics to identify this initial subset of adopted adaptation metrics. These metrics include four binary metrics (yes/no), which tend to be precursor metrics for more in-depth evaluation in the future. The following seven metrics were selected as ready for adoption from Metro's climate adaptation project:

1. Has vulnerability assessment been conducted?
2. Have adaptation actions been prioritized?
3. Have vulnerable assets been mapped with transit-dependent and low-income populations?
4. Number of injuries/medical emergencies to workers and riders by temperature and rainfall.
5. Does the agency have overheating standards for public transport facilities and rolling stock?
6. Capacity to monitor weather and temperature conditions in real time at key locations in service area.
7. Extreme weather impacts on service delays and cancellations.

These metrics serve to:

- Determine the completeness of Metro's current climate mitigation and adaption efforts
- Identify the extent of implementation of Metro's mitigation and adaption strategies
- Indicate the level of employee and customer consideration in the implementation of such strategies
- Understand and monitor the extent of EMS implementation and integration efforts that need to be performed
- Gauge the agency's engagement and commitment for continual improvement as a function of its core mission of moving people safely and reliably regardless of external potentially impactful conditions

Metro will begin to track these metrics at the close of the project and intends to use these both to measure progress toward adaptation and to identify goals related to expansion of the program. These metrics will be added to the agency's EMS, with performance to be published annually, possibly in an appendix to the agency's Energy and Resource Report, indicating any progress gains and identified challenges.

Metro environmental staff and EMS administrative staff will annually re-evaluate current metrics, benchmark progress on tracking and integration, and consider adoption of additional metrics as the agency's climate work progresses. Metro has a goal of adopting two additional metrics annually based on how rapidly climate work advances. This goal is intended to enable the agency to gradually begin systematically tracking adaptive progress. Annually, previously-adopted metrics will all be re-evaluated for continued relevance and maintained, modified, or dropped accordingly. When considering adoption of additional metrics, staff will also re-evaluate the relevance of the UEPI metrics and pursue follow-up metric development work, if necessary. This process will also be documented and published annually.

Outreach Strategies and Climate Adaptation Roundtable

Metro contracted with Climate Resolve for elements of the outreach strategy: to develop a Climate Adaptation Messaging Strategy; to plan, organize, and host a Southern California Transit Climate Adaptation Roundtable discussion; to plan and moderate a Climate Adaptation Webinar; and to develop a video that can be used as either a public service announcement or as a tool in climate adaptation awareness efforts. The strategies and detailed notes of the roundtable are included in Appendix D.

The messaging strategy identifies various relevant climate adaptation messages for different audiences. The purpose of the strategy document ("Climate Change Adaptation Pilot Project Outreach Plan") is to serve as a reference for climate adaptation work moving forward. The audiences targeted include the Metro Board of Directors, elected officials, and service area residents, as well as transit-dependent riders and discretionary riders. Metro staff will use this messaging strategy when developing outreach materials to aid in developing appropriate and relevant messaging techniques to particular audiences.

The following is a summary of the roundtable and webinar events. All roundtable and webinar materials are posted on the Metro website at www.metro.net/ecsd.

Overview: Los Angeles Transit Climate Adaptation Roundtable

As part of the Climate Change Adaptation Pilot Project Outreach Plan, Metro hosted a one-day roundtable event on May 9, 2013 for transit agencies and industry professionals in Southern California to begin exchanging information and strategies for climate adaptation within the transit sector. Presentations throughout the morning set the groundwork for the rest of the day, with presentations highlighting the work already being done on the local and national level in transit planning and an explanation of the current best science for climate change in the Los Angeles region. An interactive panel and lively discussion followed in the afternoon. The rest of this section outlines the key take-home messages identified from the speakers and their slides.

Introduction

Los Angeles, commonly referred to as "the City of Smog," is quickly becoming the "City of Sustainability," and Metro is at the forefront of this leap forward. The demand for transit is growing throughout the region as Angelenos are stepping away from their cars and relying increasingly on public transportation to get where they need to go. Union Station in Downtown Los Angeles is

representative of this transition, as thousands of travelers now bustle through the landmark transit hub on a daily basis.

In response, Metro's service area is expected to grow rapidly over the next several decades, with the expansion of rail lines, bus service, and connections throughout the region. However, to grow responsibly, Metro is committed to reducing its GHG and prioritizing clean air, clean water, and clean and renewable energy technologies within the agency. With a ridership of more than a million people a day, Metro recognizes its critical role in Los Angeles County and in Southern California as a whole, striving to create livable communities for all Angelenos.

To meet its goals for sustainability, Metro recognizes that operations are a key component to success, with bus and rail operations as the crucial on-the-ground support to complete initiatives moving forward. One of the biggest challenges the agency faces is how to use best, new, and emerging technologies to reduce emissions and prepare for the effects of climate change and more frequent extreme weather events in the years to come.

Setting the Stage: Potential Climate Impacts in Los Angeles

Los Angeles is a city envied by many. On a given day, Angelenos can start their day in the mountains hitting the slopes and finish at the beach to catch some waves in the setting sun. The climate—lots of sunshine and warm temperatures—is one of the things that draw visitors from all over the world. Local science, however, shows that the climate in Los Angeles is changing. Across the globe, climate change is linked to increasingly severe weather—and the LA region will be no different.

Groundbreaking science out of UCLA's Department of Atmospheric and Oceanic Sciences indicates that big changes to the region's climate are coming by mid-century. More specifically, these impacts will not be the same throughout the Los Angeles region; with this highly-precise research, scientists can, for the first time, forecast the difference between one side of the Santa Monica Mountains and the other.

The first climate analysis, focusing on temperature, revealed that the Los Angeles region will be warmer by mid-century, with average annual temperatures rising 4-5°F, with coastal regions warming more slowly than the surrounding deserts and mountains. In addition, the occurrence of "extreme heat days," days when temperatures exceed 95°F, is expected to increase substantially—threefold on the coast and up to 5–6 times in the desert and mountain areas.

Further analysis will consider snowfall, precipitation, and Santa Ana winds. While the details are not yet known, it is certain that Los Angeles will see increasingly

extreme weather in the years to come. With this information in tow, planners throughout the region may begin considering risk management; given the high probability of increasingly extreme weather, agencies and communities must act now to prepare and move forward in the face of extreme heat, increased flooding, droughts, and wildfires.

Across the region, agencies and communities will feel the impacts of a changing climate. If Metro and other transit agencies are to continue to provide excellent service in a safe manner, they will need to prepare for coming operational threats.

Climate Change Planning and Implementation Principles at Metro

GHG emissions are the biggest contributor to global climate change. While emissions come from a variety of sources, private single-user vehicles are the largest contributor to a household's carbon footprint. Public transportation is a viable alternative for many—especially in Los Angeles—who wish to reduce their footprint and do their own small part in reducing the impact of climate change. Metro provides alternatives, not only through public transit access, but also through public electric vehicle charging stations across the region.

Increased use of public transit means more than fewer cars on the road. More transit often means traffic congestion relief (which leads to increased fuel efficiency and fewer GHG emissions for the cars on the road) and a transition to multimodal "complete" streets, where buses and trains often share nearby space with more pedestrians and bicyclists.

Despite the fact that public transit is a less-dirty alternative for single-users, transit still comes at a cost for the environment, producing more emissions as ridership increases. In response, Metro is taking big steps to reduce emissions and prepare for climate change with the help of the American Public Transportation Association (APTA) and FTA.

APTA, a non-profit organization serving as an advocate for the advancement of public transportation programs and initiatives in the United States, has created a Recommended Practice (APTA 2011) to assist transit agencies in developing a Climate Action Plan. In exchange for being a member, APTA provides agencies with support for internal sustainability efforts and information for improving cost-effectiveness while offering support as agencies prepare for the effects of climate change.

Metro has used APTA's recommendations in the development of its own Climate Action Plan. In addition, Metro has adopted a fluid PDCA cycle within Operation's EMS documentation. This cycle encourages strategic planning,

options analysis and Climate Action Plan development, implementation of the plan, and continuous monitoring and improvement.

Overview of CAAP and FTA Pilot Project

California is often considered a leader in climate change policy planning. The State implemented a number of policies in recent years to ensure agencies and communities are doing their part to both mitigate emissions and prepare for climate change impacts. The California Global Warming Solutions Act of 2006 (AB32) is one notable example. The law requires the State to reduce its GHG emissions down to 1990 levels by 2020. Other relevant laws and regulations include the Sustainable Communities and Climate Protection Act of 2008 (SB 375), amendments to the California Environmental Quality Act in 2007, and the adoption of the California Climate Adaptation Strategy.

In addition to the above drivers, Metro has other reasons to consider climate adaptation within operations. While the exact nature and magnitude of climate impacts is not yet known, the agency must consider the risks of potential extreme weather events. Across the region, service disruptions have already occurred during periods of extreme heat and heavy precipitation; these incidences are likely to increase in the future if Metro does not adequately prepare. Identifying portions of the transit system that are already vulnerable, or that may become vulnerable, will help guide planning, and prevent disruptions in the future.

Critical assets and services to be considered in climate adaptation planning include any infrastructure, equipment, and property currently owned and operated by Metro, including bus operations, light and heavy rail, and equipment yards. The agency also has several large infrastructure projects in progress that will remain a cornerstone to their service for decades to come. Throughout the building process, Metro must consider future climate impacts if they are to ensure optimal performance and safety in new and existing development.

Given the fairly mild climate of Southern California, regional transit agencies do not need to worry about extreme winter snowstorms and cold, as many others across the nation do. However, transit operations are still threatened by extreme weather events throughout the year: sea-level rise, heavy precipitation and flooding, and extreme heat. While only one rail location (the Blue Line in Long Beach) is expected to become vulnerable to expected sea-level rise, the Expo Line may also become vulnerable as it expands westward in the years to come. Heavy rains and flooding may impact underground stations on the Red Line and negatively affect infrastructure above-ground, although none has yet been reported. Extreme heat has the farthest reaching effects to the operations of the agency, potentially leading to equipment malfunction, railway buckling, fleet breakdown, and labor interruptions. Strong-blowing Santa Ana winds have also threatened service in the past, although largely due to external power outages rather than internal complications.

As a result of expected impacts of climate change and extreme weather, Metro has actively considered options for adaptation. New technologies to withstand extreme heat, such as heat-resistant track materials and white "cooling" boxes for equipment, are being tested for effectiveness and efficiency. Metro has completed a CAAP, but the plan is largely fluid as the agency considers the best way to integrate adaptation into management, operations, and planning. Financial costs of new technologies and anticipated negative impacts from extreme weather are now being considered on all current and future projects.

As one of seven pilot projects within FTA's Climate Change Adaptation Initiative, Metro is currently concentrating on increased outreach with local transit agencies and relevant organizations to share its progress in climate adaptation. Moving forward, the agency hopes to continue coordination with FTA on future projects and continue its work on adaptation-complementary programs, including EMS integration and sustainability projects. In the long term, Metro would like to assess all of its fixed-asset vulnerabilities and implement criteria to prioritize asset management, develop GIS-based tools to incorporate climate impacts, integrate research that considers extreme weather impacts to vulnerable populations, and possibly participate in the budding carbon market.

Across the region, Metro is not the only transit agency considering the impacts of climate on operations. Of those groups in attendance, a majority have already begun thinking about climate adaptation strategies within their organization, with many already taking steps towards adaptive planning.

Planning for Impacts to Operations: An Interactive Panel

Every day, frontline employees are on the ground grappling with the impacts of extreme weather and actively working to make the Metro system safe, efficient, and reliable; a discussion on climate adaptation within the agency would be incomplete without their unique perspective. Four such frontline representatives shared their perspectives and thoughts on extreme weather impacts, integration of new technologies, and general operations management. Panel participants included Metro staff from Rail Fleet Services, Wayside Systems, Vehicle Technology, and Bus Operations and Maintenance.

From this panel, it was evident that Metro has experienced the effects of extreme weather in the past, often on its rail fleet and service. Extreme heat has led to two major chronic issues: disruption in propulsion services and failure of on-board HVAC systems. Additionally, heavy precipitation actively encourages rust in the steel frames of rail cars, causing accelerated wear to vehicles.
In response to all of the above issues, Metro instituted a regular preventive maintenance program for all systems. With a huge number and wide variety of light rail vehicles at varying life stages, this is no easy task, but Metro remains committed to ensuring a reliable and resilient organization and system.

Metro Climate Adaptation Webinar

Climate Resolve and Metro staff analyzed the outcomes of the May 9 roundtable to come up with three possible focus areas for a follow-up outreach event within the scope of the pilot. The focus areas include:

- Building off of the roundtable discussion to share additional information on Metro's climate efforts
- Identifying and outlining existing and forthcoming policies, programs, and resources available to transportation agencies for climate adaptation planning
- Creating an accessible forum to increase audience engagement and participation

Metro and Climate Resolve staff considered various possible delivery methods to address these issues and chose to conduct a webinar for this second outreach effort. The webinar format allowed Metro to include a larger, more varied set of stakeholders while addressing the focus areas identified above. The webinar, entitled "Climate Adaptation Planning for Transit and Fleet Operators," included the following agenda:

- Introduction – Cris Liban, Deputy Executive Officer, Environmental Compliance Services, Metro
- Overview of FTA Pilot Program on Climate Change Adaptation – Brian Alberts, Program Analyst, Federal Transit Administration
- GHG Accounting: A Look into Metro's GHG Inventory – Cheryl Laskowski, Environmental Specialist, AECOM
- Climate Change Policy: Opportunities for Funding and Synchronization – Erin Sheehy, President, Environmental Compliance Solutions, Inc.
- Emerging Technologies and Funding Opportunities – Fred Silver, Vice President, CALSTART

All of the presentations are available at http://www.metro.net/ecsd.

The two-hour webinar included dozens of participants at the local, state, and national levels. While a majority of the attendees are involved in the transportation industry, professionals representing planning, public works, regulatory agencies, education, and private sector consultants were also represented. Each of the presentations was followed by a lively question and answer discussion, at which participants asked questions pertaining to defining the boundary of what to quantify in conducting a GHG inventory, how federal energy policy may stimulate additional regulatory requirements for GHG reductions, and issues pertaining to the safe storage and transport of hydrogen with buses, among others.

Each of the presentations put forth a set of important messages and key takeaways for the audience. These thoughts include the following:

- There are necessary steps to begin climate planning for an agency; conducting a GHG inventory helps agencies assess their emissions sources and how to identify areas to target to reduce emissions.
- Mitigating an agency's emissions, and accounting for the benefits of an agency's service, are two important steps toward climate adaptation planning.
- Conducting a vulnerability assessment of an agency's assets is important for setting priorities for current operations, SGR, and integrating best practices into planning and construction of future transit systems.
- California is at the forefront of climate change policy, with significant revenues and resources already in place to help the transportation sector reduce its GHG emissions.
- Regulatory requirements are incentivizing innovations in technology and the need for agencies to convert their vehicle fleets; there are a number of programs in place for California entities to obtain funding to procure for these cleaner vehicles.

Overall, the webinar put forth a diverse set of resources available to the transportation industry to help agencies begin or enhance their climate mitigation and adaptation planning. Upon conclusion of the webinar, a survey was circulated to all of the participants asking for their feedback on the usefulness and relevance of the presentations and on potential topics for follow-up outreach and collaborative efforts that would fall outside of the scope of FTA pilot. Metro intends to continue a regional discussion on climate adaptation planning and will look to build upon the relationships developed from the two outreach events in this pilot to continue that conversation.

Outreach Video

Metro has developed a 100-second video to highlight some of the agency's key environmental initiatives that are helping to prepare Los Angeles for the impacts of climate change. The video is intended to depict the following messages:

- Metro is helping to build a sustainable, reliable, and complete transportation system for today and for the changing environment of tomorrow.
- Metro is at the forefront of clean fleet technology for its buses, which has produced significant reductions in air pollutants.
- Metro is helping to reduce congestion and lower emissions through rideshare programs and innovative projects such as the ExpressLanes and installation of EV charging stations at several park-and-ride lots.
- Metro is working to reduce its impacts on the environment through planning and construction of an expanded regional rail system.

- Metro is building a multimodal transportation system, funding pedestrian and bicycle improvements throughout the county.
- Metro's patrons are part of the solution, in that their use of public transportation helps Los Angeles to reduce its GHG emissions from private automobiles.
- Together, Metro and riders are creating a better future for LA.

The full 100-second version of the video can be made available upon request at sustainability@metro.net or by calling (213) 922-1100. The video storyboard can be found in Appendix D. The video has been segmented by topic to produce several 15-second iterations of the full version. These 15-second versions will be played at all Metro monitors in rail and bus station platforms, and longer segments of the video will be played in other locations such as TransitTV (TV monitors watched by bus riders), Metro purchased time slots, and similar venues.

Metro ECSD and the Metro Communications Department will continue to collaborate on outreach opportunities, including multi-media opportunities to increase awareness of Metro's environmental efforts pertaining to climate adaptation. This messaging is essential to Metro's riders, as well as the general public, in becoming aware of the many initiatives Metro is undertaking to ensure a safe, resilient, and sustainable system for its patrons in light of changing environmental conditions in the future.

SECTION 4

Lessons Learned

This project is a highly-specific instance of implementing climate adaptation principles within the operations of a large multi-faceted agency such as Metro. While Metro had already completed an agency-wide vulnerability and criticality assessment, the challenge of incorporating climate adaptation into a regular and self-perpetuating program remains. Metro identified the agency's EMS program as a possible route for implementation at the agency's maintenance facilities and sought the development of asset management databases and metrics to support EMS integration.

One challenge encountered by Metro staff early on was "employee buy-in" on the topic of climate change. The majority of individuals at the Bus and Rail Maintenance Divisions level place exclusive priority on daily maintenance, seeing that their work includes preparing for a wide variety of extreme events and circumstances. Given the emphasis that Division staff placed on achieving a regular roll-out schedule day by day, many did not immediately connect with concerns over long-term climatic shifts and the direct impact to their maintenance work. As a result, it became effective for the project staff to simply discuss discrete severe-weather events (such as high winds, high heat, and heavy rain) and the possible increase in frequency of these events. Removing the "Climate Change" element from the discussion and instead re-focusing the conversation toward an emphasis on extreme weather events facilitated the conversation with many internal agency staff members who otherwise may not have been interested or cooperative.

Weather impacts are typically chronic, long-term, and indiscrete impacts that are difficult to measure, and, thus, it is difficult to evaluate the impacts' costs. Several concepts for information gathering were suggested such as "tagging" maintenance orders/logs with weather information at the time of the incident, using the cost of a breakdown combined with the likelihood of a severe weather event to develop a cost versus risk likelihood, or using past maintenance records with a weather "multiplier" to estimate costs associated with weather.

As mentioned in Section 3, independent research by Metro staff found a correlation between weekly temperature averages and weekly bus breakdown averages, even with preventive maintenance. While this challenge was not critical to the success of the project, it is an ongoing issue that Metro staff will continue to address.

Metro staff have developed metrics and began the process to incorporate their implementation through two avenues:

- EMS Action Plans related to CAAP strategy implementation
- Actions associated with operations and ancillary activities, specifically Design and Construction

Outreach efforts also revealed the following challenges and observations:

1. While Metro leads the nation and the region in Climate Action Planning, much of the region still struggles with either the concept of planning for extreme effects of an evolving climate or the implementation of strategies that are related to the issues of climate.
2. Metro's programs, communications materials, and staff knowledge help frame the issue of climate change impacts, but this does not mean that frontline personnel remain stagnant or are not responding to current issues and concerns. Frontline personnel at Metro have to deliver reliable and safe transit service at all times. Addressing asset breakdowns has led to a collection of best practices that can be correlated to extreme weather event incidents and assist in a more systematic approach to planning and executing strategies to reduce these issues, both for Metro's existing and expanding system.
3. A regional approach to adaptation is needed, but coordination and resources to facilitate this dialogue remain a challenge. While programs exist throughout Los Angeles County to individually address mitigation and adaptation efforts, there is a need to more systematically and collectively approach the issues to become more effective. Awareness workshops and training such as those offered through this project are needed; however, expanding this conversation across the public, private, and non-profit sectors and across industries remains a challenge.
4. Active public engagement remains to be seen. Through Metro's video outreach, the public will have an opportunity to better understand how their ridership helps to reduce their impact on the environment, and how Metro is working to provide a resilient and reliable system for its riders for decades to come. Metro recognizes that public realization of the importance of the public's contribution, and their individual mitigation and adaptation actions can make a difference; thus, Metro should seek to continue to engage the public and help to increase awareness on the climate conversation, wherever possible.

SECTION 5

Next Steps

Metro is committed to providing reliable service for its riders, and one element of this commitment is ensuring that the agency plans and prepares for stronger and more frequent severe weather events related to climate change. Metro will continue to track its climate adaptation performance through the agency-wide rollout of the EMS and closely track how the EMS changes to include more and more climate-related elements. Since the EMS is a self-perpetuating management procedure, Metro anticipates learning from what new climate management ideas emerge moving forward.

Metro has also begun a second and more detailed Asset Vulnerability Assessment. This revision to the current CAAP is intended to inform 1) the specific vulnerabilities in the fixed assets of our existing system, and 2) the planning, design, construction, and operation of our new rail lines.

Post-pilot, Metro has plans to further examine the issues associated with transit user's mobility by investigating climate impacts on low-income, disadvantaged, and particularly vulnerable transit-dependent populations.

Objectives of future efforts will also consider increased knowledge of how transit agencies can adapt to climate change and extreme weather, advancement of the state of practice for climate adaptation with concrete examples, development of strategic partnerships, and an increased visibility of climate adaptation work at both the regional and national levels.

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APPENDIX

A

Los Angeles Metro Survey

What impacts do you experience during ***heavy rain*** *events, and how do you respond?*

Respondents	Impacts	Mitigation
Respondent 1	No Response	No Response
Respondent 2	many stops are close to the roadway and waiting passengers get splashed by passing traffic	move away from the curb
Respondent 3	Secondary containment curb at 61a floods and overflows as there is no cover. Building 61a leaks/floods in areas, mold/IAQ issues. Open air carwash permits discharge of pH outside our permitted range on occasion in heavy rain. This should be remedied with the new carwash. The temporary carwash at the CCP to be constructed will be open air, and I don't know enough of the system to determine how it will function.	Any secondary containment should be covered in future construction. We spoke of installing a canopy, however, the area is in flux due o construction activities. Building 61a needs to be demolished or have a new roof installed.
Respondent 4	Potential interruptions in telecommunications due to flooded cable vaults or power outages	It depends. Sometimes we can relay on a backup generator or pump out a flooded area. Other times we just need to wait it out.
Respondent 5	Building Roof Leaks / Parking Lot Flooding due to either orientation on a hilly lot or lack of maintenance of the pavement / Stormwater Basin flooding / Fuel Island Roof Leaks / Slick Yards -	install tarps and apply sealant wherever possible. Most times, this can be done after the weather is dry. Same thing with storm drains.
Respondent 6	Slip and fall issues at divisions and bus speed slows impacting on time performance	Communicate safety and with bus service slow down as necessary
Respondent 7	No Response	No Response
Respondent 8	Some storm drain grates become clogged with vegetation and/or debris and no longer allow rain water to drain into storm drain causing minor flooding in adjacent area.	Division personnel clear storm drain grate to allow rain water to drain into storm drain.
Respondent 9	UST "positive shut down" occurs when rain water seeps into the UST sumps and activates sensors. This causes product delivery interuptions to the fuel islands and maintenance bays	Temporary fix: cover the manways during rain events.
Respondent 10	Unsafe conditions due to slippery surfaces, fallen tree leaves and droppings, possible power outage, roof leaks, as well as certain areas may experience flooding.	Educate staff and contractors of the safety concerns to ensure working, driving, and performing their maintenance duties safely. Also, ensure closing the areas affected by the rain (flooded areas to put cones around), etc.
Respondent 11	Divisions experience an increase in underground storage tank sensor alarms (sumps).	Facilities Maintenance inspect the sumps and evacuate rain water.
Respondent 12	If the problem is widespread, we can have more outages than we have generators to support and leads to crossing gates staying down, loss of train control, or loss of station lights & communications. Also in heavy rain, trees or tree limbs can fall on the OCS, taking track out of service.	Tree trimming. Deploy LASD/LAPD to close crossings, take the line out of service.
Respondent 13	Most Importantly -Experience problems with flooding due to drains plugging drains	very diffucult to maintain open drainage, sometime issues related to poor construction at facilities
Respondent 14	Depending on the intensity of the rain, there might be flooding in the Plaza level Records Management and possibly some leaks in the building. Power outages causes issues because no one can work without electricity and computers in the building. The emergency generator will handle the load for the critical data centers and building lighting. Communication to the buses and other critical functions should not be affected but power outages can and have been very disruptivem, including service to our customers.	Sand bags are placed in various areas where there is flooding.
Respondent 15	Little Facilities issues. More Buses related i.e defrosted windshield wipers	Discuss it with Maintenance staff, talk about changes in the weather i.e Hot , rain
Respondent 16	Maintenance Shop roof start leaking and working condition become unsafe and employees are unable to performe maintenance of equipment.	wait for facility dept to come and patch roof basically nothing much we can do
Respondent 17	the shop roof leaks	don't work where the roof leaks
Respondent 18	Power Outage	We have a backup generator

Respondent 19	There is seldom heavy rain. In moderate rain there are engine/transmission parts outside subject to oil washing off	the biggest source is the metal bins which are covered with tarps. 2. Engine/transmissions left out. Solution: Build free standing roofs to cover the parts. Will the government provide the money to do so?
Respondent 20	Area adjacent to shop rollup doors turns into a lake and eventually flood over into the shop	Have staff put up barriers to limit spillover
Respondent 21	NR	NR
Respondent 22	most if not ALL buses leak when it rains many windshield wipers are problematin when it rains. power outages it is many times impossible to fuel buses (CNG pumps are ALL electric). i do not let employees out in the division yard during lightning.	rain and wet coaches inside try to dry out as much as possible rain and windshield wipers try to make repairs as needed.
Respondent 23	we have minor water leaks at fueling station also several nabi buses leak inside passenger and driver area. Rain make work place slippery	we call property maintenance for fuel station and repair buses as needed slow down use caution.
Respondent 24	certain portions of the bus yard floor. Div 7 fuel station has extensive roof leaks and sensitive electronic (farebox vaulting equipment) gets wet. Our underground storage tank farm manway covers leak causing our UST leak detection/monitoring system to go into alarm, creating positive shut-down status	Attempt to cover sensitive electronic equipment and UST manway covers with plastic sheets or rubber mats.
Respondent 25	NR	Nr
Respondent 26	Div 18 yard gets flooded. Streets that surround the division also get flooded	barricades around deep water
Respondent 27	some roof leakage in the hallway to the locker rooms, rain water causes electrical problems with the buses causing component failiure	mop and buckets, bus wiring defects are found and repaired, very long and tedius process
Respondent 28	NR	NR
Respondent 29	Anticipation of windshield wiper malfunctions 2. buses leaking water due to heavy rain 2. difficulty servicing and fueling buses due to buses being wet	have a preventative maintenance program checking on wipers and wiper motors while buses are being serviced
Respondent 30	bus roofs and windows leak water into the buses	we do our best to ensure all windows and doors are shut on every bus. We also work to seal all leaky windows and roofs
Respondent 31	NR	NR
Respondent 32	We have roof leaks at the fuel station. The shop area is not too bad an occasional leak, nothing too significant. Coaches coming in to the shop slide. The pot holes around the yard get bigger.	Call facilities maintenance at 2-6614. The drains are kept clean in the yard and also on top of the roof. Have the maintenance personnel drive slow and with caution when entering the shop. Still waiting for yard concrete repair to begin. No real start date.
Respondent 33	1.Occasional momentary power outage. 2.unsafe conditions due to wet slippery floors 3.Buses pull in the shop and bring large amounts of water coming off the buses too. 4.Employees get wet and have to work in the cold wet. 5.ground tanks sensor and alarms go off and shut down our diesel pumps. 6. creates slip hazards at fuel station and shop. 7. Buses slide alittle as the pull to a stop in the shop.	1. remind employees of the weather conditions and how it affects their daily duties. 2. ask employees to grab a rain coat and stay as dry as possible. 3. ask employees to drive extra slow and do not come to abrupt stops to minimize skidding and sliding. 4. Ask employees to be extra vigilent about mopping puddles in the shop.
Respondent 34	1) Yard Storm Drains Slow or Will Not Drain. 2) Fuel Station Roof (Flat) very poor drainage. 3) Inground storage tanks (Oil, Coolant etc) do not operate.	1) Make the best attempt to clear the drain 2) Assign personnel to use brooms to push standing water to the down drains.
Respondent 35	I have found that there are roof leaks at Division 9 when it rains, UST alarms are triggered by rainwater, and water pools in a low spot next to the shop.	Try and cover the manholes that leak and cause the UST alarms. Facilities Maintenance has recently taken temporary measures to stop the roof leaks, but permanent repairs are still required. We manually move the pooled water after the rain has stopped.
Respondent 36	In meeting we ask all employee to cover all drain an we have all drain mark to were the water flow.	We check all system and if repair's are needed we notifly the proper department.
Respondent 37	NA	NA
Respondent 38	NR	NR
Respondent 39	NR	NR
Respondent 40	NR	NR

What impacts do you experience during ***extreme heat*** *events, and how do you respond?*

Respondents	Impacts	Mitigation
Respondent 1	No Response	No Response
Respondent 2	Bus Breakdown	Ride with Patience
Respondent 3	No Response	No Response
Respondent 4	Computer, network, and telecommunication equipments get overheat and malfunction	good maintainence/ backup fans
Respondent 5	The HVAC fails at many substations along our Rail lines, many times compromising SCADA.	bring water/ work indoor/ thermos jugs
Respondent 6	drink water to prevent heatstroke	water, caps, shade
Respondent 7	No Response	No Response
Respondent 8	AC may stop working	Keep good facilities maintainence
Respondent 9	Overheated electronic equipments shut down and lead to fueling and maintainence operations problems	Beeter cooling/ventilation in electronics rooms
Respondent 10	employees get strokes, A/C units break, overheated equipments, and landscaping will require additional watering to ensure maintaining healthy plants	educate staff and contractors to ensure drinking fluids and staying hydrated, wear hats, and always work safely
Respondent 11	No Response	No Response
Respondent 12	Track buckling and overheated wire	Impose a speed limit
Respondent 13	employees get strokes, A/C units break, overheated equipments	drink water, schedule maintainence regularly, redundant systems
Respondent 14	Overheated electronic equipments (A/C, telecomunication equipments)	Addiitional cooling towers are brought online. For the data center an additional rented A/C unit is utilized.
Respondent 15	Very little	Discuss this in tailgate meetings and local safety subcommittee meetings
Respondent 16	Employees get dehydrate and work load increase for A/C related repairs	Try our best to deal with heat and bring extra water bottel from home
Respondent 17	none, Div. 06 is very near the beach and infrequently gets hot	NA
Respondent 18	Employees	we have filtered water and fans throughout the shop
Respondent 19	during hot weather, the employees are provided with water to keep them hydrated. The AC are checked before hot weather arrives	in case of an AC failure, each department has numerous fans
Respondent 20	staff working in the shop and yard are exposed to heatstroke	we have chilled gatorade and what in the shop for their consumption as needed. They are heavily encouraged to stay hydrated
Respondent 21	NR	Nr
Respondent 22	HOT DAYS airconditioning problems some times buses over-heat fron lack of scheduled radiator cleanings. batteries that are poor condition usuaslly fail when weather makes big changes hot / cold	clean radiators replace failed batteries (no preventitive maintenance program when dealing with bus batteries)
Respondent 23	WE GET A LOT OF AIR CONDITIONING FAILURES ON BUSES ALSO WE GET MOST OF OUR WORK ON 2ND SHIFT IN THE SUN WHICH CAN CAUSE HEAT EXHAUSTION	TRY TO WORK OUT OF SUN WHEN POSSIBLE DRINK PLENTY OF WATER AND REST WHEN ALLOWED
Respondent 24	Excessive bus road-failures for A/C or engine cooling system problems. Shop and fuel station air compressors overheat and fail. Office A/C units fail to cool office spaces appropriately. Employees have to take multiple water breaks.	Replace revenue service with a fresh bus and repair BO bus ASAP and return to revenue service. Conact Facilities Maintenance Department to repair air compressors and office A/C problems Ensure employees have adequate water supply
Respondent 25	NR	NR
Respondent 26	buses tend to overheat. Service personal get dehydrated.	power wash radiators, inform employees to keep hydrated drink lots of water
Respondent 27	The buses can overheat due to inadequate cooling systems, Bus a/c systems are taxed to the max with the opening and closing of doors,	Divison 2 has a continous program od flushing the external radiator to help keep them clear of debris and a continous a/c program to insure that the systems are at peak performance,
Respondent 28	NR	NR

Respondent 29	1. higher occurrence of a/c breakdowns and overheating.	1. continually promote and deploy preventive maintenance programs to reduce the amount of these specific breakdowns. i.e., continuing program to replace a/c filters on a daily basis; be aware of buses that may have a/c problems while at the fueling station; turn off a/c when bus is waiting to be serviced; clean and wash debris off radiators to ensure unobstructed air flow; check and replace radiator caps; recently completed campaign to replace thermostats on all buses.
Respondent 30	Bus engines tend to overheat and bus air conditioners break.	In the spring months we do radiator cleaning projects and keep up on the preventative maintence with the bus ac units.
Respondent 31	NR	NR
Respondent 32	No problem with heatstroke. On really hot days we have the usual brake downs. Eng overheating and A\C units in the coaches go down. It takes the operators longer to leave the yard. The inside of the busses take longer to cool down.	Have safety meeting on heat management. Try to keep the employees hydrated. We have a preventive maintenance program for maintaining the A\C and Engines in the coaches. Have mechanics work on the overheating problems.
Respondent 33	1. A/C units on buses either break or dont cool the bus as expected especially with the bus fully loaded and all the passenger body heat adds to the situation. 2. heat stroke is an constant issue for employees 3. engines over heat more. 4. fatigue sets in for all employees 5. sweat becomes a hazard for mechanics and tools can slip from their grasp.	1. ask employees to check all cooling systems and make sure the fluid levels are topped off. 2. remind employees to drink fluids. 3. ask employees to go get a drink of water if they are seen sweating alot or get a small break. 4. ask employees to keep an eye out for one another and be aware of heat stroke symptoms.
Respondent 34	1) Coach engine overheating 2) Coach HVAC system not cooling well enough 3) Mid-day temp's at the fuel station (Very High) 4) Mid-day temp's inside shop (High)	1) Engine radiatior water flush, assign coach to later yard departure 2) Water flush engine radiator. Ensure all windows are closed and allow coach to run closed-up until interior temp becomes acceptable or repair HVAC system if required. 3) Do not allow coaches awaiting service to stack up bumper to bumper or even close. Make room for the air to move. Use large size swamp coolers and fans to keep the air moving. Take many water breaks. 4) Use as many fans as possible to keep air moving. Drink plenty of water. Use shop CNG extraction fans if needed to keep air moving.
Respondent 35	Buses tend to overheat if the radiator has not been cleaned recently. Employees are susceptible to heat stroke, the shop offers little relief from the heat.	We have a yearly project to steam clean radiators prior to the hot season to reduce equipment failures. I provide employees with Gatorade on hot days so they stay hydrated and do not lose electrolytes.
Respondent 36	We like all employee know to drank alot off water and to stay in a cool place.	We call all equipment in that have problems. We let all employee know to try to fine a spot that is cool.
Respondent 37	very hot on fuel islands very stagnet air, ac units break	by fans
Respondent 38	NR	NR
Respondent 39	NR	NR
Respondent 40	NR	NR

*What impacts do you experience during **blackouts** , and how do you respond?*

Respondents	Impacts	Mitigation
Respondent 1	No Response	No Response
Respondent 2	No Response	No Response
Respondent 3	Power interruption-- some equipments need to be started manually	call in staff and restart the equipment
Respondent 4	Not good for computer equipment that datainformation get corrupted or lost	good maintainence/ backup fans
Respondent 5	This is not an issue because the emergency generator is scaled large enough to handle the needs to run the control center.	Check by electrician
Respondent 6	Rarely afftected	N/A
Respondent 7	No Response	No Response
Respondent 8	equipments would not work	Emergency generators
Respondent 9	Loss of power to the Veeder Root systems will cause the fueling systems to shut down	BPut the Veeder Root monitors on the emergency circuit
Respondent 10	service delays and interruptions	communicate directly with management and staff who are responsible for restoring power
Respondent 11	No Response	No Response
Respondent 12	Multiple location are not able to support with a limited number of backup generators	shut down grade crossing and/or stations
Respondent 13	No impacts due to lack of conditioned air	Increase AC crew size
Respondent 14	the building has only emergency lighting and no A/D	The emergency generator provide electricity to the data centers in the building.
Respondent 15	No impacts	No impacts
Respondent 16	Lack of lighting create unsafe condition inthis situation we wait for light or power to restor	Pray for power to restore quick
Respondent 17	no compressed air (mechanics air tools, blowing out busses) working in the dark, no computers	work with electric or hand tools, sweep busses out, work in areas with emergency lighting, enter data at a later date...
Respondent 18	The loss of power impacts us, we cannot fuel our buses.	We have to send our buses to another division to get them fueled
Respondent 19	Loss in power shuts down the air compressors and power for electrical equipment.	We do have emergency generators which switch on in power failures.
Respondent 20	No impact, have emergency generator.	If generator fails to work then all shops activities are modified to minimize safety hazards.
Respondent 21	NR	NR
Respondent 22	during black-outs the division is unable to CNG fuel.. importane support computers fail.	work around the problem
Respondent 23	WE HAVE TO RE-BOOTH COMPRESS NATURAL GAS FUELING STATION COMPRESSORS ADS NEEDED	TRY TO CUT BACK ON EXCESSIVE ELECTRICAL USEAGE
Respondent 24	Blackouts or brownouts with limited shop light usage at night. Loss of power to some PC's. Some PC's are essential to issue work assignements, employee payroll and most important roll-out.	Contact Facilities Maintenance Dept. Some brownouts repairs are beyond their control since the source may be a City or County wide.
Respondent 25	NR	NR
Respondent 26	were are the fueling department so any power loss inpacts our operation	have personal on hand to get buses to other divisions to refuel buses and also inform BOC to have operators refuel at other divisions before pulling in
Respondent 27	Div. 2 has new back generators that handle the maintanice shops and office.The issues arise when the generators do not switch over and come on line. The CNG fuel compressors do not have backup generation and would not be powered should a major blacout occure	Start the generator manually.and not fuel buses at Division 2, Other division may be able to provide fuel of Division 2 buses.
Respondent 28	NR	NR

Respondent 29	Bus servicing and fueling comes to a halt; cng compressors shut down. back up generator comes on but usually does not support full shop functions. fueling experiences long delays until problem is resolved.	check all fuel tank gauges and determine which buses have enough fuel to run until operator has a chance to refuel; take buses to another division to fuel and service. clean buses the best possible way.
Respondent 30	When a power outage occurs we have to evacuate the maintenance building because our emergency generator only supplies minimal lighting in the maintenance shop. We can not fuel buses because our fuel compressors are all electric.	We reroute buses to other near by divisions for fuel and service until we regain power.
Respondent 31	NR	NR
Respondent 32	It dose affect the operation. We have a generator that kicks in with in 30 seconds and we can resume limited operation.	We check the Emergency power generator every Sunday for operation.
Respondent 33	black outs shut down our computers and lights momentarily. A back up generator should turn it all back on, but the process stops all work clerical and mechanics working until things get re situated.	NR
Respondent 34	1) Back-up generators do a reasonable job. Most importantly is ensuring safety is a focus.	1) Monitor shop safety situations and handle no power problems as they arise.
Respondent 35	Loss of electricity at the operating division severely impacts our work. Fueling cannot continue without electricity, the shop is not properly lit, air compressors do not work, many work areas are unsafe when not properly lit. The emergency generator that is in place does not help with most of those things, it only provides some of the lighting and power to select outlets.	If the power outage will be for an extended period or if it is planned, we request an emergency portable power source. This is slow in coming and takes several hours to connect due to incompatibility between our connections and the portable generator. The electrical panels should be updated to easily connect to our generators to avoid the long power outages. Mostly, we continue working the best we can with what we have. If other operating divisions have power, we will send our buses to the other divisions for fuel and service. We also send personnel to those divisions to reduce the impact on their operation.
Respondent 36	NR	NR
Respondent 37	unknown	unknown
Respondent 38	NR	NR
Respondent 39	NR	NR
Respondent 40	NR	NR

*What impacts do you experience during **high winds** and how do you respond?*

Respondents	Impacts	Mitigation
Respondent 1	No Response	No Response
Respondent 2	No Response	No Response
Respondent 3	Trashing blowing around yards, SWPPP issue	No Response
Respondent 4	damage of radio and microwave antennas	Ensure antennas are well braced and perodically inspect for rusted or corroded parts
Respondent 5	No Impact	No Response
Respondent 6	Landscape/trees and limbs may fall.	Contact landscape contractor and have them resolve the problem
Respondent 7	No Response	No Response
Respondent 8	Canopies or tarps over scrap metal bins, trash bins or recycling bins are damaged.	Contact facilities maintenance about damaged canopies for repair or replacement
Respondent 9	power outages to divisions, and shut down the UST monitors	put UST monitors on the emergency circuit
Respondent 10	catenary line complications, falling trees/poles, communications issues	Educate staff and contractors and ensure performing frequent tree trimming and PM work to avoid safety issues and service interruption
Respondent 11	roll-off container canopies are damaged or area complete loss	invest in permanent structures for roll-off containers and part storage
Respondent 12	Damage to overhead line, often from trees. Can also lead to widespread utility power outages	Tree Trimming
Respondent 13	Power outages mostly from local utilities, tree falls onto fencing, right of ways, roadways, and catenaries	Reduce trees and landscape around stations and ROW's
Respondent 14	Nothing only possibility of trees falling in the transit plaza	No Response
Respondent 15	natural disaster we work with control center and Facilty Maintenance	Safety programs and practices evacation drills
Respondent 16	Yard become unsafe and chancis of accident increase	Nothing wait for strome to calm down
Respondent 17	none	NA
Respondent 18	No Response	No Response
Respondent 19	Most work is done inside large buildings and there no trees or lines to blow away.	In case of high winds stay inside.
Respondent 20	Have not had severe enough conditions. We do have Hipower Edison lines traversing our yard that are a potential risk.	In a worst case scenario, we would remove all staff form the propery to a safe location.
Respondent 21	No Response	No Response
Respondent 22	windstorms can result in power outages. communications will sometimes fail	use of celular communications equipent
Respondent 23	WE CLOSE SHOP DOORS AND SLOW YARD SPEED FOR SAFETY ISSUES	# 9 ANSWERED ABOVE, USE CAUTION THROUGHT OUT YARD AND WORK AREAS
Respondent 24	Damage to facility awnings, roofing, shop roll-up doors, landscape	Secure items as safe as possible and contact Facilities Maintenance.
Respondent 25	No Response	No Response
Respondent 26	have safe7 forms on hand if any employee see aan unsafe condition	inform city/county departments of conditions could arise
Respondent 27	The latest impact with high winds blew dirt, dust, leaded,paint and bird dropping from the CNG ventalation duct work that ceated a health hazard.	Had a hazard materials contractor brought in to perform crealup.
Respondent 28	No Response	No Response
Respondent 29	I have no known issues or problems regarding this weather issue	No Response
Respondent 30	High winds can cause the fuel cylinder lids on top of the buses to open up.	During fuel cylinder inspections we repair all broken latches and ensure the covers are secured properly.
Respondent 31	No Response	No Response
Respondent 32	We have not have any issues with communication or falling trees. We have the tarp on the trash bins blow off. Trash around the shop.	We bought a new tarp cover for the metal container and got estimates on construction of a new cover area for the Metal Bin. Still pending. Keep the shop clean.
Respondent 33	1. High winds also cause momentary power outage. 2. strong winds also blow debris around the yard and shop. Usually spreading trash around and causing debris to get in the eyes of employees.	Remind employees about the dust flying in the air. Ask employees to cover trash cans and to keep papers covered with paper weights.

Respondent 34	Approach every tasking with extreame caution everyone keeps watch on eveyone. No less than (2) assigned to road call and they will proceed with caution. If the situation dictates all personnel will remain undercover until the situation improves.	No Response
Respondent 35	Mostly we have experienced excessive trash and dirt blowing in the yard during high winds. We have had a few buses damaged by the wind blowing the fuel tank covers open. The facility is generally not harmed by the winds, just a lot of clean up.	Clean up the shop and yard. We inspect compartment locks and latches to reduce or eliminate the occurance of road calls/damage.
Respondent 36	No Response	No Response
Respondent 37	none	unknown
Respondent 38	No Response	No Response
Respondent 39	No Response	No Response
Respondent 40	No Response	No Response

*What weather events have the **most significant impact** on your work?*

Respondents	Impacts
Respondent 1	No Response
Respondent 2	No Response
Respondent 3	General rain will wash steam rack over spray to the storm drains. This contains soap and oil. TRC was looking into installing a secondary drain catch outside of the pit area. Now would be the time to install it as area is dug up for the next couple weeks due to 1SF construction
Respondent 4	No Response
Respondent 5	Rain, When wet Rail cars are brought into the shop, water runs down into the pits, damaging industrial equipment. There are slip and trip hazards. Our parking lot floods.
Respondent 6	Wind
Respondent 7	No Response
Respondent 8	Wind: Damages canopies over scrap and trash bins.
Respondent 9	Rain
Respondent 10	All of the previousely mentioned weather conditions, rain, hot weather, windy conditions, etc.
Respondent 11	Rain events contribute to UST sensor alarms and requires evacuation of rain water from sumps, secondary containment units and part bins.
Respondent 12	Lightning - causes power outage
Respondent 13	All types mentioned. Put more thought into design and not asthetics of stations. Strict control over construction details for drainage.s
Respondent 14	Nothing that has not already been addressed.
Respondent 15	No Response
Respondent 16	Extream heat and cold particularly cold since no heating arrangment at division
Respondent 17	N/A...severe weather incidents are so uncommon it is of very little affect
Respondent 18	No Response
Respondent 19	1. Power failures 2. Heat 3. earthquakes
Respondent 20	Heavy rains cause the flooding of the shop.
Respondent 21	No Response
Respondent 22	wet weather probably has the greatest impact because not much is done to be proactive in this arena.
Respondent 23	RAIN MAKES SHOP AREA VERY SLIPPERY,HEAT MAKE WORKING CONDITIONS DIFFECULT
Respondent 24	Heat and rain related issues.
Respondent 25	No Response
Respondent 26	winds and dust blowing, early morning fog
Respondent 27	The single lardest problem is rain water on old bus electrical systems. This causes electical shorts to the systems and buses stall and components fail. When the older buses are sent threw the midlife program, wiring harnesses are not included. They should be.
Respondent 28	No Response
Respondent 29	Rain and power outage
Respondent 30	Hot weather generaly causes the most impact because the buses break down more frequently, operators and mechaincs production slows down, and overall the people working outside in the high temps are miserable.

Respondent 31	No Response
Respondent 32	No Response
Respondent 33	Since we are close to the beach we get alot of different weather conditions. We get a lot of strong winds and fogg at night. We also have to deal with cold and heat.
Respondent 34	Earthquake brings a with it many different situation that can and do include after shocks. This makes any type of operation very risky.
Respondent 35	Rain with high winds seems to have the largest impact, causing water issues both in the shop and facilities, in addition to damaging the buses. Also, rain causes the buses to be dirty both inside and out.
Respondent 36	Forg and rain
Respondent 37	more heat and cold we could use better protections around the fuel islands
Respondent 38	No Response
Respondent 39	No Response
Respondent 40	No Response

APPENDIX

B

EMS Integration/Asset Management Report

Transit Climate Change Adaptation Pilot Program:

LA Metro's EMS Adaptation Plan & Climate Impacts Assessment of Assets

First Environment, Inc.

April 25, 2013

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Appendix A – Extreme Weather Risk Assessment

Appendix B – Action Plan to Incorporate Climate Adaptation into Metro's EMS

Appendix C – Asset Identification Meeting Report

Appendix D – EMS Asset Assessment Process Memo

Appendix E – Metro EMS Asset Assessment

EXECUTIVE SUMMARY

Adapting to climate change is an ongoing concern to transit organizations in metropolitan areas around the world. "The frequency of extreme weather is up over the past few years, and people who deal with infrastructure expect that to continue. Leading climate models suggest that weather-sensitive parts of the infrastructure will be seeing many more extreme episodes, along with shifts in weather patterns and rising maximum (and minimum) temperatures." (New York Times, July 26, 2012)

As Southern California's largest transit provider, the Los Angeles County Metropolitan Transportation Authority (Metro) has begun the efforts to mitigate and adapt to potential climate related impacts to its facilities and operations. To enhance the efforts to protect Metro's assets; and provide guidance and leadership to transit agencies throughout the country, Metro secured a federally funded Federal Transit Authority (FTA) grant to implement this Transit Climate Change Adaptation Assessment Pilot. Metro is one of seven agencies across the country that is advancing the state of practice for adapting transit systems to climate change. The FTA grant to Metro identifies four tasks:

- Task 1: Development and implementation of a plan for the integration of adaptation principles into Metro's Environmental Management System (EMS) that can be applied agency-wide
- Task 2: Development of a tool or modification of an existing software application to evaluate and track climate risks associated with Metro's fixed and rolling assets
- Task 3: Development of adaptation set of metrics to measure and assess Metro's progress in addressing adaptation
- Task 4: Development of an outreach plan to create internal and external stakeholder awareness of Metro's adaptation efforts

First Environment, Inc. was awarded the contract to work with Metro on Tasks 1 and 2 of the FTA grant. This report, therefore, focuses on Tasks 1 and 2. The report refers to Tasks 3 and 4 where applicable.

This plan developed under Task 1 documents the framework and elements of an EMS and specifically uses Metro as a case study to demonstrate how a transit agency can integrate adaptation to climate change into its EMS. It examines the 17 elements of an ISO 14001 EMS that fall under policy; planning, implementation and operation; checking and corrective action; and management review. The plan describes how adaptation to climate change can be integrated into and addressed within Metro's existing ISO 14001 certified EMS.

The plan for Task 1 establishes that the Metro EMS provides an excellent structure in which to manage adaptation and, more broadly, that it would provide an excellent structure for other transit agencies to use. The EMS, which is structured on the Plan-Do-Check-Act (PDCA) cycle, facilitates ongoing integration of climate change risks into operations and planning. Specifically, the methodology in the EMS used to identify and prioritize environmental impacts provides a process that can be modified to address risk to assets from severe weather. Then the prioritized risks can be managed within the other component of the EMS. Improvements to harden assets to climate risks can be integrated into the process for setting improvement objectives in the EMS. Operational changes to protect assets can be identified and integrated into procedures, inspections, training and emergency planning already addressed within the EMS. The effectiveness of adaption efforts can be tracked and evaluated using the existing EMS processes and finally, management review can provide a process to keep management apprised of the progress in managing this risk.

To help insulate Metro's operations and services from extreme weather-related impacts, the case study for Metro was developed for 3 scenarios: augmenting Metro's existing EMSs, expanding Metro's EMS operations-wide, and expanding Metro's EMS to the entire agency.

Task 2 provides guidelines to develop a tool to assess climate risks to assets addressing:

- Criticality
- Vulnerability to precipitation, heat, and wind
- Rate of change

It provides a methodology for Metro, as well as guidance to other transit agencies, to assess risk to its assets over time using Indicators of Risk. Building on Metro's completed Climate Action and Adaptation Plan (CAAP), the methodology identifies assets at risk to climate change impacts over time that can effect reliability, service, maintenance, planning, and state of good repair (SGR) – when assets are functioning normally (reliably) and within their useful life.

It is necessary to consider how the impacts of climate are changing over time. The climate is in flux and the conditions that agencies experienced in the past and are experiencing today are changing.

Under Task 2, it was determined that Metro's existing materiel management system could provide a platform to evaluate and track evaluation and tracking of climate risks associated with Metro's fixed and rolling assets. Using the climate risk evaluation methodology identified in Task 1 that builds on Metro's CAAP, a pilot program was undertaken to use and test the methodology. The program was undertaken with Metro personnel who evaluated selected assets for criticality and vulnerability to precipitation, heat, and wind.

To determine the rate of change, default indicators for risk over time were used. Developing indicators for Southern California is one of the next steps recommended in this report for Metro.

The application of the methodology resulted in a prioritization of the risk to the selected assets to various climate impacts, which could be in the included in Metro's maintenance and materiel management system with minor modifications to the system.

TASK 1: INTEGRATION OF ADAPTATION PRINCIPLES INTO EMS

This section of the report focuses on Task 1: Integration of Adaptation Principles into Metro's EMS. The plan also includes relevant discussion regarding all the tasks and how they interrelate with this task, each other, and the EMS. The plan builds on Metro-specific efforts, plans, policies, and commitments related to climate change adaptation including Metro's *Climate Action and Adaption Plan* (CAAP) and describes how these will be integrated into and addressed within Metro's existing EMS to help insulate Metro's operations and services from extreme weather-related impacts. It also provides guidance through Metro's example to other transit agencies, of any size, seeking to integrate climate adaptation measures into their existing organizational structures and activities.

The plan assesses three scenarios. The first addresses the incorporation of adaptation strategies from the CAAP into the existing EMSs at Metro. The second scenario addresses the recent commitment of Metro to develop an EMS operations-wide. Utilizing the approach taken for the existing EMSs, the plan lays out how the adaptation effort for the existing EMSs can be built on, modified and expanded operations-wide. Finally, although not a commitment of Metro to implement, the plan provides a third scenario that could be used for a Metro-wide EMS that would pull in activities throughout all of Metro. This third scenario is presented for completeness and so that other transit agencies could be informed on how an agency-wide EMS that addresses adaptation might be structured.

The plan also provides a methodology for Metro and other transit agencies to assess current and future risk to its assets over time from severe weather impacts using Indicators of Risk. The methodology builds on Metro's completed CAAP and provides a methodology for other agencies to identify assets at risk to climate change impacts that can effect reliability, service, maintenance, planning, and state of good repair – when assets are functioning normally (reliably) and within their useful life.

The plan includes:

- An overview of the challenges of transit brought by climate change and the current state of practice in the transit industry
- A review of Metro's relevant sustainability, EMS and climate change efforts including the CAAP, to provide a perspective on the current situation
- A general introduction to Environmental Management Systems and the specific requirements of ISO 14001, the management system standard used by Metro
- A model for integrating adaption into an EMS
- The Metro specific integration methodology, which lays out the specific steps for Metro to modify and augment its EMS implement to incorporate the CAAP and more generally its adaptation efforts including the additional tasks under the FTA grant.
- A conclusion that addresses the capacity of Metro to implement the plan and identifies gaps

In general, it is clear that the Metro EMS is an excellent vehicle with which to embed adaptation efforts into Metro operations to proactively reduce, manage and mitigate risks associated with climate change.

ADAPTATION AND TRANSIT: THE CHALLENGE AND THE RESPONSE

Existing weather patterns are changing and in many cases more severe weather events are occurring. This is complicated by the fact that weather impacts will continue to be in transition as greenhouse gas emissions continue to increase. While it is not clear what the rate of change will be, evidence suggests that it is most likely accelerating.

In December 2012, US DOT Federal Highway Administration published Climate Change & Extreme Weather Vulnerability Assessment Framework that stated, "It is important to recognize, however, that typical historical climate conditions are unlikely to be representative of all future climate conditions. Although analysis of the past can yield useful 'analogs' for certain types of weather events and the resulting impacts, the climate is changing and some future climate impacts may go beyond the range of impacts that have occurred in the recent past. Furthermore, it is unlikely that the trends of past decades will persist unchanged into the future; especially on longer timescales (greater than 30 to 40 years) simply extending past trend lines into the future may underestimate future changes. For example, for all parts of the United States, the rates of warming for the 21st century are expected to be greater than the rate of warming between 1900 and 2000. Similarly, sea-level rise rates have increased in recent decades, and they are expected to increase still more in coming decades."[1]

As a result, transit organizations are facing challenges to assets and operations on a scale they have not previously encountered. A recent study by the Federal Transit Administration (FTA), "Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation FTA Report No. 0001," confirms and identifies the current impacts of climate change on transit assets nationally and projects out the impacts expected by the end of the century.

> The most disruptive near-term impact is likely to be intense rainfall that floods subway tunnels and low-lying facilities, bus lots, and rights-of-way. Heat waves will stress materials, buckle rails, and jeopardize customer and worker safety and comfort. In the longer term, rising sea-levels, compounded by worsening storm surges, will threaten assets in many coastal areas. Landslides, heavy snowfall, wildfires, droughts, and power blackouts also pose threats. The increased frequency of extreme events (such as heat waves and severe storms) will be more challenging to manage than gradual effects such as a steady rise in average temperatures. In addition, of low probability but high risk, there is a potential for abrupt climate change impacts, such as rapid ice sheet collapse and abrupt sea-level rise. (Flooded Bus Barns and Buckled Rails, August, 2011)

The FTA study recognizes that risks to transit vary by region and by specific characteristics and locations of the transit organization's assets. In recognition of this, many transit organizations are recognizing that their specific challenges from climate change have serious and wide impacts across their operations and are taking a proactive approach. They are assessing their risks and identifying actions to address and mitigate this risk.

Their responses are in some cases individual efforts or in other cases are occurring through the FTA Transit Climate Change Adaptation Assessment Pilots program. The FTA Transit Climate Change Adaptation Assessment Pilots program awarded grants to seven agencies across the country to conduct climate change adaptation assessments. Metro was awarded one of these Pilots grants. The FTA grant builds on on-going adaptation strategies that are identified in Metro's CAAP that are already underway; ensuring that the results of the grant will be implemented. An overview of these pilot efforts, including that of Metro, is presented on the FTA's website, http://www.fta.dot.gov/sitemap_14228.html.

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[1] http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/vulnerability_assessment_framework/page03.cfm#Toc345418504

The pilot projects are advancing the state of practice for adapting transit systems to the impacts of climate change. The effort is in keeping with broader long-term goals to address state-of-good repair needs and enhance transit safety. The projects assess the vulnerability of transit agency assets and services to climate change hazards such as heat waves and flooding. The agencies are also developing initial adaptation strategies that fit with their transit agency's structure and operations. The results of the pilots will be available at their completion and will be available on the FTA website.

Unlike other transit organizations funded by the FTA pilot, Metro has already completed its vulnerability and criticality assessment and is currently implementing the strategies outlined in its CAAP. Specifically in the area of climate adaptation, Metro has commenced its efforts using its FTA pilot to lay out the foundation to operationalizing climate adaptation strategies. Using this scenario as a backdrop, Metro has developed the following objectives for this pilot: 1) Capitalize on Metro's current climate change adaptation work and link these results to Metro's organizational structure and activities including the development of implementation tools using EMS Principles; 2) Develop a set of metrics against which adaptation strategy performance could be measured; and 3) Develop and implement an outreach plan to create and integrate climate adaptation awareness in other sectors of the region.

In addition to working with the FTA, Metro has been working with the American Public Transportation Association (APTA). As a member of APTA's Sustainability Committee, Metro has been a member of the Climate Change Working Group (CCWG) that has been providing guidance on greenhouse gas emissions and climate change. Metro is also a member of the Sustainability Metrics Group that is currently developing *Sustainability Metrics*. Metro is also a signatory of *APTA's Sustainability Commitment.* . In recent years, the CCWG developed *Recommended Practice for Quantifying Greenhouse Gas (GHG) Emissions from Transit* and *Recommended Guidelines for Climate Action Planning*. Metro has adopted these recommended practices and became a signatory of the *APTA Sustainability Commitment*. The *Sustainability Commitment* acknowledges APTA members for preserving the environment, being socially responsible and maintaining economic viability, with an overall contribution to quality of life. Signatories of the APTA *Sustainability Commitment* report on sustainability indicators/metrics that include water use, GHG emissions and savings, energy use, recycling levels/waste, operating expenses, unlinked passenger trips, and vehicle miles traveled.

CLIMATE ACTION AND ADAPTATION PLAN (CAAP) OVERVIEW

Metro's support of sustainability and climate change efforts at the national level and its own pursuit of best practices led to the development of the Metro's CAAP in June 2012. The CAAP established a framework for Metro to reduce GHG emissions and prepare for impacts of climate change. In this effort, Metro utilized APTA's *Recommended Guidelines for Climate Action Planning* that is based on best practices and a management system framework of Plan-Do-Check-Act.

The CAAP characterizes the critical services and assets, identifies the impacts of climate variability and climate change on Metro's assets and services, identifies the vulnerability of these assets and services, and provides adaptation options. Within this effort, "The adaptation study represents a high-level screen, designed to identify some of the most important Metro services and assets that are likely to be affected by climate change." (p.37)

Criticality of assets was determined by asking the question, "If this service or asset were removed from the transit system, would the transit system be fundamentally different?" The CAAP identified the following assets as critical: Bus Fleet, Bus Rapid Transit Service, Heavy Rail, Light Rail, Rail Rehabilitation, and Rail Fleet. Focusing on each passenger station, a criticality index was developed to rank each station. Criticality was dependent on ridership, connectivity, and joint development. The criticality of non-passenger facilities was based on expert opinion.

The CAAP identified the most important impacts of climate change on Metro's services and assets – periods of extreme heat and episodes of heavy precipitation. It presented a number of models that show the observed change and variability in temperature and precipitation since 1910, as well as a number of models that project increases in temperature through the end of this century. The precipitation models are not as certain and they project both drier conditions as well as heavy rainfall events through the end of this century. The CAAP shows the mean temperature and precipitation projected for 20 year periods: 2010-2039; 2040-2079; and 2080-2099. The CAAP considered projected sea level rise and the possible impact on Metro's assets. Given the location of Metro's assets, it was determined there is little risk currently to Metro assets. However, for new projects, the locations of the projected future floodplains should be taken into account as part of the planning process.

The CAAP provided a qualitative assessment of vulnerability focused on periods of extreme heat and episodes of heavy precipitation and the asset's exposure, sensitivity, and adaptive capacity. The CAAP did not assess current assets for sea level rise because current assets were deemed not vulnerable to sea level rise. The vulnerability assessment considered the exposure of the asset to the impacts, the effect on the asset and the ease of addressing adaptation for the impacted assets. The critical assets assessed for vulnerability included Bus Fleet, Bus Rapid Transit right-of-way, Heavy Rail, Light Rail, Measure R[2] construction work and planned assets.

The potential adaptation options focused on activities that Metro could consider in its efforts to increase its resilience to extreme heat and heavy precipitation. They included:

- Improved Inspection and Monitoring
- Railway Upgrades
- Stormwater Management
- Underground Station Upgrades
- Measure R Siting and Alternatives
- Worker Rules and Heat

These options are currently integrated in agency activities through other programs administered through Metro's Environmental Compliance and Services Department. This current FTA pilot effort will not only

[2] Measure R is Metro's Capital Program.

consolidate these related parallel efforts, but will consolidate under an EMS the coordinated implementation agency-wide.

METRO'S EMS EFFORTS

Metro committed in its Board adopted 2009 *Environmental Policy* to establish and use an Environmental Management System (EMS) as its primary tool in applying sustainable principles and practices in its planning, construction, operations, and procurement to protect the environment for present and future generations. The EMS provides the structure for managing all environmental issues initially for Metro at two facilities; Red Line Maintenance of Way Yard and Division 10 Bus Yard. Red Line Yard's EMS is third-party certified to meet the requirements of international standard *ISO 14001, Environmental management systems — Requirements with guidance for use* (ISO 14001 Standard). Division 10, along with other agency-wide sites, is seeking certification to the ISO 14001 Standard in 2013. The ISO 14001 Standard is considered an international best practice for EMSs and is a management system standard that focuses on compliance with environmental regulations and improved environmental performance.

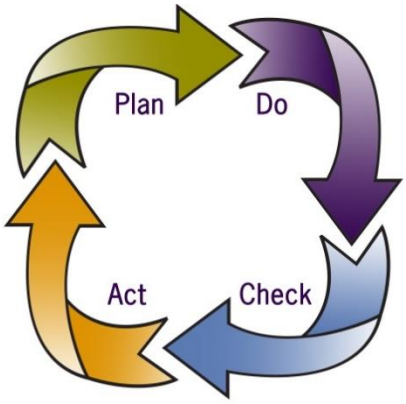
Since 2008, Metro has been working with the FTA to build its EMS. Metro was one of eight transit agencies that participated in the FTA's EMS training and assistance project to implement an ISO 14001 certified EMS. The FTA offered this training in support of President's *Executive Order 13148 Greening the Government Initiative* and *Executive Order 13274 Environmental Stewardship and Transportation Infrastructure Project Reviews,* which directed federal agencies to promote environmental stewardship in the nation's transportation system while streamlining the environmental review and development of proposed transportation projects. Integrating Adaptation into Metro's EMS builds on the efforts of the June 2012 CAAP and current EMS efforts.

OVERVIEW OF ENVIRONMENTAL MANAGEMENT SYSTEM CONCEPTS

An EMS is used by an organization to manage its environmental performance and ensure continual improvement. This makes it an ideal vehicle to address and manage related challenges that expand the understanding of the environment. Adaptation to climate change is an example of one of these issues that is well suited to management within an EMS.

An effective EMS is typically structured around a Plan-Do-Check-Act (PDCA) cycle. The PDCA cycle is critical to developing a system that can lead to continual improvement. The system engenders a continual cycle of setting relevant objectives and targets, planning and implementing to meet these targets, checking the progress, and reviewing the results in anticipation of setting new objectives and targets. An EMS is designed to encourage an organization to develop a better understanding of its existing and potential interactions with the environment, positive as well as negative, and to use this knowledge to improve performance.

An EMS provides systemized knowledge and control of environmental impacts and risks from ongoing operations. It also provides a framework to reduce these impacts on an ongoing and rational basis. The EMS can include an organization's operations as well as those of its contractors, service providers, and suppliers; to the extent that the organization exerts control or influence over these other entities. It provides the organization with the ability to identify and manage environmental interactions while providing an overarching management structure that communicates requirements and supports compliance and performance.



An EMS organizes existing environmental programs and streamlines management of them. Further, the results of these programs feed into the EMS and support such EMS functions as change management and performance reporting. The EMS interacts with existing functions including the contracting, budgeting, purchasing (including the proposal and solicitation process), and information technology (IT) processes so as to simplify both the operation of the EMS and the performance of these functions.

USING THE ISO 14001 STANDARD TO ADDRESS ADAPTATION

The international standard *ISO 14001: 2004, Environmental management systems — Requirements with guidance for use* provides a model for the contents of an EMS and is considered a best practice for environmental management systems. The system encourages the use of PDCA in the meeting of environmental responsibilities, structuring the entire system so that the elements are ordered in a PDCA cycle. The standard, which has over 250,000 users world-wide[3], is used by transit agencies internationally. Adoption in the US has been more limited, although some leaders in transit are using it. Metro is one of these transit organizations.

The standard is broken into five major sections, which incorporate 17 sub-clauses. The major sections (Policy; Planning; Implementation and Operation, Checking; and Management Review) and the sub-clauses (Environmental Policy; Environmental Aspects; Legal & Other Requirements; Objectives Targets and Programs; Resources, Roles Responsibilities & Authority; Competence, Training & Awareness; Communication; Documentation; Control of Document; Operational Control; Emergency Preparedness & Response; Monitoring & Measurement; Evaluation of Compliance; Nonconformity, Corrective Action & Preventive Action; Control of Records; Internal Audits and Management Review) are introduced below. An ISO 14001 EMS is intended to create a continual cycle of planning, implementing, reviewing and improving the actions that the organization takes to meet its environmental intentions.

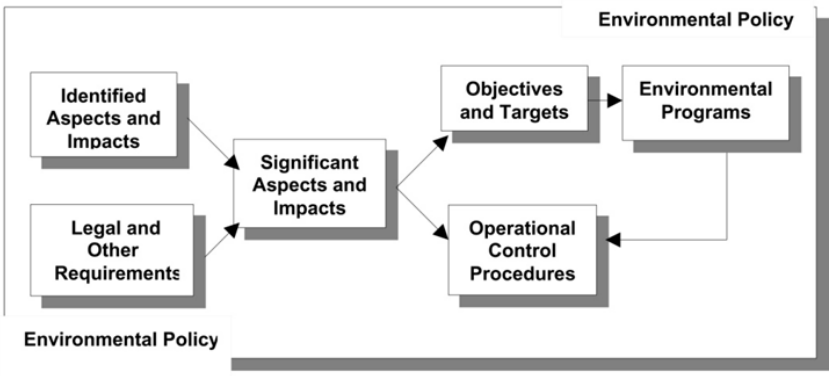
An EMS structured around the requirement of ISO 14001 can be expanded to accommodate adaptation and response to climate change as well as broader sustainability issues such as climate mitigation. The same elements that are used to manage traditional environmental performance can be augmented to manage these additional concerns. The advantage of this approach is that it includes adaptation challenges within the continual improvement cycle and integrates it into an existing structure that is already used to manage related issues – a structure with which the organization is already familiar. Metro has introduced the possibility of using the EMS principles as a climate change management tool as early as 2010 (http://www.metro.net/about_us/sustainability/images/2010/D3-Cris-Liban-Summit-Presentation.pdf) Provided below is an overview of the requirements of the sub-clauses of the Standard augmented with a discussion of how adaptation to climate change can be fit within these sub-clauses. This is followed by specific details of how Metro can do this utilizing the existing EMSs at Metro and Metro's CAAP.

General Requirements

ISO 14001 allows flexibility with regard to the operations included in an EMS. For this reason, organizations identify the scope of the specific operations included in the EMS.

Policy

Development of an EMS starts with the **Environmental Policy**. The organization defines and commits to a policy that is relevant to the nature, scale, and environmental impacts of the activities it conducts, the products it supplies, and the services that it renders. To conform to the ISO Standard, the policy, at a minimum, includes commitments to prevention of pollution, compliance with environmental laws and regulations and other requirements, and continual



[3] www.iso.org

improvement of the EMS. The environmental policy establishes an overall vision of environmental performance against which all subsequent actions can be judged; and is the foundation upon which the EMS is built. It also is made available to the public and as such is critical in communicating more broadly the environmental intent of the organization. The figure below illustrates the relationship between the policy and other elements of an ISO 14001 EMS.

An organization can include in its policy a commitment to address adaptation to climate change. This provides to the organization the understanding that adaptation is an important issue that will be addressed within the EMS.

Planning

Information and data gathered as part of the planning components feed into the rest of the EMS. For example, one of the planning efforts for the organization requires the identification of **Environmental Aspects** and any potentially significant environmental impacts associated with its activities, products or services. An environmental aspect is any element of the organization's activities, products or services that can interact with the environment. An environmental impact is any change in the environment, wholly or partially resulting from the organization's activities, products or services. Impacts can be positive or negative, as shown in Table 1 below:

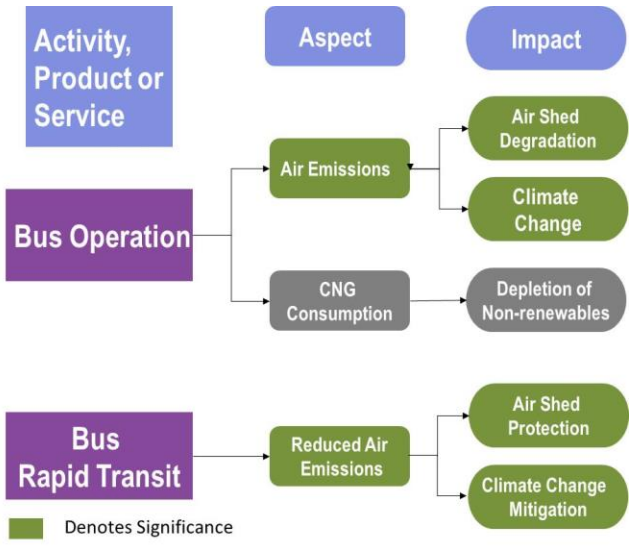
TABLE 1: ENVIRONMENTAL ASPECTS SUMMARY

Activity, Product, Service	Category	Aspect	Impact
Bus Operation	Activity	Consumption of CNG	Depletion of nonrenewable fuels
Bus Operation	Activity	Generation of Air Emissions	Degradation of the airshed
Bus Rapid Transit (BRT)	Service	Reduction in air pollution emissions[4]	Preservation of the air airshed

Although significance is not defined in the Standard, the significance of environmental impacts is determined by the organization using a methodology consistent with its environmental policy. See figure below.

Example of Determining Significant Aspects

Just as environmental aspects link environmental impacts to the activities that create them so that the activities can be addressed and managed, climate change impacts can be linked to their effects on transit assets and services and provide the basis for planning to address the management of assets so as to minimize or eliminate the climate change impacts. For example, risks to asset types from climate change impacts, such as high heat days can be evaluated against criteria established in the CAAP to determine the assets most at risk. The determination of climate risks for Metro assets is addressed more specifically in Task 2 of the FTA pilot.



Under **Legal and Other Requirements** legal requirements and other commitments to which the organization is

[4] Associated with replacement of automobiles and vans.

bound are identified and addressed within the EMS. Organizations that have made commitments that are not necessarily legally requirements are required ensure that they identify and meet those commitments or requirements also. Other requirements may include internal commitments such as perhaps a green purchasing requirement as well as external commitments such as a commitment to implement the APTA sustainability metrics. Within adaptation to climate change, an organization may identify any commitments such as those contained in a climate action plan and ensure that they are managed within the EMS.

Objectives and Targets consistent with the environmental policy are developed to address significant impacts. Programs are then developed to establish the plans and their associated schedules, resources and responsibilities so as to achieve the environmental objectives and targets. Using the risks identified to assets from climate change, objectives and targets can be used to set adaptation goals and ensure they are implemented. For example, if the risk assessment identifies that high temperatures present increasing risk to rails, an objective could be set to evaluate current rail specifications against future high heat exposure. For Metro, the CAAP can also be consulted as a source for objectives and targets. Monitoring of objectives and targets will also be addressed in Task 3 of Metro's FTA pilot.

Implementation and Operation

As part of this element in an EMS, **Resources, Roles, Responsibility and Authority** for the EMS are defined. To include adaptation in the EMS, responsibilities for addressing adaptation can be included and documented in this element.

Competency, Training and Awareness requires the identification of competency requirements and training needs and the implementation of appropriate training. To address adaption, this element can be augmented with any training required to address adaptation such as training on preparing for extreme weather events.

Procedures are implemented for **Communication**, both internally and externally, related to the environmental activities of the organization, to demonstrate management commitment, address concerns and questions, raise awareness and provide information about the organization's environmental management system and performance. Specific internal and external communication processes for communicating adaptation responses can be addressed under this element. For Metro, this would include the stakeholder outreach program included as Task 4 under the FTA pilot program.

EMS Documentation describing the elements of the EMS with pointers to related documentation is required in an EMS. This may be in the form of a manual or a set of linked procedures. Supporting documents and records are also included under documentation. **Control of Documents** ensures that documents can be located, periodically reviewed, kept current, remain legible, are dated and readily identifiable, are maintained in an orderly manner, and are retained for a specified period of time. Specific documentation and records related to adaptation can be included within the EMS documentation and the documents maintained under the document control element of the EMS.

Having identified the operations and activities at the organization that are associated with significant environmental aspects, **Operational Control** ensures the organization plans its operations and activities (including maintenance) to ensure that they are carried out under specified conditions. Documented procedures are developed where their absence could lead to deviations from the environmental policy and the objectives and targets. Specific adaptation related activities can also be addressed within this element. Using the asset risk assessment for severe weather, For example, additional equipment preparations may be required in advance of severe weather events.

Emergency Preparedness and Response procedures ensure that there will be an appropriate response to unexpected or accidental incidents. **Resources, roles, responsibilities and authorities: Emergency preparedness and response:** The organization's response to severe weather events such as flooding can be included within this element.

Checking and Corrective Action

Monitoring and Measurement requires that the EMS includes specific procedures to measure, monitor and evaluate its environmental performance and the EMS, and to ensure the reliability of equipment or systems providing the data. To address adaptation, monitoring and measurement provides an opportunity to track not only the organization's adaptation efforts, but also its experience of weather impacts related to climate change. Including weather impacts allows the organization to trend its results, evaluate costs and make adjustments in its adaptation strategy. For Metro, monitoring and measurement will include the metric identified under Task 3 of Metro's FTA pilot.

Evaluation of Compliance requires that the organization periodically evaluates compliance with relevant environmental legislation and regulations and other requirements to which the organization subscribes. This links directly to Legal and Other Requirements under Planning above. To address adaption, this element includes compliance with other external or internal commitments on addressing adaptation as identified under Legal and Other Requirements.

Critical to ensuring the continual improvement of the EMS is the **Nonconformity and Corrective Action and Preventive Action** process, which is used to investigate and mediate potential and actual non-conformances. This includes identifying and addressing the underlying causes so that non-conformances do not reoccur. The existing process for addressing nonconformities can be expanded to include any non-conformities associated with the management of adaptation.

The organization will develop procedures for the identification, maintenance and disposition of environmental and management system **Records**. Existing records controls can be expanded to adaptation related records.

The requirement to establish and maintain a program for periodic **Internal Audits** serves as a check on the entire EMS. The internal audit program can be expanded to include procedures on how Metro is integrating adaptation efforts.

Management Review

Management Review closes the continual improvement loop requiring that top management periodically review the EMS to ensure its continuing suitability, adequacy and effectiveness. Adaptation can also be included in management review. Such things as adaptation objectives, targets and programs and adaptation metrics, as well as weather related events impacts can be included.

METRO EMS ADAPTATION INTEGRATION STEPS

EMS Current Situation

Metro has two existing EMSs; one of which is fully implemented and certified to the ISO 14001 standard, and the other, which is implemented and will be certified to the ISO 14001 standard. Metro is committed to expanding EMS beyond the existing EMSs to all Operations (Bus and Rail). The existing EMSs are:

- Red Line Maintenance of Way Yard – certified to ISO 14001
- Division 10 Bus Yard – in the process of certifying to ISO 14001

An effort to expand EMS has commenced in October 2012 with the intent of certifying all of Metro operations to the ISO 14001 standard. [5]

Planning Session

An initial planning session was held with Metro on May 15-17, 2012, to define how Metro should incorporate the CAAP's recommendations as it moves toward evaluating specific options for adapting to climate change within their EMS. A second planning visit occurred on Sept 17-19. The specific focus included:

- Investigating climate vulnerabilities at a higher level of specificity in the EMS, and
- Exploring implementation climate adaptation principles at the operations level through the existing EMSs and roll out of EMS.

The planning session considered additional adaptation issues and how they could be incorporated into the EMS. These include areas that are to be addressed as additional tasks under the FTA grant:

- Addressing asset risk from climate change in M3 or other tool (Task 2).
- Exploring the monetary and social costs of climate impacts and adaptation options as part of Adaptation metrics (Task 3);
- Developing a communications strategy for the adaptation component of the CAAP and subsequent adaptation activities (Task 4); and

First Environment conducted an intensive Planning Session with Metro's Environmental Compliance and Services Department (ECSD) to review Metro's Red Line EMS and identify Metro's work to date regarding climate adaptation. First Environment worked with Metro to evaluate each element within the existing EMS against its ability to support adaptation generally and the CAAP specifically and identify necessary changes and augmentation necessary to incorporate adaptation efforts into the EMS. In addition to working with the ECSD, First Environment interviewed managers from Buses, Rail, and Quality Assurance.

Major Findings from the Planning Session included:

1. The CAAP, which is guiding efforts for the EMS adaptation module, has identified Metro's critical passenger assets and vulnerabilities using information on Ridership, Connectivity, and Joint Development. Critical Non-passenger assets are identified by relying on expert opinion. From a systems standpoint, a refinement of the components that contribute to expert opinion would add an additional level of consistency and reliability The criteria for Non-passenger assets could focus on the operational value of an asset.

[5] The existing EMSs are those EMSs that were in place at the time this study was commenced in 2012. They include the Red Line Yard and Division 10. Division 10 will be certified along with other Metro locations, such as Division 9, 21, and 11.

2. Metro is committed to expand EMS to all Operations (Rail and Bus).

3. Metro's ECSD prepared a survey and received responses from 40 operations personnel who identified impacts of and mitigation efforts for extreme weather (high temperature, precipitation, black outs/brown outs, etc.)

4. Based on experience with weather changes, operations staff is addressing adaptation issues at the operations level of the organization. While it may not be coordinated agency-wide, yet, adaptation planning is already happening at the operations level so that they can provide reliable service. Examples include Winter and Summer Prep Campaigns for Buses to minimize impact (i.e., roadcall or service delay) of extreme heat and precipitation and construction of permanent covers over waste bins where wind blows tarps off regularly.

5. The ISO 14001 EMS model (Plan-Do-Check-Act) provides structure for identifying, managing, and monitoring weather impacts/climate change in the existing EMSs and all operations.

6. The EMS includes a pre-structured avenue for communication of climate-related issues, i.e., structure for communicating sustainability and adaptation metrics internally and externally.

7. The EMS could be a vehicle that integrates extreme weather related Emergency Response plans that are increasingly focused on extreme weather issues (this is subject to debate and need to be confirmed with Homeland Security Department).

8. State of Good Repair/Useful life of all equipment and facilities is affected by climate change such as increases in:

    a. Heavy Rain
    b. Wind
    c. Dust storms
    d. Debris
    e. Rising ocean levels

9. Metro employs a Maintenance and Materiel Management System, M3, which has the potential to be modified to allow the assets to be assessed for climate risk.

The results of the planning session were then used to inform the remainder of this report. Provided below is the action plan to incorporate adaptation into the current EMSs. A discussion is also provided to explain how adaptation can be integrated into the operations-wide EMS which Metro is initiating. In addition, since the plan is intended to also provide a guide to other transit organizations, a third scenario has been added to demonstrate how adaptation could be incorporated in an EMS that is enterprise-wide. While adaptation is currently being addressed through other non-EMS related ESCD efforts, it was thought beneficial to provide a demonstration of how they could be incorporated into an EMS as well. This would bring in such activities as Planning, Transit Project Delivery (Construction) and Administration that are not included within the currently planned EMSs.

Incorporating Adaptation into the Metro EMS

Metro plans to incorporate and manage adaptation strategies outlined in the CAAP within its EMS. Currently, this means that EMS efforts at Metro will have to be integrated into the two existing EMSs within Operations, the Red Line Maintenance Yard and Division 10. In the near future, the expansion of the EMS into other Metro facilities will require the similar inclusion of the adaptation strategies. The Environmental Compliance and Services Department (ECSD) that has been leading these efforts will continue to do so as adaptation is integrated into the existing EMSs, and as the EMS is rolled out operations-wide.

The plan for inclusion of adaptation within the EMS identifies specific modifications, additions and revisions to Metro's EMS to incorporate adaptation at the existing EMS facilities and at the operations level and at the agency level. Modifications and revisions are organized around each element in ISO 14001, which is consistent with the structure of Metro's EMS.

General Requirements

Scope

The scope of the EMS is a general requirement of ISO 14001. The existing facilities each have a defined scope of what operations are included in the management system.

The current scopes for the existing EMSs include:

- Redline Yard (Trains) for electric train and vehicle maintenance operations. This includes fueling, cleaning, rail car overhaul/repair, non-revenue vehicle overhaul/repair, systems overhaul/repair (compressor facility, rail communications, wayside signals, and wayside traction power), system material storage, and contracted pesticide and weed control.
- Bus Maintenance Division 10 (Yard and Facilities) for bus and vehicle transportation and maintenance operations. This includes bus operations, maintenance, washing and fueling, as well as vehicle parking.

Existing EMS:
Although the EMS will be augmented to include adaptation, the scope of operations included remains the same so no revisions are required to address adaptation.

Operations:
A scope for operations will need to be expanded from the existing EMSs to include the additional operations. However, no specific adjustments need to be made to address adaptation.

Metro-wide:
For a metro-wide system, it would be necessary to expand the scope to include activities involved in Planning, Transit Project Delivery, and Administration. This inclusion would ensure adaptation needs are identified during the planning and construction phases of new projects.

Environmental Policy

Metro maintains an ambitious agency -wide environmental policy. The policy recognizes Metro's commitment to efficiently providing public transit services that improve the quality of life and the environment in the communities it serves. It also includes a commitment to sustainable practices, renewable energy and outreach. The policy has been approved by the Board of Directors.

Existing EMS:
The current environmental policy for the existing EMSs adopts the agency-wide policy and adds specific ISO 14001 commitments to a preamble applicable to them. Responsibility for the development of the policy lies with an EMS Core Team, consisting of representatives from operations, document control staff, and the EMS Administrator at the facility. The Core Team has other critical responsibilities within the existing EMSs.

To incorporate adaptation into the existing EMS, the preamble in the policies will be further augmented with a commitment that addresses adaptation. Using the suggested or similar language, the EMSs will amend the preamble to commit to reducing the risk of weather related impacts to Transit assets and operations to ensure efficient and reliable service and protect the environment. Including an adaptation commitment in the EMS facility policies is not a requirement, but it is an initial way to communicate to all personnel that adaptation is an important concern at Metro and part of the EMS.

Operations:
The approach of augmenting the corporate policy with a specific preamble that includes the commitments made in the EMS policies can be continued for all of operations. Taking this approach would mean that the existing policy commitments in the EMS preamble and the corporate environmental policy would be applied un-changed to all of operations.

Metro-wide:
In a Metro-wide EMS, it would make sense to consider revising the agency-wide policy to include the additional commitments made in the EMS and operations level policy preambles. In an enterprise-wide EMS a single policy provides a consistent approach and it would eliminate the need to augment the corporate policy with a preamble.

Planning

Environmental Aspects

To address the ISO 14001 requirements, the EMSs have already established, implemented, and currently maintain procedures and spreadsheets to identify the environmental aspects of the activities, products and services at the EMS facilities. This includes determining those aspects that have or can have significant impact(s) on the environment (i.e., significant environmental aspects). The EMS Core Team is responsible for the identification and determination of significant impacts.

Metro will similarly assess the risk to its assets from the effects of extreme weather events and use this assessment to plan for and manage adaptation, Using a methodology similar to that used for identifying environmental aspects and impacts, the methodology will involve identifying both the vulnerability of the assets to climate change impacts and criticality of the assets. The methodology includes a time component that incorporates the predicted increases in risks in the future. This methodology can provide guidance to any agency: whether or not they have an EMS. Details of the methodology can be found in Appendix A. Task 2 illustrates the use of the methodology. Provided below is an overview of the risk assessment methodology and its relationship to the Environmental Aspects process currently within the Metro EMS.

TABLE 2: EXAMPLE OF ASSESSING CLIMATE RISK TO ASSETS

Process	Identify	Link to	Define	Apply	Determine
EMS aspects and impacts evaluation	Activities, products, and services	Environmental Aspects associated with activities, products and services	Environmental Impacts associated with environmental aspects	Evaluation criteria to determine significant aspects and impacts	Significant Aspects and Impacts
Parallel Asset Assessment for Climate Risk	Assets	Potential regional weather related impacts	Weather risks to assets	Evaluation criteria to determine significant weather related risks	Assets at significant risk to weather related Impacts

Existing EMSs:
The existing EMSs will transition and augment the information in the CAAP on risk from climate change.. Metro will add an Extreme Weather Risk Assessment for each type of weather impact associated with climate change to assess the risk to the EMS facility assets from severe weather. Most likely the risk assessment will be documented in Metro's Maintenance and Materiel Management System, M3. Task 2 of this report demonstrates how this can be accomplished as a case study.

To support the completion of the Extreme Weather Risk Assessment, Metro will develop a procedure and guidance similar to the aspect procedures and guidance to document its process. This will be maintained in the Aspects section of the EMS Manual.

Operations:
For the expansion of the EMS to all of operations, the process and documentation to assess risk used at the EMSs will be expanded to all operations and maintenance assets. Severe weather impacts assessed will include high heat days, extreme precipitation events including flooding and mud slides, and high winds including wildfires.

Criticality: For those assets that have already been scored in the CAAP, the scoring will be reviewed, prior to use by the EMS Aspect Team. For those assets that were not evaluated in the CAAP, Metro will use the methodology described for Division 10 above to evaluate the criticality.

Vulnerability: Metro will use the same approach and methodology laid out for the facilities with EMSs.

Rate of change: The values calculated for the existing EMSs will be used to evaluate rate of change.

Metro will develop an operations-wide procedure based on the EMSs' procedure to document the process to identify risk to assets from climate change and based on the EMS procedures. The worksheet to evaluate risk will be a standard operations-wide form, but the evaluation of risk will be performed on a facility-by-facility basis by the EMS Aspect Team. This provides a uniform approach and allows for facility-specific information to be assessed.

Metro-wide:
If Metro decides to implement an EMS Metro-wide, the approach to climate adaptation would require some additional focus on Planning, the Highway Program, and Transit Project Delivery as identified in the CAAP. A planning checklist for adaptation concerns can be developed and reviewed as part of the planning process. This would ensure climate risks are integrated into the planning process and the resulting output. For capital projects, the planning process could be used to develop the initial risk categorization for the risk spreadsheet. Once the capital project becomes operational, the spreadsheet would then be turned over to operations, who would maintain and update it as part of the operations EMS.

In addition, construction activities are also identified in the CAAP as having severe weather risks that should be addressed. The risks from severe weather impacts need to be assessed on a task-by-task basis within each project. Metro's contract documents, specifically in the Design Criteria, require consideration of climate impacts and are reviewed during the design and construction process. Since construction is generally performed by an external organization, the contracting process can identify the need for a severe weather risk reduction plan which would then be the responsibility of the contractor to develop and implement. The EMS would then be used to manage the communication between Metro and the contractor on this issue.

Procedures that address the process for including adaptation issues in Planning and Construction would need to be developed and added to the EMS.

Legal and Other Requirements

Within the existing EMSs, Metro has established, implemented and currently maintains an EMS procedure that describes the process by which they identify and have access to the applicable legal requirements and other requirements to which it subscribes as related to its environmental aspects. The responsibility for identifying these lies with the Environmental Compliance and Services Department.

Currently, there are no legal requirements with regard to adaptation. However there are Metro Board policies and plans, such as the CAAP and external commitments made by Metro such as the APTA sustainability metrics that potentially relate to adaptation and are considered other requirements as defined by ISO 14001. These are provided in Table 3 below.

TABLE 3: OTHER REQUIREMENTS POTENTIALLY RELATED TO ADAPTATION	APPLIES TO:		
	Existing EMSs	Operations	Metro-wide
CAAP	X	X	X
Renewable Energy Policy, 2011	X	X	X
Green Construction Policy, 2011	X	X	X
Environmental Liabilities Assessment and Reporting, 2009	X	X	X
Water Use and Conservation, 2009	X	X	X
Energy and Sustainability, 2008	X	X	X
Construction Demolition Debris Recycling and Reuse Policy, 2007	X		X
Alternative Fuel Initiative, 1993	X	X	X
Air Pollution Episodes Policy, 1989, 2006	X	X	X
Signatory - APTA Sustainability Metrics Commitment	X	X	X
Recommended Practice for GHG Inventories (APTA)	X	X	X
2008 Metro Sustainability Implementation Plan	X	X	X

Existing EMSs:
The relevant Metro policies and plans and external commitments will be added to the list of other requirements for the facility EMSs. ECSD will identify the specific requirements within the policies, plans and commitments that apply to the EMSs.

The existing procedure addressing legal and other requirements will be used. The purpose in the procedure will be augmented to include the identification of all legal & other requirements associated with severe weather risks. Additional revisions to the procedure will be made to include severe weather risks with environmental aspects, so that both are addressed.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide.

Objectives, Targets and Program(s):
Within the existing EMSs, Metro has established, implemented, and maintained documented environmental objectives and targets, at relevant functions and levels within the organization. This is documented in an EMS procedure. To address adaptation, the existing process will be leveraged to include the consideration of objectives and target to address reduction or elimination of significant risks to assets from severe weather events.

Existing EMSs:
The existing EMSs will augment the existing Objectives and Targets Procedure to include evaluating assets at significant risk from severe weather impacts when setting objectives and targets. The EMS Core Team will then set objectives and targets and develop programs to reduce or eliminate the risk

using the existing templates in the EMS just as they currently do in the EMS. Examples of how this is done are provided below.

Example 1, Evaluating buses at risk from high heat for an objective and target: As a significant risk, it would be appropriate for the maintenance facility to set an objective and target to address this risk. In fact, the bus maintenance facility has already informally set an objective and target and developed a program to address vulnerability of buses to high heat days, having recognized the impact high heat days were having on the buses. They implement an early spring inspection and maintenance program and perform additional inspections on high heat days to proactively address the severe weather impacts.

Example 2, Evaluating the dumpster at risk from high winds for an objective and target: If the EMS Aspect Team determines that the dumpsters fall into the category of an asset at significant risk from high winds, they could set an objective and target to reduce or eliminate the risk. They could evaluate alternatives to the current situation such as different types of covers, relocating the dumpsters or constructing a permanent cover. From this, Metro can include the proposed remedy in the budget, using the assessment of risk as justification.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
If an EMS is set at the metro-wide level, a slightly different approach to the setting of objectives and targets can be undertaken that provides a more strategic approach to adaptation and environmental improvements. The existing process for developing metro-wide policies would serve as the base. The groups, divisions and departments would then identify what they would be required to do to support the policies and implement that. This would not preclude the setting of objectives and targets and development of programs at lower levels to address specific risks, but it is an effective methodology to align leadership's intent with performance.

Implementation and Operation

Resources, Roles, Responsibility and Authority

At the EMS facilities, Metro management ensures the availability of resources essential to establish, implement, maintain and improve the EMS. This includes a procedure that assigns responsibilities, EMS Roles and Responsibilities Matrix that identifies specific positions and responsibilities in the EMS and an organizational chart that identifies the reporting structure within Metro relevant to the existing EMS facilities.

Existing EMSs:
The roles and responsibilities to address climate change risks will rely on the existing procedure and matrix. The procedure's purpose will be augmented to include adaptation to severe weather events. The Emergency and Homeland Security Preparedness Manager, who is responsible for planning for and responding to severe weather events will be added to the matrix. The EMS Core Team will be identified as responsible for assessing severe weather risks and determining adaption objectives and targets. The matrix establishing existing roles in the EMS will be reviewed to ensure that any responsibilities specific to adaptation to climate change are identified.

Operations:
The documentation for the existing EMSs will be used by all of Operations.

Metro-wide:
The documentation for the existing EMSs can be used Metro-wide.

Competence, Training and Awareness

The existing EMS Competence, Training and Awareness Procedure provides that employees receive:

- General EMS Awareness - basic EMS training including New Employee Orientation;
- Job -Specific EMS Training - Significant Aspects & Operational Control (Work Instructions);
- Emergency and Regulatory-Required Training - Responders or personnel who can potentially be exposed to an emergency situation within the Red Line Yard

In addition, contractors /suppliers/vendors working at EMS facilities receive EMS Training.

Training is identified on the Annual Training Plan and tracked in the Training and Development (T&D) Database. Competency of employees to perform EMS related tasks are evaluated and determined by their Supervisor.

Existing EMSs:
To address severe climate impacts the EMS facilities, the existing procedure will be relied on. The EMS awareness training will be augmented with information regarding:

- the addition to the policy regarding adaptation
- the significant climate risks identified for the EMS facility
- objectives and targets related to adaptation

The job specific EMS training will be reviewed and revised to address specific risks associated with the job and any required efforts to mitigate the impacts of severe weather events. The emergency training will be revised in consultation with the Emergency and Homeland Security Preparedness Manager to address responses to severe weather event emergencies. Likewise the contractor training (brochure) will be reviewed and revised to ensure climate challenges are addressed. The method for scheduling and tracking training will be unchanged. As within the existing EMS, competency regarding mitigation and response to weather related events will be determined by the Supervisor.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs will be expanded Metro-wide.

Communication

With regard to its environmental aspects and environmental management system, Metro has established, implemented and maintained a Procedure for Communication that includes:

a. internal communication among the various levels and functions of the organization, and

b. receiving, documenting and responding to relevant communication from external interested parties.

The procedure relies on the existing communication lines of authority and communication methodologies employed by Metro. For external communication this involves the Communication Department as well as the EMS facilities and ESCD. Under Task 4 in the FTA pilot, the Communication Department will be overseeing communication efforts to internal and external stakeholders on adaptation. Since the Communication Department is not included in the existing EMS or the Operations-wide EMS, communication would be handled as communication from an external party and if

requirements were included would be handled as another requirement under legal and other requirements.

Existing EMSs:
The EMSs will rely on the existing processes for communication within the EMS. The communication procedure's purpose will be revised to include adaptation to severe weather. ECSD will work with the Communication Department on adaptation messaging.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide. In addition Metro may wish to implement external communication to publicize its adaptation efforts.

Documentation

At the existing EMS facilities, Metro uses a procedure to establish practices related to the documentation of the core elements of the EMS. This procedure describes the interaction of the environmental documents and the flow of information between various types and levels of EMS documentation. This section of the EMS also includes definitions.

Existing EMSs:
The documentation procedure will not require revision and will be used as is. Climate risks and other related terminology will be included in the Definitions.

Operations:
The procedure and definitions will be used for operations.

Metro-wide:
The procedures and definitions can be used Metro-wide.

Control of Documents

The existing EMSs have a procedure, Control of Documents, within the EMS which describes the requirements for controlling documents. They also maintain a matrix that lists the documents within the EMS, which includes information on the current version, responsibility for control of the document and review schedule.

Existing EMSs:
The existing EMSs will use the current procedure to control climate related documentation. Documents will be added to the Document Matrix.

Operations:
The procedure and matrix used for the existing EMSs will be expanded to all of Operations. The procedure will be a single operations-wide procedure. Document Matrices will be set up at various levels depending on the responsibility for the documents. Climate adaptation documentation will be added to the Matrixes.

Metro-wide:
The approach and procedure used for operations could be expanded Metro-wide.

Operational Control

The existing EMSs use an EMS Procedure, Operational Control, to address the development of work instructions to address EMS requirements. A list of work instructions developed under the procedure is also maintained as is a procedure that addresses control of contractors.

Existing EMSs:
The methodology for development of work instructions described in the operational control procedure will be used by the existing EMSs to address adaptation to climate change. The existing EMSs will review the significant extreme weather impacts and the assets with which they are associated. Appropriate controls to minimize the impacts will be identified and these will be added to existing work instructions. Where it is identified that new work instructions are required to control these impacts, they will be developed as defined under the operational control procedure. New procedures will be added to the list of work instructions. Any required training will be included in the Job -Specific EMS Training. Additional requirements identified for Contractors can be addressed by the current Contractor Management Procedure.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide.

Emergency Preparedness and Response

The existing EMSs have established an EMS Procedure for Emergency Preparedness and Response. The procedure references the existing Metro-wide emergency response plan, *System-Wide Hazardous Materials Emergency Response Plan* and ensures that the existing EMSs are prepared to implement it and that appropriate follow up to incidents or drills occur. The existing EMSs also maintain a list of possible incidents with appropriate follow-up summarized on it. Currently severe weather events are the responsibility of Emergency and Homeland Security Preparedness Manager and are not addressed in the EMS.

Existing EMSs:
The existing EMSs will utilize the existing procedure for emergency preparedness and response to address severe weather emergencies at the EMS facilities. The responsibilities for weather related emergencies, which lies with the Emergency and Homeland Security Preparedness Manager, will be added as will reference to any relevant plans. The existing EMSs will use the processes in the existing procedure to ensure they are prepared to respond to severe weather events and that appropriate follow-up occurs.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide. In addition Metro may wish to implement external communication to publicize its adaptation efforts.

Checking

Monitoring and Measurement

The existing EMSs have established an EMS Procedure, Monitoring and Measurement, to monitor and measure on a regular basis the key characteristics of its operations that can have a significant environmental impact. The procedure includes the documenting of information to monitor performance, applicable operational controls and conformity with the organization's environmental objectives and targets. It also addressed the use of calibrated or verified monitoring and measurement equipment.

Monitoring and measurement is evaluated annually on the evaluation form. The CAAP includes strategies to address adaptation that involve monitoring and measurement.

As part of the FTA Transit Climate Change Adaptation Pilot Study, Metro will be defining appropriate metrics for adaptation (Task 3).

Existing EMSs:
The existing EMSs will modify their procedure on monitoring and measurement to include the collection and monitoring of any adaptation metrics adopted by Metro that are appropriate to their operations including any in the CAAP deemed relevant and those identified under Task 3 of the FTA pilot. M3 will be explored for its capability to ensure the necessary monitoring occurs and will also be referenced in the procedure. Relevant metrics will also be added to the Monitoring and Measurement Evaluation Form and be included in the annual review. If the monitoring involves any monitoring equipment, it will be added to the monitoring and measurement calibration log and will be maintained and calibrated or verified, as necessary.

Adaptation related objectives targets and programs set by the existing EMSs will be monitored as defined in the procedure and be documented on the monitoring and measurement of objectives and targets form.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide.

Evaluation of Compliance

Consistent with Metro's commitment to compliance, the existing EMSs have established an EMS Procedure for periodically evaluating compliance with applicable legal and other requirements. Metro keeps records of the results of these periodic evaluations on self-audit forms.

Existing EMSs:
Adaptation is not a subject of legal requirements at this time. However, other requirements such as the commitment to the APTA Sustainability Metrics Commitment will be assessed as part of the evaluation. As Adaptation falls under Other Requirements, we recommend Evaluation of Compliance for Adaptation commitments to Internal Audit procedure. The adaptation commitments that will be subject to the evaluation of compliance are those listed as part of as Other Requirements under 4.3.2 Legal and Other Requirements. Self-audit forms will be developed for other requirements

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide.

Nonconformity, Corrective Action and Preventive Action

The existing EMSs have established, implemented and maintain an EMS Procedure that addresses Nonconformity, Corrective Action and Preventive Action. The procedure addresses dealing with actual and potential nonconformity(ies) and for taking corrective action and preventive action.

Existing EMSs:
No change to the procedure is required. Any nonconformances associated with adaptation will be addressed within the existing procedure.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide.

Control of Records

The Existing EMSs have established an EMS Procedure, Control of Records, for the identification, storage, protection, retrieval, retention and disposal of records. The procedure is consistent with the Metro Corporate Records Management Policy. Records related to the EMS and their requirements are listed on the records matrix.

Existing EMSs:
The existing EMSs will use existing records procedures. The records associated with adaptation will be added to the records matrix. Examples include records of risk analysis; adaptation objectives, targets, and programs; and adaptation monitoring and measurement.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide. In addition Metro would include records of external communication and outreach to publicize its adaptation efforts, project records regarding adaptation, and construction records involving adaptation.

Internal Audit

The existing EMSs have established an EMS Procedure, Internal Audit, to ensure that internal audits of the EMS are conducted at planned intervals to determine whether the EMS conforms to planned arrangements for environmental management including the requirements of ISO 14001, has been properly implemented, and is maintained. Results are provided to management. The audits are scheduled and an audit checklist is used by the audit team who have received auditor training.

Existing EMSs:
The existing procedure will be used and adaptation as addressed within the EMS will be audited to ensure that adaptation efforts have been implemented as part of the EMS internal audit. The Auditor Training will be evaluated to determine if additional training on adaptation should be developed and implemented. The EMS Audit Checklist will be augmented to include an assessment of adaptation policy commitments; the climate risk analysis for assets; adaptation objectives targets and program; adaptation related training, communication, and work instructions, adaptation monitoring and measurement and any other adaptation-related audit questions.

Operations:
The approach used for the existing EMSs will be expanded to include all Operations.

Metro-wide:
The approach used for the existing EMSs could be expanded Metro-wide.

Management Review

The existing EMSs have established an EMS Procedure, Management Review to review the performance of the EMS yearly. Senior Management are invited to attend Management Review meetings.

Input to management reviews include:

a. results of internal audits and evaluations of compliance with legal requirements and with other requirements to which Metro subscribes,

b. communication(s) from external interested parties, including complaints,

c. the environmental performance of the organization,

d. the extent to which objectives and targets have been met,

e. status of corrective and preventive actions,

f. follow-up actions from previous management reviews,

g. changing circumstances, including developments in legal and other requirements related to its environmental aspects, and

h. recommendations for improvement.

The outputs from management reviews include decisions and actions related to possible changes to environmental policy, objectives, targets and other elements of the environmental management system, consistent with the commitment to continual improvement.

Existing EMSs:
The existing EMSs will use the existing management review procedure and include in management review adaptation performance, the extent to which objectives and targets address adaptation are achieved, changing circumstances related to adaptation, and recommendations for improvement that include adaptation.

Operations:
Adaptation will be included in management review as it is at the existing EMSs. However, the expansion of the system will require consideration of staged levels of management review such as management review at the facilities level which are then rolled up for senior Management into a single management review.

Metro-wide:
The approach used for the operations could be expanded Metro-wide.

CONCLUSION

As demonstrated by the plan detailed above, Metro, with its existing and planned expansion to its EMS, is well situated to address adaptation to climate change using a consistent and structured approach. The EMS provides the structure to take the CAAP from a plan to identifiable actions for implementation. The underlying assumption of a management system is that a system built with the proper structure, resources and processes will result in improved performance. This is as applicable whether the intent is achieving compliance and improved environmental performance or managing adaptation. The EMS provides a platform that will support Metro's ambitions to reduce risk to its assets from climate change and will provide an example to the transit industry of best practices. The use of the EMS to manage climate change is also consistent with supporting the state of good repair of assets as it provides a methodology to proactively address climate changes that affects the conditions necessary to ensure state of good repair.

Structure and Resources

The use of the EMS to manage and address climate risk also provides efficient use of resources. The EMS is already established as shown by the plan, and for the most part the existing structure; resources and personnel can be relied upon to expand the system to include adaptation. The initial effort will require additional effort and augmentation of existing resources – just as additional resources were required to develop the EMS. The additional effort required to address adaptation; however, will be far less than that required for the EMS. Once adaptation is rolled into the EMS, the effort and resources to maintain it will only marginally exceed that already required for the EMS.

Cultural Compatibility

For the existing EMSs, the integration of management of adaptation to climate change into the EMS should pose minimal disruption. The existing EMSs are already familiar with management system principles and as indicated by the interviews have informally recognized that they are already responding to changing weather challenges. Integrating climate change into the new operations-wide EMS should present no additional challenges than those associated with the development of the EMS. Nevertheless, Metro has the existing EMS experience that it can draw on. In particular the use of the core team is a best practice and assists in driving support for the management system through the organization.

Challenges and Limits

While most of the integration of adaptation to climate change into the EMS uses existing EMS processes, the assessment of climate change risks to assets will require a new parallel process to determine significant aspects. The CAAP partially addresses the inputs to this process, and additional information needs to be developed to augment the CAAP. These include:

- Identification and assessment of local impacts from climate change – this can be derived from existing regional and local studies
- A breakdown of assets into appropriate groups to assess vulnerability to climate change. This will be addressed as part of Task 2
- Development of a consistent criteria for assessing criticality for non-passenger related assets
- Development and application of a risk algorithm to assess overall risk to climate change to assets
- Integration of the risk algorithm into M3
- Documentation of the process for the EMS

NEXT STEPS

Integrating adaptation into Metro's existing EMS and operations-wide EMS requires Metro to work through the elements as described in this plan. The next steps that are particular to Metro are identified in Appendix B: Action Plan to Incorporate Climate Adaptation into Metro's EMS. In addition, Metro started a methodology to assess assets in the CAAP, which is Metro's first step at assessing the vulnerability of its passenger stations. The augmentation required to assess Non-passenger assets and rolling stock is identified in the Aspects section of this plan.

TASK 2: GUIDELINES TO DEVELOP TOOL TO ASSESS CLIMATE RISKS TO ASSETS

Metro's Environmental Management System's (EMS) Adaptation Plan provides a methodology for Metro, as well as guidance to other transit agencies, to assess risk to its assets over time using Indicators of Risk. The methodology builds on Metro's completed Climate Action and Adaptation Plan (CAAP) and provides a methodology to identify assets at risk to climate change impacts over time that can effect reliability, service, maintenance, planning, and state of good repair (SGR) – when assets are functioning normally (reliably) and within their useful life. Identifying the assets at risk and incorporating adaptation strategies requires development of a tool or modification of an existing software application to evaluate and track climate risks associated with Metro's fixed and rolling assets.

This report provides guidelines to develop a tool for Metro, along with transit agencies more generally, to address asset risk from climate change. The report provides a working example by applying Metro's Maintenance and Materiel Management System (M3) – a product used by Metro and other transit agencies across the country that include MTA New York City Transit, Dallas Area Rapid Transit, and Utah Transit Authority among others. Building on the EMS Adaptation Plan that addresses activities, products, and services, these guidelines provide a tool and methodology to identify the criticality and vulnerability of fixed and rolling assets so that Metro can take appropriate measures to reduce vulnerability to extreme weather. This report demonstrates how any agency can systematically review its assets in their entirety so that it can prioritize the criticality of its at-risk assets over time – and ultimately identify viable strategies to consider when developing capital and operating budget actions to avoid current and future risks and impacts.

As the FTA stated in Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation, "Climate change adaptation is essentially responsible risk management. It involves planning for system preservation and safe operation under current and projected conditions, recognizing that **hazard mitigation** costs less than the damage from inaction. Adapting to climate change impacts will require interdisciplinary efforts among engineers, planners, frontline maintenance and operation staff, strategic planners, emergency response experts, and others. It is a long-term effort that will require not so much doing entirely different things, but doing some of the same things in a different way."

The FTA study also identifies factors for success. These include outside efforts such as those at the federal and state level to champion the effort and the embedding of climate impacts into existing work streams. This issue affects all parts of the organization and has the potential to affect the state of good repair of any asset if not properly managed. It also says climate change risk assessment has a high degree of uncertainty and is in flux. As the global climate is currently changing as the temperature of sea is rising; it is necessary to continually revisit the effects of climate impacts, the criticality of assets and the agency's preparedness.

Following the FTA report, the FHWA re-emphasized that the climate is in flux. FHWA's Climate Change & Extreme Weather Vulnerability Assessment Framework that was published in December 2012 stated, "[T]ypical historical climate conditions are unlikely to be representative of all future climate conditions." It is possible to use historical data to analyze weather events and resulting impacts; however the climate is changing and future impacts may "go beyond the range of impacts that have occurred in the recent past." In other words, we can no longer rely on historical information but must consider how the climate is changing and the impact it will have on assets.[6] Thus, it is necessary to consider the rate of change by examining Indicators of Risk, and screen for assets at risk within the near and long term.

6 http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/vulnerability_assessment_framework/page03.cfm#Toc345418504

ASSET MANAGEMENT

To address asset risk from climate change, an agency can build off any system that identifies the agency's assets by class and location. The system may be a simple customized spreadsheet or database, or an accepted system that is used nationally or internationally. Examples of systems that are widely used throughout the transit industry that are in various stages of development include:

- FTA TERM Lite
- ISO 55000 – Asset Management Standard
- Commercial-off-the-shelf tools such as the Maintenance and Materiel Management System (M3) – public transit Enterprise Asset Management software that is used by Metro

FTA TERM Lite

In 2011, the FTA presented the Transit Economic Requirements Model (TERM) Lite - an analysis tool provided to help transit agencies assess assets by their:

- State of Good Repair (SGR) Backlog by total dollar value and asset type
- Level of annual investment to attain SGR or other investment objective
- Impact of variations in funding on future asset conditions and reinvestment needs
- Investment priorities - by mode and asset type

According to the FTA's TERM Lite User's Guide[7]:

> TERM Lite is a PC-based computer application that was designed to estimate an agency's transit capital investment needs over an extended time horizon. The model estimates the total amount of annual capital expenditures required over a twenty-year period to maintain or improve the physical condition and performance of the agency's transit infrastructure. These annual expenditure estimates are provided for each of two major capital investment categories — (1) asset rehabilitation and replacement, and (2) performance improvements — and are further subdivided by transit mode, asset type (e.g., vehicles, stations, structures, etc.) and urbanized area characteristics. The model output also includes estimates of the physical condition of the agency's transit asset base — both for the current year and for a 20-year forecast period. Asset condition forecasts are directly impacted by the asset condition replacement policies applied by the user.
>
> TERM Lite's design allows the user to control a wide range of model input parameters (e.g., asset replacement and rehabilitation assumptions, and financial assumptions) to facilitate the analysis of a wide range of investment scenarios.

Ultimately, TERM Lite provides a tool for transit agencies to monitor and manage SGR of their assets and support their long-term capital plans. Ultimately, TERM Lite helps a transit agency monitor its current SGR backlog and asset conditions, as well as manage its SGR backlog and identify what level of investment is required to attain SGR in 10 and 20 years. For the long term capital plan, it helps an agency prioritize using multi-criteria prioritization, rank its projects, and develop a long-term SGR plan.

ISO 55000 Asset Management

The ISO 55000 Asset Management Standard is an emerging standard expected to be released in 2014 (source: Woodward). ISO, the International Organization for Standardization, is an international standards setting body that is composed of national standards organizations throughout the world that convene to

[7] http://www.fta.dot.gov/documents/TERM-Lite_Quick_Start_Guide_(v1.8)_508_compliant2b.pdf

establish and promote best practices. ISO 55000 is based on Publicly Available Standards (PAS 55), the British Standards Institution's requirements for the optimal management of assets. It is aligned with other management systems – including ISO 14001, ISO 9001, OSHAS 18001, and ISO 31000 Risk Management. ISO 55000 standards include:

- 55000: provides overview concepts and terminology in asset management
- 55001: specifies requirements for good asset management practices the "Asset Management System" – not a specification for an asset information management system
- 55002: provides interpretation and implementation guidance for an Asset Management System

Metro's M3 – Maintenance and Materiel Management System

Metro's M3, is a commercial-off-the-shelf (COTS) fully integrated, public transit Enterprise Asset Management software suite. It is designed to integrate with commonly used transit systems such as fuel and fluids management, automated vehicle location (AVL), human resources, finance and procurement. The technical design is multi-tier client/server that allows access from all Metro locations to a central data system. Its reporting capabilities track Metro's key performance indicators, and the system includes a search engine for ease of use, searching and printing reports.

M3 supports asset management, inventory and warehouse management, as well as bus, rail and facilities maintenance. It is integrated with Metro's purchasing and financial systems to create a seamless environment and eliminate duplication of data. The system utilizes and resides on computer hardware accessible at all Metro locations.

Historically, the M3 contract developed the system requirements for M3 as a singular, integrated, system that would meet the comprehensive needs of the MTA's operations function. Metro eventually expanded the project scope beyond solely bus maintenance to incorporate - rail maintenance, facilities maintenance, as well as asset, inventory, warranty, fuel and fluid management. Metro is currently planning the next generation of M3 that is expected to be completed within the next 3 years.

METRO CASE STUDY

Metro's case study shows how Metro and any transit agency can address asset risk from climate change by identifying the criticality and vulnerability of assets over time, using Metro's EMS Adaptation plan and Metro's M3 as a template. Building on Metro's ISO 14001-certified EMS and Adaptation Plan at the Red Line Yard (RLY), First Environment developed a methodology to screen for the assets at risk. In particular the methodology provides a tool for a transit agency to:

1. Identify assets
2. Screen assets for criticality
3. Screen assets for vulnerability to precipitation, heat, and wind
4. Screen for Indicator of Risk Over Time – Rate of Change
5. Assess the Risk on the asset

1. Identification of Assets

M3 is a database of all Metro's assets and provides a database of assets within its ISO 14001 certified facility in the Red Line Yard (RLY). They are broken down by vehicles, equipment, and buildings by location. Metro's M3 readily provides a listing of all of Metro's assets by class and location.

To identify the assets specific to the RLY Metro prepared a report of all assets associated with the. Assets include vehicles, equipment, and buildings RLY (see snapshot of RLY equipment list below). From that, First

Environment worked with its local subcontractor Beacon Management Group and operations staff at RLY to identify those assets, which were actually assigned to RLY and within the scope of the RLY EMS. Only assets within the RLY scope were considered. The report from this meeting is in Appendix C: Asset Identification Meeting Report and summarized below.

First Environment worked with Beacon Management and the RLY operations staff to verify physically that the assets listed in Metro's M3 were currently located at the RLY. It is necessary to note that while equipment may be assigned to the RLY, the equipment may not be actually located there from day to day. Equipment that is not at the RLY is not within the scope of Metro's RLY EMS. For example, non-revenue passenger vehicles may be assigned to RLY for administrative purposes within M3; however, these vehicles are not actually located at the RLY on a regular basis.

Red Line Yard Equipment

Equipment	Equipment Code	Equip Class	Equip Type	Current Facility
Air Compressor	070820	SHOP EQ (ELEC-MECH)	AIR COMPRESSOR	20
Projector	155140	OFFICE EQUIPMENT	PROJECTOR	20
Diagnostic Analyzer	156084	DIAGNOSTIC	ANALYZER	20
Portable Steamer	156744	SHOP EQUIPMENT	PORTABLE	20
Generator	156945	SHOP EQ (ELEC-MECH)	GENERATOR	20
Computer Switch	158492	COMPUTER	SWITCH	20
Diagnostic Analyzer	173001	DIAGNOSTIC	ANALYZER	20
Laptop Computer	177611	COMPUTER	LAPTOP	20
Railbound Equipment	19-0006	NON REV RAILBOUND EQUIPMENT	Railbound Equipment	20
Centrifugal Pump	197855	PUMP	CENTRIFUGAL PUMP	20
Diagnostic Meter	197952	DIAGNOSTIC	METER	20
Shop Eq	203014	SHOP EQ (ELEC-MECH)	MACHINE	20
Lift	203019	LIFT	LIFT	20
Rail Organization Equipment	203022	Rail Organization Equipment	Rail Org Equip	20
SHOP EQ (ELEC-MECH)	203185	SHOP EQ (ELEC-MECH)	MACHINE	20
Monitor	203679	COMPUTER	MONITOR	20
Jib Crane	203681	SHOP EQ (MECHANICAL)	JIB CRANE	20
Server	203682	COMPUTER	SERVER	20
Property Equipment	203673	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203680	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203691	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203692	PROPERTY EQUIPMENT	PROPERTY	20
Property Equipment	203706	PROPERTY EQUIPMENT	PROPERTY	20

RLY Assets: Partial snapshot of M3 Report

For the purpose of testing the methodology, First Environment and Beacon identified 12 classes of assets within the RLY to screen for criticality and vulnerability that represented the operations of RLY in different locations throughout the yard. The sample assets focused primarily on stationary assets at the RLY. Rolling stock included truck assemblies that are on rail cars. The assets include:

- Stormwater collection system
- Outdoor waste accumulation area
- Underground car hoist
- Truck assembly – on train
- Truck assembly – spare
- Wheel Truing Machine
- Bridge Crane
- Portable Steamer
- Power Substation
- Third Rail
- Trainway Feeder
- Signals

2. Screening of Assets for Criticality

The next step is to screen assets for criticality. In relationship to the asset assessment, criticality is defined as something that is essential to operations without service disruption. Essentially, the question is, "*If this service or asset were removed from the transit system, would the transit system be fundamentally different*?" A critical service or asset would be extremely difficult or costly to replace or to substitute. As the EMS Adaptation Plan draws from Metro's CAAP, this definition of criticality is consistent with Metro's CAAP.

As a group, the RLY EMS Core Team assessed each asset for criticality based on the following criteria: most critical, somewhat critical, and not critical.

Infrastructure such as the third rail and a power substation are necessary to provide service; and without them, there is no rail service. If they were removed from the transit system, the system would be fundamentally different. An example of critical rolling stock is the truck assembly on the subway cars. Without the truck, the train does not move; and hence no train service.

A somewhat critical asset example is the signal in the train yard. Service can be provided without a signal. They can be replaced by human flaggers. Another example is the wheel truer. The wheel truing machine sharpens the steel wheels that are placed on trucks. A train can still run with flat wheels, although it is not desirable; and the spare wheels may be adequate in the event the wheel truing machine is not available for a short period of time.

A portable steamer is an example of an asset that is not critical for operations. The steamer assists with maintenance on the trucks; however, service does not depend on it. Furthermore, it is relatively easy to replace.

To test this methodology, First Environment prepared Beacon Management to work with Metro's RLY EMS Core Team. Beacon met with the EMS Core Team and presented a sample of assets that would represent all levels of criticality. At this meeting Beacon and the EMS Core Team also assessed the assets for vulnerability. The results of the meeting are summarized in Appendix D: EMS Asset Assessment Process Memo.

3. Screening of Assets for Vulnerability

As a group, the EMS Core Team assessed each asset for vulnerability, which is defined by the level of exposure an asset has to extreme weather impacts. Metro's extreme weather impacts identified in the EMS Adaptation plan are heavy precipitation, high heat, and wind. They were scored as: most vulnerable; somewhat vulnerable; and not vulnerable.

This assessment is also qualitative and is consistent with Metro's CAAP. The vulnerability of a service or asset is a function of its exposure, sensitivity, and adaptive capacity with respect to a particular impact of climate variability or change. Each of these three concepts from the CAAP is described below, focusing on examples of periods of extreme heat and episodes of heavy precipitation:

- **Exposure:** Is the service or asset exposed or protected from extreme heat or heavy precipitation? (e.g., assets located underground are not as exposed to high temperatures as assets located aboveground)
- **Sensitivity:** If exposed, does extreme heat or heavy rain cause damage or negatively affect the service or asset? Are there thresholds at which impacts occur? (e.g., air conditioning units start to break down and cause damage around 100°F; rail buckling can begin around 110°F)
- **Adaptive Capacity:** Which assets are most easily replaced? Which can be moved or changed to reduce exposure or sensitivity? (e.g., subway trucks are mobile and can be moved in response to or anticipation of flooding)

Table 4 presents the results of the Core Team's preliminary assessment for assets and their criticality and vulnerability to each weather impact.

TABLE 4: PRELIMINARY ASSESSMENT RESULTS

Asset	Criticality	Vulnerability		
		Extreme Heat	Heavy Precipitation	Wind
1. Stormwater collection system	3	1	3	1
2. Outdoor waste accumulation area	2	1	2	3
3. Underground car hoist	2	1	1	1
4. Truck assembly- on train	3	1	1	1
5. Truck assembly- off of train (spare)	3	1	1	1
6. Wheel truer	2	1	2	1
7. Bridge crane	1	1	1	1
8. Portable steamer	1	1	1	1
9. Power Substation	3	2	2	2
10. Third Rail	3	1	2	1
11. Trainway Feeder	2	2	2	2
12. Signals	2	3	2	1

Scoring Guide:

Criticality (essential to operations without service disruption)
3. Critical
2. Somewhat critical
1. Not critical

Vulnerability (exposure to climate conditions)
3. Vulnerable
2. Somewhat vulnerable
1. Not vulnerable

4. Screening for Rate of Change in Severity of Weather Impacts

The impact of extreme weather on the assets is changing over time and it is no longer possible to rely on institutional knowledge and history at transit agencies to plan for and address climate change. As indicated in Metro's CAAP and Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation, weather patterns are shifting and the models in the CAAP show average rates of increase in high heat days and extreme precipitation for a periods 25 years from now until the end of the century. Climate change also affects wind patterns. Current models of climate change indicate high winds associated with the Santa Ana phenomenon are expected to decrease and shift in seasonality toward drier periods, resulting in greater dust. Wind and other regional and local impacts associated in climate change also need to be researched for inclusion as an impact.

While there are no short-term (5-30 year climate) models readily available to show the average changes over planning periods for Metro's extreme weather events, it is necessary to develop Indicators of Risk to plan for both short-term operations and long-term capital improvements. Without them, it is not possible to identify costs and develop specific resilience strategies by asset class and/or individually; and identify the time frames when action is necessary.

First Environment recommends developing Indicators of Risk that quantify, on average, the increase in extreme weather events that will affect Metro over the next twenty years and beyond as shown in the Aspects section of the EMS Adaptation Plan. The time periods are:

0 – 5 Years

5 – 10 Years

10 – 20 Years

20 – 50 Years

These time periods are provided to support shorter term operations needs and longer term capital planning requirements. It is necessary for operations personnel to understand the impact of weather on their operations for 0 – 5 years as they plan and allocate staff and materiel on an annual basis and project budgets for 5 years. It is necessary to examine the mid and long term time periods for trends and identify when risks will change so that the transit agency can prepare accordingly. This allows for capital planners to revisit their capital plans and provides insight to the potential impact on the operations budget. Furthermore, it provides capital planners a mechanism to assess their assets in advance for impacts on SGR.

Indicators of Risk identify the scale of the risk associated with these impacts during the planning horizons. They include Days Over 90 Degrees Fahrenheit (Extreme Heat), Heavy Precipitation, and Wind.

Using the Indicators of Risk, Metro can perform a Rate of Change assessment that takes into account the various impact scenarios from regional climate models.

An example of using Indicators of Risk is available from New Jersey Transit (NJ TRANSIT) – the largest statewide transit agency in the country. NJ TRANSIT prepared a report, "Resilience of NJ TRANSIT Assets to Climate Impacts" to determine the potential risks of weather related events on its stationary assets. As there were no short-term (5-20 year climate) models available to predict NJ TRANSIT's extreme weather events, they developed Indicators of Risk that quantify, on average, the increase in extreme weather events that will affect NJ TRANSIT over the next twenty years and beyond. These Indicators identify the scale of the risk associated with these impacts. For NJ TRANSIT in the northeast section of the country, they include Days Over 90 Degrees Fahrenheit, Sea Level Rise, and Storm/Flood Frequency. Below is the Days Over 90 Indicator.

NJ TRANSIT Days Over 90 Indicator

Days over 90 degrees Fahrenheit are problematic for NJ TRANSIT. To demonstrate the magnitude of increased heat events and increased frequency for NJ TRANSIT, First Environment used annual projection data from the Union of Concerned Scientists, in partnership with ATMOS Research and Consulting and Texas Tech University. First Environment took the annual projection data and prepared an average number of days over 90 degrees Fahrenheit for each planning horizon and emission scenario that was based on the IPCC emissions scenarios. The data was trended to supply a percentage increase for each horizon timeframe. A table was also formulated with each data point, fitted with a polynomial trend line and coefficient of determination calculation.

NJ TRANSIT DAYS OVER 90 INDICATOR

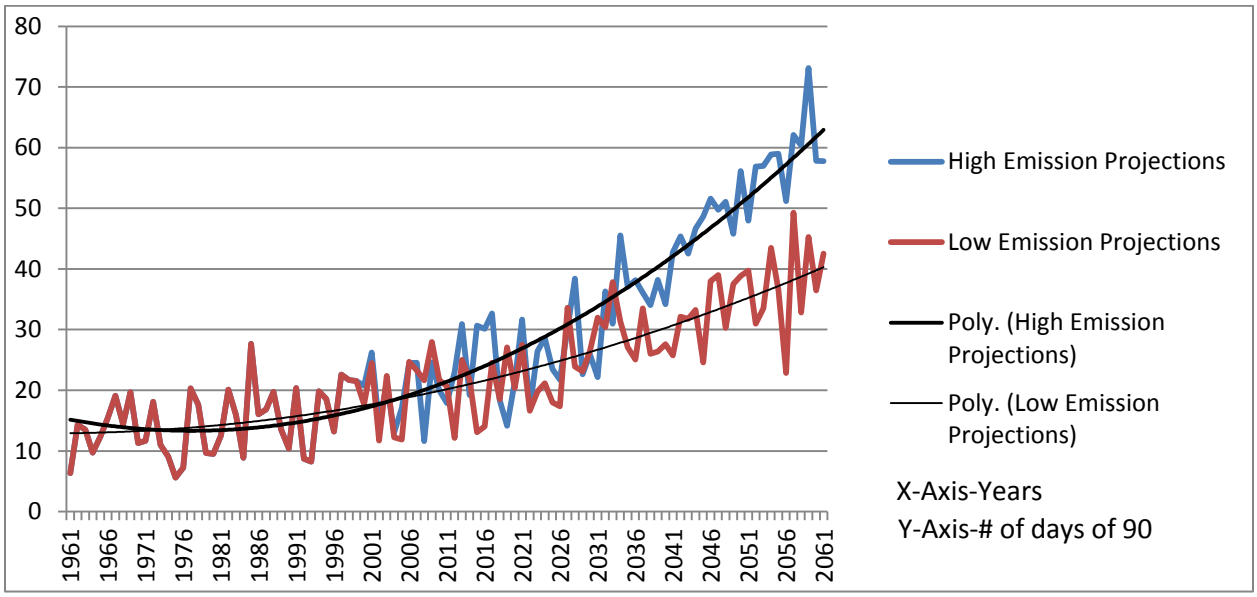


TABLE 5: NJ TRANSIT DAYS OVER 90 INDICATOR SUMMARY

Years	Baseline Ave.	Increase in Days over 90 – Trend High Emissions	Increase in Days over 90 - Trend Low Emissions	% Change Trend – High Emissions	% Change Trend Low Emissions
1980-1999	16.3				
2012-2016		26	22	57%	37%
2017- 2021		28	24	74%	45%
2022- 2031		33	26	100%	58%
2032- 2061		47	32	187%	95%

Since these values were not available for Metro, default factors were assigned for each climate impact as follows:

Rate of Change

3= significant

2 = somewhat significant

1 = not significant

For illustrative purposes, First Environment provided sample Rates of Change for each asset and weather impact: extreme heat, heavy precipitation, and wind (provided in Appendix E: Metro EMS Asset Assessment). There are models in the CAAP for long-term change such as 2010-2039 and 2040-2079; however they do not quantify, by average, the increase in extreme weather events that will affect Metro within the operational planning horizons. Table 6 provides an **example** for extreme heat.

TABLE 6: HEAT ASSET ANALYSIS						
Sample Assets	Criticality	Vulnerability	Rate of Change (Illustrative)			
			Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	1	*1*	*1*	*1*	*2*
2. Outdoor waste accumulation area	2	1	*1*	*1*	*1*	*2*
3. Underground car hoist	2	1	*1*	*1*	*1*	*2*
4. Truck assembly- on train	3	1	*1*	*1*	*1*	*2*
5. Truck assembly- off of train (spare)	3	1	*1*	*1*	*1*	*2*
6. Wheel truer	2	1	*1*	*1*	*1*	*2*
7. Bridge crane	1	1	*1*	*1*	*1*	*2*
8. Portable steamer	1	1	*1*	*1*	*1*	*2*
9. Power Substation	3	2	*1*	*1*	*1*	*2*
10. Third Rail	3	1	*1*	*1*	*1*	*2*
11. Trainway Feeder	2	2	*1*	*1*	*1*	*2*
12. Signals	2	3	*1*	*1*	*1*	*2*

While the actual models have not been developed, yet, this illustrative assessment shows that there is not an impact on the assets in the short term or medium term. The impact is scored as not significant, 1, for the 0 – 5 year, 5 – 10 year, and 10 - 20 year periods. However, there is a somewhat significant impact in 20 – 50 years; and the impact is scored as 2. The Indicator of Risk is the same for each asset, but can differ for time periods. .

5. Assess Assets at Risk

Using this methodology, Metro or any transit agency can identify its specific critical assets and take appropriate measures to reduce its vulnerability to extreme weather as it changes over time. The risk associated with each asset and weather impact is determined by multiplying the criticality by the vulnerability by the rate of change for each weather impact (criticality x vulnerability x rate of change = asset risk level). The assets with the highest scores are at immediate risk to climate change impacts that can effect reliability, service, maintenance, planning, and state of good repair (SGR) – when assets are functioning normally (reliably) and within their useful life. The risk will then be managed though adaptation actions just as significant aspects and their associated activities are managed within the EMS.

The purpose for determining the risk to climate change impacts is to provide a methodology to prioritize Metro's assets and rank them. The weighting is based on a combination of Metro's professional knowledge and climate models. The purpose of this exercise is not to apply a formula to establish exact risk, rather it is to aid in prioritization so that adaptation measures can be addressed.

To demonstrate the tool, asset risk level tables were created for extreme heat, heavy precipitation, and wind for the Red Line Yard. Table 7 on page 41 shows the asset risk level for wind. The Outdoor Waste Accumulation Area and the Power Substation have high scores. They are currently being affected by wind. They require attention in the near future. Meanwhile, the Portable Steamer is not at risk, nor is it critical or vulnerable to the impact of the wind.

Table 8 on page 42 provides a comparison among weather impacts for each asset; furthermore, the table demonstrates how assets may be at risk to some weather impacts and not to others. For comparison purposes, all assets with Risk scores greater than 10 were highlighted as assets requiring attention. The high score with Stormwater Collection System for precipitation would indicate that it is currently at risk during rain storms; meanwhile wind and heat do not have an effect on the system that would require immediate

attention. This tool provides transit managers a way to manage their assets and plan for the future reasonably.

Once identified as requiring attention, Metro Operations personnel may utilize the information to make informed decisions on how to protect and preserve assets from weather impacts. For example, one appropriate course of action would be to establish that the Outdoor Waste Accumulation Area may require construction of a permanent cover. Actions may include planning, construction and inspection of the cover. A procedure for the inspection may be required and its creation and implementation can be tracked using the EMS Adaptation module.

The tool helps Metro identify the assets that are at immediate, short-term, and long-term risk. Once identified, it is possible to take appropriate measures to protect its assets and reduce its vulnerability to climate change.

TABLE 7: WIND ASSET ANALYSIS

Sample Assets	Criticality	Vulnerability	Rate of Change (Illustrative)				Wind Risk (Illustrative)			
			Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
2. Outdoor waste accumulation area	2	3	*2*	*2*	*3*	*3*	*12*	*12*	*18*	*18*
3. Underground car hoist	2	1	*2*	*2*	*3*	*3*	*4*	*4*	*6*	*6*
4. Truck assembly- on train	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
5. Truck assembly- off of train (spare)	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
6. Wheel truer	2	1	*2*	*2*	*3*	*3*	*4*	*4*	*6*	*6*
7. Bridge crane	1	1	*2*	*2*	*3*	*3*	*2*	*2*	*3*	*3*
8. Portable steamer	1	1	*2*	*2*	*3*	*3*	*2*	*2*	*3*	*3*
9. Power Substation	3	2	*2*	*2*	*3*	*3*	*12*	*12*	*18*	*18*
10. Third Rail	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
11. Trainway Feeder	2	2	*2*	*2*	*3*	*3*	*8*	*8*	*12*	*12*
12. Signals	2	1	*2*	*2*	*3*	*3*	*4*	*4*	*6*	*6*

Asset Risk Level for wind as identified by Metro to test the methodology

TABLE 8: ASSET RISK SUMMARY

Sample Assets	Heat Risk (Illustrative)				Precip Risk (Illustrative)				Wind Risk (Illustrative)			
	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0 - 5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	3	3	6	18	18	18	27	6	6	9	9
2. Outdoor waste accumulation area	2	2	2	4	8	8	8	12	12	12	18	18
3. Underground car hoist	2	2	2	4	4	4	4	6	4	4	6	6
4. Truck assembly- on train	3	3	3	6	6	6	6	9	6	6	9	9
5. Truck assembly- off of train (spare)	3	3	3	6	6	6	6	9	6	6	9	9
6. Wheel truer	2	2	2	4	8	8	8	12	4	4	6	6
7. Bridge crane	1	1	1	2	2	2	2	3	2	2	3	3
8. Portable steamer	1	1	1	2	2	2	2	3	2	2	3	3
9. Power Substation	6	6	6	12	12	12	12	18	12	12	18	18
10. Third Rail	3	3	3	6	12	12	12	18	6	6	9	9
11. Trainway Feeder	4	4	4	8	8	8	8	12	8	8	12	12
12. Signals	6	6	6	12	8	8	8	12	4	4	6	6

CONCLUSION

In conclusion, Metro and transit agencies throughout the country have already been experiencing and will continue to experience weather related impacts due to climate change. They can expect more frequent service disruptions and must consider how the weather is affecting SGR for its assets. The next immediate step for Metro is to prioritize its critical and vulnerable assets operations-wide; and determine which resilience strategies it wants to implement for all its infrastructure and rolling stock. This report provides a methodology to prioritize its assets; however, Metro has to identify its Indicators of Risk for 5, 10, and 20 – 50 year time frames for the region using regional climate models, so that it understands its vulnerability to extreme weather over time. Once the Indicators of Risk are identified for Metro or any transit agency, it is possible to identify costs and develop specific resilience strategies by asset class and/or individually; and identify the time frames when action is necessary.

In addition to identifying the Indicators of Risk, mapping of Metro's assets would provide another tool to determine immediate vulnerability. Mapping allows an agency to group its assets by class so that larger scale campaigns can be developed to address climate impacts. It also provides a necessary tool for construction planning.

An maintenance and materiel management system, such as Metro's M3 can house Metro's risk assessment. It could also be used more generally within the EMS to track progress on objectives and targets and corrective and preventive action which are tracked in paper, for example. Tables can be set up within the database; and task orders related to adaptation can be issued and tracked.

Finally, once Metro identifies the risks to its assets and the timeframes, Metro can identify resilience strategies for non-passenger assets and the costs associated with implementing them. This allows Metro and any transit agency to integrate adaptation of its assets into planning and operations and to move from reactive to proactive management of assets affected by climate change.

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GLOSSARY

Term	Definition
Certification:	Used to verify the conformance of an organization's management systems to a standard or other requirement. Also sometimes referred to as registration. (http://www.anab.org/resources/glossary.aspx).
Continual improvement:	Ongoing effort to improve processes and performance.
Element:	A component of an EMS.
Environmental aspect:	Characteristics of an organization's activities or products or services that can interact with the environment.
Environmental impact:	Any change, positive or negative, to the environment.
Environmental management system (EMS):	A framework for organizations to structure their management of environmental responsibilities and impacts.
Environmental performance:	Measurable results of an organization's impacts on the environment.
Environmental risk:	The chance that a negative impact to the environment will occur.
Executive order:	Policy directives issued by the President of the United States which do not require legislative action.
ISO 14001 international standard environmental management systems (requirements with guidance for use):	An international standard that establish requirements for environmental management systems.
Plan-Do-Check-Act (PDCA) cycle:	A four step model for implementing change. The ongoing repletion of the four steps leads to continual improvement.
Significant aspect:	Aspect that has a meaningful impact on the environment whether positive or negative.
Sustainability:	Using resources and impacting the environment to fulfill social and economic needs in a way that allows their continued use now and in the future.

APPENDIX A:
Extreme Weather Risk Assessment

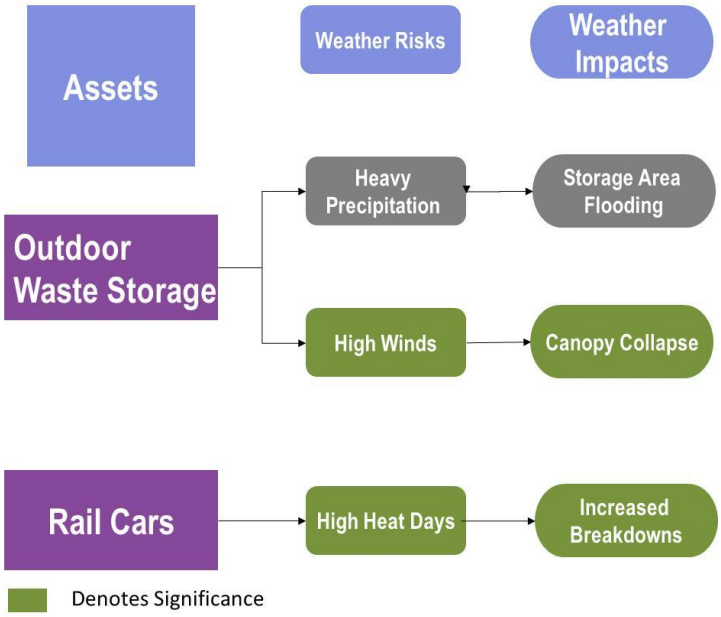
APPENDIX A:
EXTREME WEATHER RISK ASSESSMENT

Metro's existing EMSs will transition and augment the information in the CAAP on risk from climate change into its EMSs. Metro will add an Extreme Weather Risk Assessment for each type of weather impact associated with climate change to assess the risk to the facility's assets from severe weather.

Weather impacts assessed will include high heat days, extreme precipitation (flooding) events, and high winds. The approach will mimic their current Evaluation of Aspect and Impact Matrix used in the EMS to assess aspects. As with the aspects and impacts, the EMS Aspect Team will assess the risk. They will use the information already captured in the CAAP and develop additional information to augment that in the CAAP as input to the spreadsheet to score their asset in the yards with regard to the criteria of:

- Rate of change in severity of weather impacts
- Criticality of the asset
- Vulnerability of the asset to a specific climate change impacts

It should be noted that the assets scored will include the assets for which they are responsible for maintaining; not just the permanent assets at the facility.



Rate of change: Using the data from the models in the CAAP, average rates of increase in high heat days and extreme precipitation events will be calculated. Climate change also affects wind patterns. Current models of climate change indicate high winds associated with the Santa Ana phenomenon are expected to decrease and shift in seasonality toward drier periods, resulting in greater dust. Wind and other regional and local impacts associated in climate change will also be researched for inclusion as an impact.

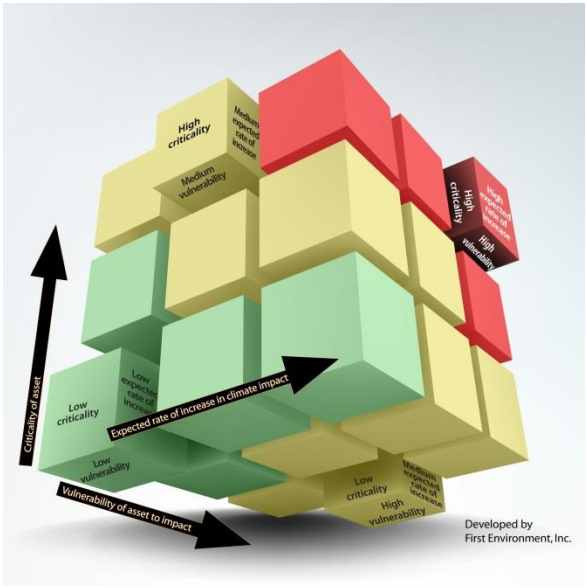
Criticality: As the Red Line Maintenance Yard has no current ridership (in the future there will be a station northwest of the facility), connectivity, or joint development projects associated with it, the CAAP identifies the Red Line Yard as a critical non-passenger asset based on expert opinion. This evaluation will be reviewed by the Red Line EMS Aspect Team prior to use in the spreadsheet. The Division 10 Yard was not evaluated in the CAAP. The Division 10 vulnerability will also be assessed by the EMS Aspect Team using expert opinion and considering such issues as the number of buses serviced, the ability to shift functions elsewhere, the role the facility plays in emergency responses, and the value of the stationary equipment and buses assigned to the facility. The facility score will be considered the criticality score for the assets within it, unless the EMS aspect team identifies and justifies an alternative scoring for specific assets.

Vulnerability: For both EMSs, Metro will implement the methodology in the CAAP to assess vulnerability of assets within the facilities. The methodology, which considers exposure of the asset to the weather impact, sensitivity of the asset to the weather impact, and the existing adaptive capacity of the asset to the impact, will also be based on expert opinion and will be performed by the EMS Aspect Team who performs the same function in evaluating aspects and impacts. They will review the activities identified for the facility existing aspect assessment, identify the related assets and assess the assets for sensitivities to climate change impacts. The methodology takes advantage of Metro's experience and knowledge of their operations.

The EMS Aspect Team in consultation with the ESCD will determine the assets that are at significant risk based on the scoring in the Extreme Weather Risk Assessment. The risks to these assets will then be managed within the EMS. The following are provided as examples of how the information in the CAAP can be brought into the EMS management.

Example 1, Evaluating buses for risk from high heat days: The number of high heat days is projected to increase with climate change. The bus fleet is a critical asset as defined in the CAAP due to the ridership. Buses are identified as assets vulnerable to high heat days in the CAAP, as they are prone to increased equipment failure and breakdowns during high heat events. While individual buses can be replaced when this occurs, it does not promote a positive experience to Metro passengers, therefore, there is limited inherent adaptive capacity with buses. These characteristics would put buses into the category of being at significant risk from high heat days as the impact is increasing and the assets are both critical and vulnerable. The EMS Aspect Team would then further break down the bus asset to identify those components such as air conditioning that are most prone to failure on high heat days.

Example 2, Evaluating dumpsters for risk from high wind events: High wind events in Southern California are projected to decrease due to climate change. However, the waste storage facilities are located outside with canvas covers which break loose and create a hazard during high wind events. While the rail maintenance yard where they are located was not evaluated for criticality in the CAAP, the EMS Aspect Team will evaluate it for criticality using the established Metro criteria. The assets within it would be assessed for vulnerability to high winds and the dumpsters would be identified as assets vulnerable to high winds. The determination as to whether the dumpsters were at significant risk from severe weather events would depend on the scoring on the Extreme Weather Risk Assessment Worksheet.



APPENDIX B:
Action Plan to Incorporate Climate Adaptation into Metro's EMS

APPENDIX B:

ACTION PLAN TO INCORPORATE CLIMATE ADAPTATION INTO METRO'S EMS

Task 1: Integration of Adaptation Principles into Metro's EMS includes relevant discussion regarding all the tasks and how they interrelate with each other and Metro's EMS. Integrating adaptation into Metro's existing facility EMSs and operations-wide EMS requires Metro to work through the elements as described in this plan. Metro's next steps are identified and outlined below for each EMS Element. They build on the Metro's current EMS and Metro's CAAP, which is Metro's first step at assessing the vulnerability of its passenger stations. The augmentation required to assess Non-passenger assets and rolling stock is identified in the Aspects section of this plan.

- Policy
  - Adopt a commitment that addresses Adaptation in the environmental policies in front of the restatement of the agency policy to address continual improvement

- Environmental Aspects
  - Adopt parallel process to aspects and impacts to identify risks to assets from climate change
  - Integrate climate risk assessment into EMS procedure to:
    - Determine significant risks to assets using CAAP
    - Drill down by asset class
    - Use EMS Aspect Team to assess risk
    - Develop procedure and guidance similar to aspects procedure and guidance for determining risk
  - Expand climate risk assessment to include high winds
  - Identify regional climate models and prepare Indicators of Risk
  - Include rate of change of impacts as part of the risk assessment criteria
  - Expand criticality criteria

- Legal and Other Requirements
  - Expand listings in Legal and Other Requirements to include requirements from CAAP and APTA Sustainability Commitment

- Objectives, Targets, and Programs
  - Revise Objectives, Targets and Programs procedure to include that the EMS Aspect Team will consider significant climate risks in setting objectives and targets
  - Review significant risks identified
  - Set objectives and targets and define action plans based on significant risks

- Resources, Roles, Responsibility and Authority
  - Revise Resources, Roles, Responsibility and Authority procedure to indicate that it addresses adaptation as well as environmental performance.
  - Add Homeland Security Preparedness Manager to the matrix as responsible for planning and responding to severe weather related events and emergencies
  - Add severe weather risk assessment responsibility to the EMS Aspects team

- Competence, Training, and Awareness
  - Revise awareness training to include revisions to the EMS
  - Include emergency training for severe weather events
  - Review work-related competency training for any revisions to job specific tasks revised under operational control

- Communication
  - Revise Communication procedure to address communication within the EMS, thereby incorporating the adaptation effort and any future additions to the EMS. Rewrite the procedure refer to itself so that when changes are made in the future, the communication procedure is already suited to address these changes.

- Documentation
  - Add new definitions to the EMS Documentation

- Document Control
  - Add any new documents to Document Control. Documents such as risk scoring worksheet.

- Operational Control
  - According to the methodology for development of work instructions described in the operational control procedure, identify appropriate controls to minimize significant extreme weather impacts and add to existing work instructions.
  - Identify and develop new work instructions that are required to control extreme weather impacts; they will be developed as defined under the operational control procedure.
  - Add new procedures to the list of work instructions, and add any required training to the job-specific EMS Training.

- Emergency Preparedness and Response
  - Use the existing procedure for emergency preparedness and response to address severe weather emergencies at the existing EMS facilities.
  - Add the responsibilities for weather related emergencies, which lies with the Emergency and Homeland Security Preparedness Manager.
  - Add reference to any relevant plans for weather related emergencies
  - Include any relevant weather related plans in the annual emergency plan review and in drills

- Monitoring and Measurement
  - Modify procedure on monitoring and measurement to include the collection and monitoring of any adaptation and mitigation metrics adopted by Metro
  - Explore using M3 to ensure the necessary monitoring occurs.
  - Add Metrics from the Metro FTA Climate Change Adaptation Pilot Study and the APTA Commitment on Sustainability to the Annual Monitoring and Measurement Evaluation Form
  - If the monitoring involves any monitoring equipment, add it to the monitoring and measurement calibration log
  - Add adaptation related objectives targets and programs and to the monitoring and measurement of objectives and targets form.

- Evaluation of Compliance
  - Revise the procedure to include the evaluation of other requirements

- Internal Audits
  - Use the existing procedure and include adaptation efforts in the internal audit leaving the audit schedule in place
  - Evaluate Auditor Training and consider adding additional training on adaptation

APPENDIX C:
Asset Identification Meeting Report

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MEMORANDUM

DATE: March 25, 2013

TO: Barbara Thomson, Betsy Delaney

FROM: Brandon Shamim

SUBJECT: Asset Inventory Report

A site visit was completed on February 14 with Fred Khan, Metro Maintenance Manager, Rail Fleet Services for the Metro Blue Line Maintenance Yard and oversees the Red Line Rail Yard located at 320 S. Santa Fe Avenue in Los Angeles.

Our observations are based on the discussion with Fred and comments shared with his 30 years of experience in the rail transportation industry. Formerly, Mr. Khan worked for the Hong Kong Rail Authority where he said they experienced more exposure to climate conditions such as monsoon rains.

Mr. Khan did mention that often in the morning when the maintenance crews arrive the temperature is close to 30 degrees and by the afternoon it can reach 80 degrees. This 50 degree along with the rainy season is predominant during December through February.

The wheels on the rail trains can cause wheels to slide and subsequently for the train to malfunction. Daily maintenance is required to turn the wheels.

Here is a snapshot of the various inventory sheets and notes:

Equipment Inventory

- Equipment coded with Facility Code 20 is Red Line Main Yard
- Equipment coded with Facility Code 61B is Maintenance of Way at the Red Line Yard- it is located at 284 S. Santa Fe Avenue which is on the Red Line campus but not on the main facility

Items to Potentially Review

Upon reviewing the inventory, we discovered that several of the parts in question in the equipment inventory are in use on the train or are permanently attached to the facility.

- Gear Box & Traction Motor= Truck Assembly- If the item is found in the Revenue Equipment section of the list, the majority of them are on the train car, there are a few spare parts which are kept according to the failure rate that is permissible

Figure 1

Figure 2

Figure3

- Portable Car Hoist- which are located up to 20 feet below ground level in the facility get flooded during rain
- Portable Steamer- Equipment Code-156744-285597- are used to clean train

Items to Exclude

- Air Compressor, Dust Collector- Facility Code 11, 30- found in Blue Line Yard in Long Beach or in Central Maintenance Facility
- Bill Validator which is revenue equipment shared with Metrolink- Facility Code 100
- Sump pumps, centrifigual pumps- attached to facility

Vehicle Equipment

Items to Exclude

Non-Revenue Passenger, Mini-van, Forklift, Pickup, Large Truck, Diesel, Full-size vans,

Items to Potentially Review

- Heavy Rail Vehicles- Revenue cars
- Bridge Crane

Figure 4

Buildings

Item to Potentially Review

- Division 20 Maintenance Building

Items to Exclude

- Most of the items are the rail facility maintenance which is not at the Red Line Yard

Miscellaneous

- Non-essential items to review

APPENDIX D:
EMS Asset Assessment Process Memo

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MEMORANDUM

DATE: March 7, 2013

TO: Barbara Thomson, Betsy Delaney

FROM: Brandon Shamim

SUBJECT: EMS Asset Assessment Process

Beacon Management Group, working in concert with First Environment, participated in a Core Team Meeting for EMS on February 26 at the Red Line Rail Yard located at 320 S. Santa Fe Avenue in Los Angeles. The intent of our participation was to present a sample asset inventory that had been previously conducted at the site with the assistance of Fred Khan on February 14.

We were presenting up to 9 different items which included a diverse sampling of what the First Environment/Beacon team felt would represent items that were either high on the criticality rating and low on the vulnerability rating and vice versa or ones that were neither. These sample assets also included a blend of both revenue and non-revenue generating assets.

The following were decided upon for the pilot:

Sample Assets

1.	Stormwater collection system
2.	Outdoor waste accumulation area
3.	Underground car hoist
4.	Truck assembly- on train
5.	Truck assembly- off of train (spare)
6.	Wheel truer
7.	Bridge crane
8.	Portable steamer
9.	Brake repair shop

A matrix was constructed that facilitated the ease of evaluating the asset based on the two criteria of criticality and vulnerability. Criticality was defined as significant to the operation of the asset for regular use and without disruption. Vulnerability was assessed based on the three elements already identified in the EMS- extreme temperatures, extreme precipitation and wind.

Metro Environmental Management System Assessment

Sample Assets	Criticality	Vulnerability		
		Extreme Heat	Heavy Precipitation	Wind
1. Stormwater collection system				
2. Outdoor waste accumulation area				
3. Underground car hoist				
4. Truck assembly- on train				
5. Truck assembly- off of train (spare)				
6. Wheel truer				
7. Bridge crane				
8. Portable steamer				
9. Brake repair shop				

The scoring was established on the following scale:
Criticality

1. Critical
2. Somewhat critical
3. Not critical

Vulnerability

1. Critical
2. Somewhat critical
3. Not critical

Observations from Evaluating Exercise

After the formal business of the meeting concluded, it was requested by Cris Liban for individuals present at the meeting to stay back and complete the exercise. Background was provided for 2 individuals who decided to stay back to have a better understanding of the need for the exercise.

I explained to the group the methodology of how the sample assets had been selected and what their role in scoring these assets was. I then invited them to review the sample assets and see if they were appropriate and if any additional ones should be added. Upon review by one of the individuals who was a Maintenance Supervisor, he suggested that perhaps Item #9 Brake Repair Shop be deleted since it was not present at the Red Line Rail Yard. He did go on to additional items that he felt were essential to the operation of the train. These included: third rail, trainway feeder and signals. Other members present acquiesced to the additions.

It was further suggested that two other members of the Core Team that could not stay for the exercise would be invited to participate in the scoring as well.

Here are the results of their evaluation:

Sample Assets	Criticality	Vulnerability		
		Extreme Heat	Heavy Precipitation	Wind
1. Stormwater collection system	1	3	1	3
2. Outdoor waste accumulation area	2	3	2	1
3. Underground car hoist	2	3	3	3
4. Truck assembly- on train	1	3	3	3
5. Truck assembly- off of train (spare)	1	3	3	3
6. Wheel truer	2	3	2	3
7. Bridge crane	3	3	3	3
8. Portable steamer	3	3	3	3
9. Power Substation	1	2	2	2
10. Third Rail	1	3	2	3
11. Trainway Feeder	2	2	2	2
12. Signals	2	1	2	3

While conducting the exercise, there seemed to be a tacit appreciation of Metro's mission and values which are deeply embedded in the Metro Operations culture and their mindset.

MISSION

Metro is responsible for the continuous improvement of an efficient and effective transportation system for Los Angeles County.

Metro Values

Safety: We commit to ensure that our employees, passengers and the general public's safety is always our first consideration.

Service Excellence: We commit to provide safe, clean, reliable, on-time, courteous service for our clients and customers.

There is further evidence that in conversations with Metro Operations management that the EMS Pilot Study is significant to Metro being viewed as a "world-class organization" that is seriously committed to long-term success to their EMS efforts.

APPENDIX E:
Metro EMS Asset Assessment

APPENDIX E:
METRO EMS ASSET ASSESSMENT

Preliminary Assessments of Criticality and Vulnerability

PRELIMINARY ASSESSMENT RESULTS				
Asset	Criticality	Vulnerability		
		Extreme Heat	Heavy Precipitation	Wind
1. Stormwater collection system	3	1	3	1
2. Outdoor waste accumulation area	2	1	2	3
3. Underground car hoist	2	1	1	1
4. Truck assembly- on train	3	1	1	1
5. Truck assembly- off of train (spare)	3	1	1	1
6. Wheel truer	2	1	2	1
7. Bridge crane	1	1	1	1
8. Portable steamer	1	1	1	1
9. Power Substation	3	2	2	2
10. Third Rail	3	1	2	1
11. Trainway Feeder	2	2	2	2
12. Signals	2	3	2	1

<u>Scoring Guide:</u>

Criticality (essential to operations without service disruption)

3. Critical
2. Somewhat critical
1. Not critical

Vulnerability (exposure to climate conditions)

3. Vulnerable
2. Somewhat vulnerable
1. Not vulnerable

Rates of Change

Rate of change and risk values in the following tables are prepared for illustrative purposes only and are not actual data. This information should not be used for assessment of Metro's rates of change and risk.

Criticality x Vulnerability x Rate of Change = Asset Risk Level

WIND – ASSET ANALYSIS

Sample Assets	Criticality	Vulnerability	Rate of Change (Illustrative)				Wind Risk (Illustrative)			
			Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
2. Outdoor waste accumulation area	2	3	*2*	*2*	*3*	*3*	*12*	*12*	*18*	*18*
3. Underground car hoist	2	1	*2*	*2*	*3*	*3*	*4*	*4*	*6*	*6*
4. Truck assembly- on train	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
5. Truck assembly- off of train (spare)	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
6. Wheel truer	2	1	*2*	*2*	*3*	*3*	*4*	*4*	*6*	*6*
7. Bridge crane	1	1	*2*	*2*	*3*	*3*	*2*	*2*	*3*	*3*
8. Portable steamer	1	1	*2*	*2*	*3*	*3*	*2*	*2*	*3*	*3*
9. Power Substation	3	2	*2*	*2*	*3*	*3*	*12*	*12*	*18*	*18*
10. Third Rail	3	1	*2*	*2*	*3*	*3*	*6*	*6*	*9*	*9*
11. Trainway Feeder	2	2	*2*	*2*	*3*	*3*	*8*	*8*	*12*	*12*
12. Signals	2	1	*2*	*2*	*3*	*3*	*4*	*4*	*6*	*6*

HEAT – ASSET ANALYSIS

Sample Assets	Criticality	Vulnerability	Rate of Change (Illustrative)				Heat Risk (Illustrative)			
			Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	1	*1*	*1*	*1*	*2*	*3*	*3*	*3*	*6*
2. Outdoor waste accumulation area	2	1	*1*	*1*	*1*	*2*	*2*	*2*	*2*	*4*
3. Underground car hoist	2	1	*1*	*1*	*1*	*2*	*2*	*2*	*2*	*4*
4. Truck assembly- on train	3	1	*1*	*1*	*1*	*2*	*3*	*3*	*3*	*6*
5. Truck assembly- off of train (spare)	3	1	*1*	*1*	*1*	*2*	*3*	*3*	*3*	*6*
6. Wheel truer	2	1	*1*	*1*	*1*	*2*	*2*	*2*	*2*	*4*
7. Bridge crane	1	1	*1*	*1*	*1*	*2*	*1*	*1*	*1*	*2*
8. Portable steamer	1	1	*1*	*1*	*1*	*2*	*1*	*1*	*1*	*2*
9. Power Substation	3	2	*1*	*1*	*1*	*2*	*6*	*6*	*6*	*12*
10. Third Rail	3	1	*1*	*1*	*1*	*2*	*3*	*3*	*3*	*6*
11. Trainway Feeder	2	2	*1*	*1*	*1*	*2*	*4*	*4*	*4*	*8*
12. Signals	2	3	*1*	*1*	*1*	*2*	*6*	*6*	*6*	*12*

PRECIPITATION – ASSET ANALYSIS

Sample Assets	Criticality	Vulnerability	Rate of Change (Illustrative)				Precipitation Risk (Illustrative)			
			Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	3	*2*	*2*	*2*	*3*	*18*	*18*	*18*	*27*
2. Outdoor waste accumulation area	2	2	*2*	*2*	*2*	*3*	*8*	*8*	*8*	*12*
3. Underground car hoist	2	1	*2*	*2*	*2*	*3*	*4*	*4*	*4*	*6*
4. Truck assembly- on train	3	1	*2*	*2*	*2*	*3*	*6*	*6*	*6*	*9*
5. Truck assembly- off of train (spare)	3	1	*2*	*2*	*2*	*3*	*6*	*6*	*6*	*9*
6. Wheel truer	2	2	*2*	*2*	*2*	*3*	*8*	*8*	*8*	*12*
7. Bridge crane	1	1	*2*	*2*	*2*	*3*	*2*	*2*	*2*	*3*
8. Portable steamer	1	1	*2*	*2*	*2*	*3*	*2*	*2*	*2*	*3*
9. Power Substation	3	2	*2*	*2*	*2*	*3*	*12*	*12*	*12*	*18*
10. Third Rail	3	2	*2*	*2*	*2*	*3*	*12*	*12*	*12*	*18*
11. Trainway Feeder	2	2	*2*	*2*	*2*	*3*	*8*	*8*	*8*	*12*
12. Signals	2	2	*2*	*2*	*2*	*3*	*8*	*8*	*8*	12

Asset Risk Level Summary

Risk values in the following table are prepared for illustrative purposes only and are not actual data. This information should not be used for assessment of Metro's rates of change and risk.

ASSET RISK SUMMARY

Sample Assets	Heat Risk (Illustrative)				Precip Risk (Illustrative)				Wind Risk (Illustrative)			
	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0 - 5	Yr 5-10	Yr 10-20	Yr 20 -50	Yr 0-5	Yr 5-10	Yr 10-20	Yr 20 -50
1. Stormwater collection system	3	3	3	6	18	18	18	27	6	6	9	9
2. Outdoor waste accumulation area	2	2	2	4	8	8	8	12	12	12	18	18
3. Underground car hoist	2	2	2	4	4	4	4	6	4	4	6	6
4. Truck assembly- on train	3	3	3	6	6	6	6	9	6	6	9	9
5. Truck assembly- off of train (spare)	3	3	3	6	6	6	6	9	6	6	9	9
6. Wheel truer	2	2	2	4	8	8	8	12	4	4	6	6
7. Bridge crane	1	1	1	2	2	2	2	3	2	2	3	3
8. Portable steamer	1	1	1	2	2	2	2	3	2	2	3	3
9. Power Substation	6	6	6	12	12	12	12	18	12	12	18	18
10. Third Rail	3	3	3	6	12	12	12	18	6	6	9	9
11. Trainway Feeder	4	4	4	8	8	8	8	12	8	8	12	12
12. Signals	6	6	6	12	8	8	8	12	4	4	6	6

APPENDIX

C

Metric Development Report

METRICS FOR TRACKING CLIMATE CHANGE ADAPTATION

April 2013

A Report to the Los Angeles County Metropolitan Transportation Authority

FTA Climate Change Adaptation Pilot Project

Urban & Environmental Policy Institute
Occidental College

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INTRODUCTION AND METHODS

The Urban & Environmental Policy Institute at Occidental College (UEPI) is pleased to transmit to the Los Angeles County Metropolitan Transportation Authority (Metro) a report on metrics for climate change adaptation. The report recommends key metrics that Metro should use to track the progress of the agency's climate change adaptation efforts.

We appreciate that Metro is among the leaders in adapting transit to the realities of a changing climate. We hope that these metrics can help the agency assess how well it is implementing its climate adaptation goals. Metrics can generate a feedback loop between actions and data that can help the agency continue to plan for operating in a changing climate. The result will be a resilient transit system that continues to serve and link Los Angeles County's diverse communities.

While the report is targeted to Los Angeles Metro, the metrics analyzed in the report should also be informative for other transit agencies.

To prepare the report, UEPI first conducted a literature review on metrics and indicators for climate change adaptation by transit operators. Climate adaptation by transit agencies is a new and evolving field, so the scan of the literature did not reveal a set of standard metrics for climate adaptation. It did, however, provide examples of metrics that transit agencies are beginning to use. UEPI also translated common adaptation actions found in the literature into potential metrics. Additional metrics emerged from discussions with Metro staff about the agency's operation.

The metrics fall into four categories: planning, operations, adaptation, and riders. Some of the metrics are binary, providing 'yes or no' answers as to whether a transit agency is taking an action related to climate adaptation. Other metrics require gathering and comparing numerical data.

UEPI generated 109 possible metrics through the literature review, related research and discussions with Metro. Since this amount of indicators would likely be unwieldy to track, we developed criteria to rank the metrics so as to identify a smaller set of priority metrics that Metro and other transit agencies could gather and analyze. Each metric was rated none, low, medium or high for each of five "core criteria" and six "multiple benefit criteria." The six core criteria are: criticality, severity, equity, feasibility, cost and best practice. The five multiple benefit criteria (so called because they measure whether a metric provides information that would help an agency address other elements of their climate change agenda) are: climate, visibility, participation and governance, design, and mitigation.

Points were summed to provide a score for each metric. Core criteria granted twice the points of multiple benefit criteria. High, medium, and low in a core criteria earned 6,4, and 2 points and earned 3,2 and 1 points in a multiple benefit criteria. Each metric could therefore receive up to 54 points.

Based on the ratings, UEPI strongly recommends that Metro track the 20 highest ranked metrics- all those metrics rated 35 or above. We provide a summary, a description of what data needs to be collected, and a justification and recommendations for each of these twenty top priority metrics. An additional 19 metrics were rated 34 or 33. We categorize these 19 as 'recommended' metrics which Metro should track if they have the capacity to measure more than 20 metrics. The agency may also choose to track some of the additional 70 metrics ranked below 33 if these metrics are particularly relevant to the agency's climate adaptation efforts.

CRITERIA USED TO RANK METRICS

Criteria	Summary	Rationale
criticality	Does metric inform risks to critical asset?	Protect critical assets
severity	Does metric inform anticipated significant risks to assets and/or riders?	Adapt to severe impacts
equity	Does metric inform impacts on transit-dependent and diverse communities/ riders?	Protect most vulnerable riders/ communities
feasibility	Is it easy or difficult to gather this data?	Understand what needs to be done to track metric
cost	Is metric cost effective to implement?	Prioritize higher impact, lower cost metrics; ensure budget is adequate to gather important data
best practice	Is metric gathered by other transit agencies or related climate adaptation efforts?	Learn from literature review and peers; be able to share data and methods
climate	Does data add to understanding of local weather/ climate?	Improve access to real time weather data and climate change forecasting
visibility	Does metric help inform public on need for climate adaptation?	Expand awareness of climate change, need for adaptation, and agency efforts
participation and governance	Does metric involve employees and/or staff and/or improve ability to coordinate actions	Broaden involvement in and coordination of adaptation efforts
design	Does metric inform system design as well as operations?	Help create resilient, widely-used system
mitigation	Does metric inform mitigation as well as adaptation?	Help reduce emissions and mitigate impacts of climate change

PRIORITY METRICS

1. Have impacts on riders been analyzed? (43 points)

Summary: Has the agency analyzed how climate change may impact the behavior, health and comfort of its riders?

Metric data: Yes or no. (Agencies may also want to track the frequency of their analysis and how many riders were interviewed as part of conducting the analysis).

Justification and recommendations: The chief mission of transit agencies is to provide convenient and safe mobility options to persons who use the system. Climate change can impact this mission by interfering with or influencing how a transit agency operates its system and by influencing the behavior of users. While agencies cannot control how riders react to a changing climate or extreme weather events in the same manner that an agency can adjust its operations or technology, it is critical to consider ways that climate change may influence users' actions and attitudes. This will ensure that climate adaptation plans and actions help protect the health and safety of riders and help maintain or expand ridership in a changing climate. A transit agency should analyze impacts on riders as part of conducting a climate change vulnerability assessment, and may want to supplement this analysis with regular surveys, interviews or focus groups. Metro gathers information on customer satisfaction on a regular basis.[1] This information includes the way that riders get to their stop of station, how long it takes them to reach their stop/ station and how long they typically wait for their bus or train to arrive. This data provides useful information on whether and how system users are exposed to sun, rain or flooded roads. The survey asks riders if they have cell phones/ smart phones, which can help determine if extreme weather alert could help users. A question on whether riders feel safe waiting for and riding the system could be adapted to ask about the rider's comfort. The agency could also query riders about whether they change their behavior when the weather is extreme, and ask customers if their stop or station has adequate shade. These questions can be added to customer surveys or gathered by some other method.

2. Has vulnerability assessment been conducted? (39 points)

Summary: Has the agency assessed its system's vulnerability to climate change impacts that are anticipate to develop in its area of service?

Metric data: Yes or no. (Agencies may also want to track how long it has been – in years - since they last conducted or updated their vulnerability assessment.)

Justification and recommendations: A vulnerability assessment lies at the heart of planning and preparedness for climate change adaptation. Conducting a vulnerability assessment allows an agency to familiarize themselves with anticipated weather and climactic changes; to analyze how these changes may affect their systems and operations; and to identify the most vulnerable assets. Understanding these likely impacts sets the groundwork for identifying and prioritizing adaptation actions to reduce vulnerability and increase the resilience of both physical infrastructure and operational systems. As more transit agencies perform vulnerability assessments, best practices will continue to evolve. Metro should keep abreast of the state of the art in climate vulnerability assessments so that it can periodically update and fine-tune its own assessment.

1 http://www.metro.net/board/Items/2012/10_October/20121010OtherSectorWESItem4.pdf

3. Mean Distance Between Failure (MDBF) for buses by temperature and geography (39 points)

Summary: How does the number of miles that buses travel, on average, before they suffer mechanical problems that require the bus to be taken out of service for repairs, vary by the temperature at the time of year of break-down and by the average temperature of the area that bus broke down in?

Metric data: Average number of miles that buses traveled between breakdowns, analyzed and arranged by A. the high temperature of the day (or average temperature of the week or month); and B. by the average summer high temperature of the agency's sub-geography.

Justification and recommendations: Metro's 2012 Climate Action and Adaptation Plan identified "Fleet breakdowns and maintenance during periods of extreme heat" as the most significant adaptation challenge facing its bus operations. [2] Tracking MDBF, which is a standard industry measurement of rolling stock reliability and performance, by temperature and geography, will allow Metro to determine if and how breakdowns are impacted by high heat. It will provide a baseline and ongoing data with which to measure the effectiveness of maintenance approaches to cope with expected increases in temperature. To track potential increases in breakdowns from both short-lasting heat waves and longer trends, we recommend analyzing breakdowns by both individual daytime high temperature of the region and by the average high temperature of weeks or months. We also recommend that Metro track MDBF by Bus Divisions and/or Los Angeles County Service Planning Areas, and calculate the average summer time high temperature of these sub-geographies.

4. Have adaptation actions been prioritized? (38 points)

Summary: Has the agency prioritized potential adaptation actions that have been identified through a vulnerability assessment, climate action plan, or other climate adaptation planning?

Metric Data: Yes or No.

Justification and recommendations: Climate adaptation planning for a medium to large size transit system will identify a range of expected impacts and vulnerabilities and a range of actions that an agency can take to adapt to anticipated impacts. To help minimize disruptions to transit service and to contribute to more resilient communities, agencies should prioritize those adaptation actions that are most likely to effectively preserve and improve operations. Prioritization of adaptation actions can be performed as part of an agencies climate planning, ideally in a formal climate action plan that includes a vulnerability analysis. Agency staff and/or consultants preparing plans can use criteria such as criticality, severity, cost, effectiveness, and equity to rate and prioritize from among the full set of identified actions. Metro should ensure that prioritized actions receive appropriate funding and implementation.

5. Have vulnerable assets been mapped with transit dependent and low-income populations? (37 points)

Summary: Has the agency mapped assets that are considered to be especially vulnerable to climate impacts with the demography of its service area, especially for low income, transit-dependent populations?

Metric Data: Yes or No.

2 http://www.metro.net/projects_studies/sustainability/images/Climate_Action_Plan.pdf

Justification and recommendations: Important steps in assessing a transit system's vulnerability to climate change involve potential weather and climactic changes; analyzing how these changes may affect their systems and operations; identifying the most vulnerable assets, and identifying and prioritizing actions to address threats to the system. Once the most vulnerable assets are identified, mapping these assets overlaid with a map of low-income, transit-dependent populations can add an important equity dimension to planning climate adaptation. Vulnerable assets that serve populations that are transit dependent are A. likely to be heavily used; and B. are important resources for populations vulnerable to climate change impacts because they are less likely to own cars or to have financial resources that would allow them to easily evacuate, to afford to miss work, etc. Metro should map its vulnerable assets with areas with high rates of poverty and low rates of car ownership to identify assets that are significant both from an operational perspective and a human needs and equity perspective.

6. Number of injuries/ medical emergencies to workers and riders by temperature and rainfall (37 points)

Summary: Track injuries and medical emergencies sustained on the system and analyze the numbers by temperature and by rainfall.

Metric Data: Injuries and medical emergencies sustained by workers and riders. Compare average number of daily medical incidents to average number of incidents on extreme heat days (Metro should adopt a definition of extreme heat for the purposed of these calculations in which temperature exceeds 91.4 degrees in downtown Los Angeles.)
Also compare average medical incident rate to days with heavy rain, defined as precipitation falling at .3 inches per hour or above.

Justification and recommendations: Higher heat[3] and increased precipitation[4] are anticipated to be two of the most significant climate impacts in the Los Angeles region. These changes to weather may pose threats to the health and safety of transit users and workers. Comparing average rates of injuries and other medical incidents with rates of such incidents on very hot days and days with heavy rain can help identify trends. If there is an increased rate of health issues reported on hot or wet days, Metro should identify strategies to minimize risks. Metro may also wish to track the **types** of injuries that occur on very hot or wet days to see if trends, and reduction strategies, emerge.

7. Does agency have overheating standards for public transport facilities and rolling stock? (37 points)

Summary: Are there design and operating standards intended to prevent and mitigate overheating in facilities or buses and trains that could cause equipment failure or discomfort , negative health impacts, or inconvenience to passengers or employees.

Metric Data: Yes or No.

Justification and recommendations: Increasingly hot weather poses challenges to the operation of equipment on buses and trains and in stations, bus yards and other facilities. Standards to prevent and mitigate the effects of overheating can help ensure more reliable and safer operations. Metro's design, procurement and operating standards should seek to ensure that engines, air conditioning and other critical systems

3 "Mid-Century Warming in the Los Angeles Region." http://c-change.la/temperature/

4 http://www.metro.net/projects_studies/sustainability/images/Climate_Action_Plan.pdf

function in high heat environments. Rolling stock and facilities should also be designed and operated so that customers and employees are comfortable during periods of high heat.

8. Ongoing and regularly convening team tasked with implementing climate adaptation plans. (37 points)

Summary: Does agency have a team of staff charged with implementing action items from climate adaptation plan (or plans) that the agency has adopted?

Metric Data: Yes or No.

Justification and recommendations: Climate adaptation plans need to be implemented to achieve the benefits of planning: forethought, prioritization, avoidance of harm, creation of a more resilient and effective transit system. Because most plans will touch upon actions that involve multiple aspects of operations, finance, customer relations, etc., Metro should establish a team of staff with responsibility to oversee implementation of adaptation plans. This team should have authority from the Board and CEO to coordinate actions and to ensure there is feedback between implementation steps and future information gathering and planning.

9. Percent of climate adaptation recommendations/ actions from adopted plans implemented (37 points)

Summary: What percent of climate adaptation action items from Climate Change plans that agency has adopted have been implemented?

Metric Data: Agency can keep track of implementation of climate change adaptation action items using three categories: 1. Implemented; 2. In process of being implemented; and 3. Not yet implemented.

Justification and recommendations: In order to meter progress in implementing climate change adaptation plans, agencies should keep track of how many action items have been implemented over time. A checklist of climate adaptation commitments and recommendations contained in adopted plans should be maintained, so that implementation or lack of implementation of each can be tracked. We recommend that Metro task the team responsible with implementing climate adaptation efforts to track the agency's progress. Metro might also explore incorporating such progress tracking into annual reports on environmental performance.

10. Capacity to monitor weather and temperature conditions in real time at key locations in service area (36 points)

Summary: Can the agency monitor temperature and precipitation in real time at key locations in the service area, or create partnerships to receive real time data from organizations with weather monitoring equipment?

Metric Data: Yes or No.

Justification and recommendations: High heat days and extreme precipitation events pose risks to transit operations and customers. Tracking weather locally can help identify weather episodes and local stresses and trigger adaptation actions at stations and other facilities. Monitoring weather also allows agencies to calculate climate adaptation metrics that rely on temperature and precipitation data. Metro should measure temperature and precipitation at its critical assets. In addition, the agency should measure this weather data

in at least one facility per Bus Divisions and/or Los Angeles County Service Planning Areas.

11. Extreme weather impacts on service delays and cancellations (36 points)

Summary: Does the agency experience more service delays and cancellations during high heat days and/or heavy rain?

Metric Data: Compare average number of daily service delays and cancellations to average number of service delays and cancellations on extreme heat days (days on which temperature exceeds 91.4 degrees in downtown Los Angeles) and days with heavy rain, defined as precipitation falling at .3 inches per hour or above.

Justification and recommendations: Equipment failures and facility closures from extreme weather may disrupt service. To understand the extent of the disrupting impact of a changing climate, agencies can compare baseline rates of service delays and cancellations with rates of these problems that occur on very hot days and days with high precipitation. Understanding the correlation, if any, between temperature and precipitation and service delays and cancellations will help agencies prepare for extreme weather days by preparing additional capacity, increasing preventive maintenance, etc. Metro should track service delays and cancellations in order to compare rates of service challenges on high heat days and days with heavy rain.

12. Percent of Metro facilities and vehicles with cool roofs (36 points)

Summary: What percentage of facilities have cool roofs and what percent of vehicles have cool roofs or cool roofs and shells designed to reflect sunlight so as to lower the interior and surrounding temperature.

Metric Data: Number of buildings owned, leased and/or operated by the agency with roofs with solar reflectance index of at least .70 for low slopes or .25 for steep slope, divided by total number of buildings and owned, leased or operated by agency. Number of buildings owned, leased and/or operated by the agency with roofs with solar reflectance index of at least .78 for low-slope or .29 for steep slope, divided by total number of buildings and owned, leased or operated by agency. Number of vehicles owned, leased and/or operated by agency with white or silver roofs divided by total number of vehicles. Number of vehicles owned, leased and/or operated by agency with white or silver roofs **and** shells divided by total number of vehicles.

Justification and recommendations: Cool roofs reduce the interior temperature of buildings[5] and cool roofs/ shells do the same for vehicles.[6] This can make customers and staff more comfortable and reduce negative health impacts from overheating. Equipment will also come under less stress, reducing failures, service delays and maintenance and replacement costs. Cooling structures and vehicles will improve fuel efficiency and reduce energy use and greenhouse gas emissions by power plants. Metro should install and retrofit cool roofs and shells on buildings and vehicles to achieve these localized benefits and also to model and encourage broader use of cool surfaces. Models predict that Installing cool roofs, cool pavements, and trees over 30 percent of the surface of the Los Angeles basin would lower the outside air temperature by about 5°F, reducing the expected negative impacts of high heat. To help inspire a broader adoption of cool surfaces, Metro should publicize its own cool roofs through signage on buildings or vehicles or other educational efforts.

5 http://heatisland.lbl.gov/coolscience/cool-science-cool-roofs

6 http://heatisland.lbl.gov/sites/heatisland.lbl.gov/files/Cool_cars_final_LBNL_project_report_v015_2011-08-08.pdf

13. Does agency conduct regular climate planning updates? (36 points)

Summary: Does the agency conduct regular climate planning updates to incorporate new climate change information, the results of adaptation efforts, and best practices into existing adaptation plans?

Metric Data: Yes or No. (Potentially also measure how long it has been since last update to climate action and adaptation plan)

Justification and recommendations: The science of climate change and the policy tools available to adapt to climate impacts are continuously changing. Metro should stay informed of the latest information on how climate change is expected to impact their region, and learn from the best practices of other agencies engaging in adaptation efforts. Metro should also measure and take lessons from its own climate adaptation programs and policies. To enable this learning, growth and refinement in climate adaptation, Metro should update its climate adaptation plans regularly.

14. Are climate adaptation indicators tracked in agency's Environmental Management System and/or Asset Management System? (36 points)

Summary: Does the agency track climate change metrics such as vulnerabilities and actions taken for adaptation of assets in existing systems that track environmental performance and/or the status of assets?

Metric Data: Yes or No

Justification and recommendations: Tracking and quantifying climate adaptation efforts can help assure that an agency is effectively responding to the risks posed by climate changes. Tracking climate adaptation metrics or indicators should be mainstreamed into agency practices and structures where possible. Data on climate adaptation can be slotted into existing information management systems such as environmental management systems and/or asset management systems. Agencies should review and plan how best to capture and track climate adaptation relate metrics in existing management systems. We recommend that Metro should draw upon the report on climate adaptation and its environmental management system prepared by First Environment to undertake this integration.

15. Number of rail kinks/ buckling by temperature and by heat island areas (35 points)

Summary: Do the number of rail kinks or buckling increase on high heat days and/or in areas that have been identified as urban heat islands?

Metric Data: Average number of rail kinks or buckling per day compared to average number of rail kinks or buckling on high heat days (above 91.4 degrees in downtown Los Angeles.) Average number of or rail kinks or buckling per mile per year of track in areas identified as urban heat islands compared to average number of rail kinks of buckling per mile of track in areas identified as not being urban heat islands.

Justification and recommendations: High temperatures can warp or otherwise damage tracks used by above ground rail. Tracking whether increased high temperature leads to more track warping can help agencies predict disruptions from climate change and better design and maintain rail systems to minimize disruptions. Metro should track damage to tracks on high heat days compared to other days of the year. Urban heat island are urbanized areas in which increased permeable surfaces lead to more retention of the sun's energy, leading to air temperatures that can be up to 5 degrees F higher during the day an up to 12

degrees F higher at night.[7] To determine how increased heat from climate change can interact with urban heat islands in its service area, Metro should seek to identify maps of heat islands in Los Angeles County and compare rates of rail bucking in these areas with rates in areas of service that are not classified as heat islands.

16. Number of technical advisors and members of the broader community included in climate adaptation team (35 points)

Summary: How many individuals who are not agency employees are on the climate adaptation team or on a public advisory committee linked to the team?

Metric Data: number of persons on climate adaptation team or an advisory committee to the team who are outside technical consultants or representatives of partner organizations or the public.

Justification and recommendations: An agency's climate adaptation team can benefit from outside technical expertise, partnerships, and public involvement. Metro should include outside stakeholders with expertise in climate change or adaptation as well as public representatives on its climate adaptation team. If it is useful to separate advisory roles from inside, decision-making roles then the agency can establish an advisory committee to the team.

17. Do agency design standards consider climate adaptation? (35 points)

Summary: Do the design standards that the agency uses to set physical and performance parameters for new lines, facilities, and rolling stock incorporate climate adaptation goals?

Metric Data: Yes or no.

Justification and recommendations: Climate change adaptation for public transit involves shaping and "ruggedizing" transit systems so that they perform well under expected future climatic conditions. Design standards are an on of the important ways that agencies mandate the parameters of new infrastructure. It therefore makes sense to include climate adaptation goals in design standards so that new transit infrastructure is built to withstand and to be resilient in the face of high heat, major precipitation, sea level rise, or other climate change impacts. Metro incorporates environmental criteria, including some related to heat, climate and energy, in its design standards. The agency should continue to update design standards as its climate adaptation goals evolve.

18. Has agency designated evacuation routes? (35 points)

Summary: Does the agency have emergency evacuation plans with designated routes, including pick up and drop off points, that could help protect passengers, staff and the general public during extreme weather emergency?

Metric Data: Yes or No.

Justification and recommendation: Climate change is expected to contribute to more severe weather episodes in the future.

Precipitation and sea level rise could lead to flooding and increased heat may be associated with more

7 http://www.epa.gov/hiri/resources/pdf/BasicsCompendium.pdf

severe fires. In the event of a weather emergency, public transit has a responsibility to ensure the safety of its users and staff. Transit can also be mobilized to evacuate or otherwise transport the broader population (residents who were not using transit when a disaster strikes). To deal with potential disasters that may be intensified by climate change, Metro should plan how its system can be evacuated- and plan how the system can be mobilized to help evacuate communities or the entire region.

19. Progress in reducing vulnerabilities based on meta-analysis of climate adaptation indicators. (35 Points)

Summary: Annual progress that the agency made towards achieving its climate adaptation goals and reducing its vulnerabilities to climate change, based on meta-analysis of indicators.

Metric Data: Measure how all metrics change over time. Calculate overall progress by averaging percentage improvement (or decline) in trends. Yes/ No metrics can count as 100 percent/ 0 percent. Because Yes/No metrics will show large swings in positive or negative direction, agency should also calculate average progress just of all numerical metrics.

Justification and recommendations: Climate change adaptation efforts and metrics cover a range of goals and topics. Measuring individual metrics will focus attention on particular aspects of climate change risks or adaptation implementation. It is also important to focus on the big picture of overall progress towards a successful climate response. One way to measure overall progress is to aggregate changes in multiple metrics. Metro should track changes in metrics annually and aggregate shifts to provide a rough estimate of progress. This numeric meta-analysis of change should be accompanied by additional quantitative and qualitative analysis of progress that Metro has made and challenges that the agency faces.

20. Funding needed and provided to implement climate adaptation (35 points)

Summary: How much annual funding is needed to implement climate adaptation plans adopted by the agency, and how much funding has been budgeted for these actions?

Metric Data: Funds required annually to implement climate adaptation actions contained in plans adopted by the agency, compared to annual funds budgeted by the agency for these purposes.

Justification and recommendations: Funding for climate adaptation actions is a sign of an agency's commitment to implementing its climate adaptation goals. Metro should track the funding that is required to implement adaptation efforts and how much money has been provided and spent on implementation.

OTHER RECOMMENDED METRICS

Metric	Score
Percent of agency's policy implementation processes that consider climate	34
Percent of all stations and lines assessed in climate vulnerability assessment?	34
Most vulnerable assets identified Y/N?	34
Percent of key assets with on site weather monitoring	34
Percent insurance premium or bond rates spread for operations/ construction that are vulnerable to climate change vs.	34
Percent of facilities with bioswales or other natural stormwater management systems	34
Critical assets identified Y/N?	33
Percent of critical assets assessed?	33
Percent of extreme weather days vs. percent of normal days with power outages and catenary line complications	33
Are the costs of severe weather events being tracked (for federal disaster aid or otherwise) Y/N?	33
Is there a cost code associated with extreme weather so employees can mark down overtime, repairs etc as weather/ climate related Y/N?	33
Percent of climate implementation team participants authorized to make changes recommended by team in the adaptation planning process.	33
Does agency utilize flood maps to determine facility design parameters such as drainage Y/N?.	33
Does agency's asset management system measure heat and flood vulnerabilities for each asset Y/N?	33
Percent of bus stops with shade	33
Does agency have policies to modify construction schedules and labor practices to protect workers from high heat Y/N?	33
How many people can the agency evacuate in the event of a weather emergency	33
Percent of weather-related service delays/ cancellations that occur in areas with above average transit-dependent populations.	33
Does agency publish regular reports or updates on climate adaptation efforts Y/N?	33

OPTIONAL METRICS

Metric	Score
Does agency have a climate change preparedness team Y/N?	32
Percent of relevant divisions/ department actively represented on team	32
Does agency collaborate with partner agencies, jurisdictions and organizations on climate adaptation Y/N?	32
Percent of stations and stops with drinking water source	32
Does agency have emergency procedures for high heat days, significant rain/ flooding events, and service interruptions Y/N?	32
Percent of passengers who can be moved by alternative modes if one or more rail lines are closed by extreme weather?	32
Do agency's environmental impact assessments and/or related documents identify the potential for disproportionate impacts to impacts to minority, low income and disadvantaged populations from potential climate impacts Y/N	32
Number of staff tasked with implementing climate adaptation actions.	32
Have major barriers to incorporating climate adaptation into implementation processes/ tools been identified Y/N?	31
Is a regional climate model available to better determine local impacts of climate change. Y/N?	31
Percent of service area covered by regional climate model	31
Percent of extreme weather days vs. percent of normal days with interruptions in telecommunications	31
What is the extra cost of extreme weather vs a baseline in $ and as percent of operating budget?	31
Loss in revenues from lower ridership on extreme weather days	31
Number of other collaborations	31
Has agency mapped urban heat islands across service area (or have access to map) Y/N?	31
Percent of metro properties with on site energy generation	31
Does agency have back up plan for failure of electric grid Y/N?	31
Percent of transit dependent service area population lives within convenient walk of train station or frequent bus route	31

Metric	Score
Participation rates of public or advisory members in its internal climate change adaptation team or committee meetings	31
Percent increase in repair and replacement costs from accelerated reduction in state of good repair due to wear of extreme weather	30
Are savings from adaptation being measured/ calculated Y/N?	30
Percent of engineering standards that include tolerances for extreme weather events at the upper bounds of climate change projections	30
Percents of above ground assets, critical assets, and vulnerable assets in urban heat islands	30
Percent of urban heat islands in service area with above average and majority transit dependent populations	30
Percent of stations with capacity and efficiency of pumping and drainage systems to cope with flooding scenarios based on future precipitation and sea level rise projections	30
Have these procedures been evaluated based on their performance in a real world weather emergencies Y/N?	30
Percent of critical and vulnerable facilities with site specific emergency plans.	30
Has agency conducted a cumulative impact analysis of climate change on the public, especially on the most vulnerable populations Y/N?	30
Percent of residents living within walking distance of transit stations and/or high quality bus corridors	30
Percent of stations with joint development plans, land use plans, and/or MOUs to increase density of housing and/or employment near station site	30
What is 'resolution' of RCM? (size of grid squares)	29
Number of real time monitoring stations	29
Ratio of monitoring stations/ service area in square miles	29
Has agency developed adaptation timeline for updating design and engineering standards Y/N?	29
Percent of assets considered to have significant vulnerability to heat	29
Percent of assets considered to have significant vulnerability to flooding	29
Percent of rail stations, bus yards and other critical facilities with back- up generator capacity	29
Percent of rolling stock that is standing reserve available to cover broken down vehicles?	29

Metric	Score
Minimum level of back-up generator capacity to allow rail and bus operations for 24 and 48 hours.	29
Percent of stations and facilities with required level of back up generating capacity	29
Does agency have demographic analysis of its service area and ridership Y/N?	29
Percentage of stations with clean mobility centers	29
Does agency request, collect, analyze and publish recommendations from public on climate change adaptation? Y/N	29
Is there a record of historical weather patterns for the service area Y/N?	28
Number of memoranda of understanding with partners	28
Percent of design and procurement standards for equipment and vehicles that require items to meet future climate conditions.	28
Percent increase in power and fuel consumption on hot days vs. normal days	28
Are there communication channels to alert public about weather-related delays, cancellations, etc Y/N?	28
Have transit dependent and vulnerable populations been identified and/or mapped using established methods Y/N?	28
Has agency surveyed riders on how their travel patterns change during high heat or heavy rain Y/N?	28
Number of stakeholders/ members of public engaged per year	28
Percent of service area covered by weather records	27
Percent foliage coverage at metro stations	27
Does agency have timeline for adaptation efforts to reduce temperature at stops and stations Y/N?	27
Percent of Metro's power generated from onsite renewable energy production	27
Percent difference in frequency of stormwater management equipment maintenance at facilities with high flood risk vs typical facility.	27
Have these communication channels been tested and evaluated Y/N?	27
Amount of money saved based on implemented preparedness action	27
Have complete range of implementation tools that Metro possesses been identified Y/N	26

Metric	Score
Percent savings for comparable extreme weather events with adaptation vs. without adaptation	26
Does agency use utilize the same climate projections/ models as partners Y/N?	26
Does agency capital and/or operating budget have category for climate adaptation or category into which adaptation funding can fit Y/N?	26
Percent of bus stops with seating	25
Records kept of outreach and numbers of stakeholders/ members of public engaged on climate adaptation in person and on-line Y/N	25
Percent of stormwater managed by agency that is managed by natural systems	24
How many years do weather records go back?	23
Minimum level of compressed natural gas reserves to power 50% of bus fleet for one week	23
Percent of this reserve natural gas currently held and available by agency	23
Has agency identified mechanism for inter-agency coordination in place for other purposes that could be expanded to target climate change adaptation Y/N	21

APPENDIX 1:
METRICS RATED FOR EACH CRITERIA

Metrics: Planning

	Have complete range of implementation processes that Metro possesses been identified Y/N	Percent of implementation processes that consider climate	Have major barriers to incorporating climate adaptation into implementation processes/ tools been identified Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)			
criticality	low	medium	medium
severity	low	medium	medium
equity	low	medium	medium
feasibility	medium	high	medium
cost * (points reversed)	low	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)			
best practice	medium	low	medium
climate	low	medium	low
visibility	low	low	medium
participation and governance	high	medium	medium
design	low	medium	low
mitigation	medium	medium	medium
Score	**26**	**34**	**31**

Metrics: Planning

	Has vulnerability assessment been conducted? Y/N	Critical assets identified Y/N?	Percent of critical assets assessed?	Percent of all stations and lines assessed?	Most vulnerable assets identified Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	high	High	medium	medium
severity	high	medium	medium	low	high
equity	medium	low	low	high	medium
feasibility	medium	medium	high	high	medium
cost * (points reversed)	high	medium	low	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	high	high	medium	medium	medium
climate	medium	medium	low	low	medium
visibility	high	medium	Low	medium	medium
Participation and gover-nance	high	medium	medium	medium	medium
design	high	high	medium	medium	high
mitigation	medium	low	low	low	low
Score	**39**	**33**	**33**	**34**	**34**

Metrics: Planning

	Impacts on riders analyzed Y/N?	Overlay of most vulnerable areas and assets with transit dependent and low-income populations Y/N?	Adaptation actions prioritized Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)			
criticality	high	medium	high
severity	high	medum	high
equity	high	high	medium
feasibility	medium	high	medium
cost * (points reversed)	medium	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)			
best practice	medium	medium	high
climate	medium	low	medium
visibility	high	high	medium
Participation and gover-nance	high	medium	medium
design	high	medium	high
mitigation	medium	low	medium
Score	**43**	**37**	**38**

Metrics: Planning

	Is a regional climate model available to better determine local impacts of climate change. Y/N?	Percent of service area covered by regional climate model	What is 'resolution' of RCM? (size of grid squares)	Is there a record of historical weather patterns for the service area Y/N?	Percent of service area covered by weather records
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	low	low	low	low	low
severity	high	medium	high	high	medium
equity	medium	medium	low	low	medium
feasibility	medium	high	medium	medium	high
cost * (points reversed)	high	low	low	low	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	medium	low	low	high	low
climate	high	high	high	high	high
visibility	medium	low	low	medium	low
Participation and gover-nance	medium	low	low	medium	low
design	medium	low	low	low	low
mitigation	medium	medium	medium	low	none
Score	**31**	**31**	**29**	**28**	**27**

Metrics: Planning

	How many years do weather records go back?	Is there capacity to monitor weather and temperature conditions in real time at key locations in service area Y/N?	Number of real time monitoring stations	Ratio of monitoring stations/ service area in square miles	Percent of key assets with on site monitoring
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	none	medium	low	low	medium
severity	medium	high	medium	low	medium
equity	none	medium	low	medium	medium
feasibility	high	medium	high	high	medium
cost * (points reversed)	low	medium	low	low	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	low	medium	low	low	low
climate	medium	high	medium	high	high
visibility	low	medium	medium	low	medium
Participation and gover-nance	low	medium	low	low	medium
design	low	high	low	low	medium
mitigation	low	medium	medium	medium	medium
Score	**23**	**36**	**29**	**29**	**34**

Metrics: Operations

	Percent of extreme weather days vs. percent of normal days with service delays and cancellations	Percent of extreme weather days vs. percent of normal days with interruptions in telecommuni-cations	Percent of extreme weather days vs. percent of normal days with power outages and catenary line complications	Mean Distance Between Failure (MDBF) for buses by temperature and geography	Number of rail kinks/ buckling by temperature and by heat island areas
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	medium	medium	medium	high
severity	high	high	high	high	high
equity	medium	medium	medium	high	medium
feasibility	medium	medium	medium	medium	medium
cost * (points reversed)	medium	medium	medium	medium	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	high	medium	medium	high	medium
climate	high	high	high	high	high
visibility	medium	low	medium	high	medium
Participa-tion and governance	low	low	low	medium	low
design	medium	medium	medium	medium	medium
mitigation	low	none	low	medum	low
Score	**36**	**31**	**33**	**39**	**35**

Metrics: Operations

	Number of injuries/ medical emergencies to workers and riders by temperature and rainfall
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)	
criticality	medium
severity	high
equity	high
feasibility	medium
cost * (points reversed)	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)	
best practice	medium
climate	high
visibility	medium
Participation and governance	medium
design	medium
mitigation	low
Score	**37**

Metrics: Operations

	Percent insurance premium or bond rates spread for operations/ construction that are vulnerable to climate change	Are the costs of severe weather events being tracked (for federal disaster aid or otherwise) Y/N?	Is there a cost code associated with extreme weather so employees can mark down overtime, repairs etc as weather/ climate related Y/N?	What is the extra cost of extreme weather vs a baseline in $ and as percent of operating budget?	Loss in revenues from lower ridership on extreme weather days
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	medium	medium	medium	low
severity	high	high	high	high	medium
equity	low	low	medium	medium	medium
feasibility	medium	medium	medium	medium	high
cost * (points reversed)	medium	medium	high	high	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	low	medium	medium	medium	low
climate	medium	medium	medium	medium	medium
visibility	medium	high	medium	medium	medium
Participation and gover-nance	medium	medium	high	medium	medium
design	high	medium	low	low	medium
mitigation	medium	medium	medium	medium	none
Score	**34**	**33**	**33**	**31**	**31**

Metrics: Operations

	Percent increase in repair and replacement costs from accelerated reduction in state of good repair due to wear of extreme weather	Are savings from adaptation being measured/ calculated Y/N?	Percent savings for comparable extreme weather events with adaptation vs. without adaptation
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)			
criticality	medium	medium	medium
severity	medium	medium	medium
equity	low	low	low
feasibility	high	medium	medium
cost * (points reversed)	medium	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)			
best practice	medium	medium	low
climate			\
visibility	medium	medium	medium
Participation and governance	low	medium	low
design	high	low	medium
mitigation	medium	high	medium
Score	**30**	**30**	**26**

Metrics: Operations

	Does agency have a climate change preparedness team Y/N?	Percent of relevant divisions/ department actively represented on team	Percent of team participants authorized to make changes recommended by team in the adaptation planning process.	Number of technical advisors and members of the broader community included in team	Does agency collaborate with partner agencies, jurisdictions and organizations on climate adaptation Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	medium	high	low	low
severity	medium	low	low	low	low
equity	low	medium	medium	high	medium
feasibility	high	high	medium	high	high
cost * (points reversed)	medium	low	low	low	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	medium	low	medium	medium	medium
climate	medium	low	low	medium	medium
visibility	medium	medium	low	high	high
Participation and gover-nance	high	high	high	high	high
design	low	medium	medium	low	low
mitigation	medium	low	medium	medium	low
Score	**32**	**32**	**33**	**35**	**32**

Metrics: Adaptation

	Number of memoranda of understanding with partners	Number of other collaborations	Does agency use utilize the same climate projections/ models as partners Y/N?	Has agency identified mechanism for inter-agency coordination in place for other purposes that could be expanded to target climate change adaptation Y/N
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)				
criticality	low	low	medium	low
severity	none	low	medium	none
equity	medium	medium	none	low
feasibility	high	high	medium	medium
cost * (points reversed)	low	low	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)				
best practice	low	medium	low	low
climate	low	low	high	low
visibility	medium	medium	low	medium
Participation and governance	high	high	medium	high
design	low	low	none	low
mitigation	medium	medium	low	low
Score	**28**	**31**	**26**	**21**

Metrics: Planning

	Do agency design standards consider climate adaptation Y/N?	Percent of design and procurement standards for equipment and vehicles that require items to meet future climate conditions.	Has agency developed adaptation timeline for updating design and engineering standards Y/N?	Does agency utilize flood maps to determine facility design parameters such as drainage Y/N?	Percent of engieering standards that include tolerances for extreme weather events at the upper bounds of climate change projections
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	medium	medium	medium	medium
severity	medium	medium	medium	high	high
equity	medium	low	low	low	low
feasibility	medium	medium	high	high	medium
cost * (points reversed)	medium	medium	low	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	high	medium	medium	medium	medium
climate	medium	medium	low	medium	medium
visibility	low	low	low	low	low
Participa-tion and governance	medium	low	medium	low	low
design	high	high	high	medium	high
mitigation	medium	low	medium	low	low
Score	**35**	**28**	**29**	**33**	**30**

Metrics: Adaptation

	Does agency's asset management system measure heat and flood vulnerabilities for each asset Y/N?	Percent of assets considered to have significant vulnerability to heat	Percent of assets considered to have significant vulnerability to flooding	Has agency mapped urban heat islands across service area (or have access to map) Y/N?	Percents of above ground assets, critical assets, and vulnerable assets in urban heat islands
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	medium	medium	medium	high
severity	high	high	high	high	high
equity	medium	low	low	medium	medium
feasibility	medium	medium	medium	medium	medium
cost * (points reversed)	high	medium	medium	medium	high
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	medium	medium	medium	medium	low
climate	medium	medium	medium	medium	low
visibility	low	low	low	medium	low
Participation and governance	medium	low	low	low	low
design	medium	Medium	medium	low	medium
mitigation	medium	low	low	low	medium
Score	**33**	**29**	**29**	**31**	**30**

Metrics: Adaptation

	Percent of urban heat islands in service area with above average and majority transit dependent populations	Percent of Metro facilities and vehicles utilizing cool roofs	Percent foliage coverage at metro stations	Does agency have overheating standards for public transport facilities and rolling stock Y/N?	Percent of bus stops with shade
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	low	medium	medium	medium	low
severity	medium	medium	low	high	medium
equity	high	medium	low	medium	high
feasibility	medium	high	medium	high	medium
cost * (points reversed)	medium	low	low	medium	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	low	medium	low	medium	low
climate	medium	low	low	medium	low
visibility	medium	medium	medium	medium	high
Participation and gover-nance	medium	low	low	medium	medium
design	medium	high	medium	high	high
mitigation	low	high	medium	medium	low
Score	**30**	**36**	**27**	**37**	**33**

Metrics: Adaptation

	Percent of bus stops with seating	Percent of stations and stops with drinking water source	Does agency have timeline for adaptation efforts to reduce temperature at stops and stations Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)			
criticality	low	medium	medium
severity	low	medium	medium
equity	high	high	medium
feasibility	medium	medium	medium
cost * (points reversed)	low	low	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)			
best practice	none	low	low
climate	none	low	medium
visibility	low	medium	low
Participation and governance	low	low	medium
design	high	high	medium
mitigation	none	none	low
Score	**25**	**32**	**27**

Metrics: Adaptation

	Percent increase in power and fuel consumption on hot days vs. normal days	Percent of Metro's power generated from onsite renewable energy production	Percent of metro properties with on site energy generation
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)			
criticality	low	low	medium
severity	high	low	low
equity	none	low	low
feasibility	medium	high	high
cost * (points reversed)	medium	low	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)			
best practice	low	low	low
climate	medium	none	none
visibility	low	medium	high
Participation and governance	low	low	low
design	medium	medium	high
mitigation	high	high	high
Score	**26**	**27**	**31**

Metrics: Adaptation

	Percent of stations with capacity and efficiency of pumping and drainage systems to cope with flooding scenarios based on future precipitation and sea level rise projections	Percent difference in frequency of stormwater management equipment maintenance at facilities with high flood risk vs typical facility.	Percent of facilities with bioswales or other natural stormwater management systems	Percent of stormwater managed by agency that is managed by natural systems
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)				
criticality	medium	high	medium	low
severity	high	medium	medium	medium
equity	low	low	medium	low
feasibility	medium	medium	high	medium
cost * (points reversed)	medium	medium	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)				
best practice	high	medium	low	low
climate	medium	low	none	none
visibility	low	low	high	medium
Participation and governance	low	low	medium	low
design	high	high	high	medium
mitigation	none	none	low	medium
Score	**30**	**27**	**34**	**24**

Metrics: Adaptation

	Does agency have emergency procedures for high heat days, significant rain/ flooding events, and service interruptions Y/N?	Have these procedures been evaluated based on their performance in a real world weather emergencies Y/N?	Are there communication channels to alert public about weather-related delays, cancellations, etc Y/N?	Have these communication channels been tested and evaluated Y/N?	Percent of critical and vulnerable facilities with site specific emergency plans.
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	medium	medium	low	low	high
severity	high	high	medium	medium	medium
equity	medium	medium	high	medium	low
feasibility	medium	medium	medium	medium	medium
cost * (points reversed)	high	high	medium	medium	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	medium	low	medium	low	medium
climate	medium	medium	medium	low	low
visibility	medium	medium	high	high	medium
Participation and governance	high	medium	high	high	medium
design	medium	medium	medium	low	medium
mitigation	low	low	none	none	low
Score	**32**	**30**	**28**	**27**	**30**

Metrics: Adaptation

	Percent of rail stations, bus yards and other critical facilities with back- up generator capacity	Does agency have policies to modify construction schedules and labor practices to protect workers from high heat Y/N?	Does agency have designated evacuation routes for buses and emergency vehicles, including pick-up and drop-off points Y/N?	How many people can the agency evacuate in the event of a weather emergency	Have transit dependent and vulnerable populations been identified and/or mapped using established methods Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	low	medium	low	low
severity	medium	medium	high	high	medium
equity	low	high	high	high	high
feasibility	medium	high	medium	medium	medium
cost * (points reversed)	medium	medium	medium	medium	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	low	low	low	low	low
climate	low	medium	low	low	none
visibility	low	medium	high	high	medium
Participation and gover- nance	medium	medium	high	high	medium
design	high	high	Medium	medium	medium
mitigation	low	low	low	low	low
Score	**29**	**33**	**35**	**33**	**28**

Metrics: Adaptation

	Percent of rolling stock that is standing reserve available to cover broken down vehicles?	Percent of passengers who can be moved by alternative modes if one or more rail lines are closed by extreme weather?	Minimum level of back-up generator capacity to allow rail and bus operations for 24 and 48 hours.	Percent of stations and facilities with required level of back up generating capacity	Minimum level of compressed natural gas reserves to power 50% of bus fleet for one week
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	medium	medium	medium	medium	low
severity	medium	high	medium	medium	medium
equity	medium	high	medium	medium	medium
feasibility	high	medium	medium	medium	medium
cost * (points reversed)	medium	medium	medium	medium	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	medium	low	low	low	none
climate	low	medium	low	low	low
visibility	low	medium	low	low	low
Participation and gover-nance	low	low	low	low	low
design	low	low	medium	medium	low
mitigation	low	low	medium	medium	low
Score	**29**	**32**	**29**	**29**	**23**

Metrics: Adaptation

	Percent of this reserve natural gas currently held and available by agency	Does agency have back up plan for failure of electric grid Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)		
criticality	low	medium
severity	medium	high
equity	medium	low
feasibility	medium	medium
cost * (points reversed)	medium	high
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)		
best practice	None	low
climate	Low	medium
visibility	Low	medium
Participation and governance	Low	high
design	Low	high
mitigation	low	medium
Score	**23**	**31**

Metrics: Riders

	Does agency have demographic analysis of its service area and ridership Y/N?	Has agency conducted a cumulative impact analysis of climate change on the public, especially on the most vulnerable populations Y/N?	Do agency's environmental impact assessments and/or related documents identify the potential for disproportionate impacts to impacts to minority, low income and disadvantaged populations from potential climate impacts Y/N	Percent of weather-related service delays/ cancellations that occur in areas with above average transit-dependent populations.	Has agency surveyed riders on how their travel patterns change during high heat or heavy rain Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	medium	low	medium	medium	low
severity	low	medium	medium	high	medium
equity	high	high	high	high	high
feasibility	high	medium	medium	medium	medium
cost * (points reversed)	medium	high	high	medium	high
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	medium	low	low	low	low
climate	none	medium	medium	low	medium
visibility	medium	medium	medium	low	high
Participa-tion and gover-nance	medium	high	high	medium	medium
design	low	medium	medium	medium	medium
mitigation	medium	medium	medium	medium	medium
Score	**29**	**30**	**32**	**33**	**28**

Metrics: Riders

	Percent of residents living within walking distance of transit stations and/or high quality bus corridors	Percent of transit dependent service area population lives within convenient walk of train station or frequent bus route	Percentage of stations with clean mobility centers	Percent of stations with joint development plans, land use plans, and/or MOUs to increase density of housing and/or employment near station site
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)				
criticality	medium	medium	medium	medium
severity	low	low	none	low
equity	medium	high	medium	medium
feasibility	medium	medium	high	medium
cost * (points reversed)	low	low	low	medium
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)				
best practice	medium	medium	none	low
climate	low	low	none	low
visibility	medium	medium	high	high
Participation and governance	low	low	low	high
design	medium	medium	high	high
mitigation	medium	low	medium	high
Score	**30**	**31**	**29**	**30**

Metrics: Planning

	Existence of an ongoing and regularly convening team tasked with implementing climate adaptation plans. Y/N?	Number of staff tasked with implementing climate adaptation actions.	Percent of top priority climate adaptation recommen-dations/ actions from adopted plans implemented	Does agency publish regular reports or updates on climate adaptation efforts Y/N?	Does agency conduct regular planning updates to incorporate new climate change information and best practices into adaptation plans Y/N
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)					
criticality	high	medium	high	medium	high
severity	high	medium	high	medium	high
equity	medium	low	medium	medium	medium
feasibility	medium	high	medium	medium	medium
cost * (points reversed)	high	low	high	medium	high
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)					
best practice	high	medium	medium	medium	Medium
climate	medium	low	medium	medium	High
visibility	medium	medium	medium	high	low
Participa-tion and gover-nance	high	medium	high	medium	high
design	medium	low	high	medium	high
mitigation	high	medium	high	medium	medium
Score	**37**	**32**	**37**	**33**	**36**

Metrics: Planning

	Are climate vulnerabilities and the adaptation of assets tracked in agency's Environmental Management System and/or Asset Management System Y/N?	Percent progress in reducing vulnerabilities based on meta-analysis of climate adaptation indicators in EMS and/or asset management system.	Funding needed to implement priority adaptation efforts	Does agency have category for climate adaptation or category into which adaptation funding can fit Y/N?
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)				
criticality	high	high	high	low
severity	high	high	high	low
equity	medium	medium	medium	low
feasibility	medium	medium	medium	high
cost * (points reversed)	high	high	medium	low
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)				
best practice	high	low	low	low
climate	medium	medium	low	low
visibility	low	medium	medium	medium
Participation and governance	high	high	high	medium
design	high	high	medium	low
mitigation	medium	medium	medium	low
Score	**36**	**35**	**35**	**26**

Metrics: Planning

	Amount of money saved based on implemented preparedness action
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)	
criticality	medium
severity	medium
equity	medium
feasibility	medium
cost * (points reversed)	high
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)	
best practice	low
climate	low
visibility	medium
Participation and governance	medium
design	medium
mitigation	low
Score	**27**

Metrics: Riders

	Participation rates of public or advisory members in its internal climate change adaptation team or committee meetings	Records kept of outreach and numbers of stakeholders/ members of public engaged on climate adaptation in person and on-line Y/N	Number of stakeholders/ members of public engaged per year	Does agency request, collect, analyze and publish recom-mendations from public on climate change adaptation? Y/N
Core criteria (none = 0 pts, low = 2 pts, medium = 4 pts, high = 6 pts)				
criticality	low	low	medium	medium
severity	low	low	low	medium
equity	medium	high	medium	medium
feasibility	high	high	medium	medium
cost * (points reversed)	low	medium	medium	high
Multiple benefit criteria (none = 0 pts, low = 1 pt, medium = 2 pts, high = 3 pts)				
best practice	low	low	medium	low
climate	medium	low	low	low
visibility	medium	low	high	high
Participation and governance	high	medium	medium	high
design	low	none	low	medium
mitigation	medium	none	low	low
Score	**31**	**25**	**28**	**29**

APPENDIX 2: LITERATURE REVIEW

A review of the literature found that the most relevant information was contained in reports on climate adaptation efforts and pilot projects by transit agencies and large cities with mass transit systems in the United States and abroad. Because climate adaptation is a relatively new field and transit operators are just beginning to focus on the task, there are a relatively small number of directly applicable studies and plans. UEPI also reviewed literature on climate adaptation focusing on infrastructure, public health, and community engagement, which contained some recommendations that may be relevant to Metro's climate adaptation plans and processes.

This appendix summarizes the results of the literature reviews. Numbers in the table of metrics derived from the literature correspond to the list of documents in the bibliography.

I. List of Metrics Suggested by Literature Review

Metric and/or adaptation action	Suggested by *
Evaluating adaptive capacity	
Regulatory and institutional tools (such as policy processes) for adapting to climate change **and** barriers to accommodating changes in climate have been identified, such as requiring regulations and design standards to be based on historic climate conditions.	1, 2

• Have complete range of implementation tools (authority and/or avenues over which an organization has control or influence in policy, planning and infrastructure) that Metro possesses been identified Y/N?
  • Percent that include climate concerns
  • Have major barriers to incorporating climate adaptation into implementation processes/ tools been identified Y/N?
	1

Mapping vulnerabilities: climate, operations, finances and service. Climate change adaptation plans must go beyond broad generalizations of climate change impacts to transit infrastructure and operations by determining what impacts are most likely to occur, and how can levels of risk associated with the impacts be estimated. Furthermore, Non-climate change related factors that might influence climate change adaptations plans should be tracked as well. These include socioeconomic and demographic factors, and federal, state and local adaptation policies.	
*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *

• Has a vulnerability assessment been conducted to identify the range of current and expected stresses on operations and system. Y/N?
  • Critical assets identified Y/N?
  • Percent of critical assets assessed?
  • Percent of all stations and lines assessed?
  • Most vulnerable assets identified Y/N
  • Impacts on riders analyzed Y/N?
  • Overlay of most vulnerable areas and assets with transit dependent and low-income populations Y/N?
  • Adaptation actions prioritized Y/N?
	1, 3, 4, 5, 6, 25,27, 28, 29

Climate modeling and weather monitoring
• Is a regional climate model (RCM) available to better determine locali impacts of climate change. Y/N?
  • Percent of service area covered by regional climate model
  • what is 'resolution' of RCM? (size of grid squares)
  • Is there a record of historical weather patterns for the service area Y/N?
  • Percent of service area covered by weather records
  • how many years do records go back?
  • Is there capacity to monitor weather and temperature conditions in real time at key locations in service area Y/N?
  • Number of real time monitoring stations
  • Ratio of monitoring stations/ service area in square miles
  • Percent of key assets with on site monitoring
	2, 4, 7, 8, 25

*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *

Operations and service
• Percent of extreme weather days vs. percent of normal days with interruptions in telecommunications
  • Percent of extreme weather days vs. percent of normal days with service delays and cancellations
  • Percent of extreme weather days vs. percent of normal days with power outages and catenary line complications
  • Mean Distance Between Failure (MDBF) for buses by temperature and geography
  • Number of rail kinks/ buckling by temperature and by heat island areas
  • Number of injuries/ medical emergencies to workers and riders by temperature and rainfall
	6, 9, 10, 12, 25, 27, 29, 30

Finances
• Percent insurance premium or bond rates spread for operations/ construction that are vulnerable to climate change Y/N?
• Are the costs of severe weather events being tracked (for federal disaster aid or otherwise) Y/N?
  • Is there a cost code associated with extreme weather so employees can mark down overtime, repairs etc as weather/ climate related Y/N?
  • What is the extra cost of extreme weather vs a baseline in $ and as percent of operating budget?
  • Loss in revenues from lower ridership on extreme weather days
  • Percent increase in repair and replacement costs from accelerated reduction in state of good repair due to wear of extreme weather
• Are savings from adaptation being measured/ calculated Y/N?
  • Percent savings for comparable extreme weather events with adaptation vs. without adaptation
	2, 27, 29, 30

Coordinating activities across departments, jurisdictions and levels of government How well your government and community responds to the consequences of climate change may not only depend on the preparedness of an individual department, but also on numerous, cumulative actions across departments, divisions and programs.	
*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *
Does agency have a climate change preparedness team Y/N? • Percent of relevant divisions/ department actively represented on team • Percent of team participants authorized to make changes recommended by team in the adaptation planning process. • Number of technical advisors (external scientific advisors) and members of the broader community (non-governmental organizations, businesses, other jurisdictional agencies and informal community leaders) included in team	4, 8
Does agency collaborate with partner agencies, jurisdictions and organizations on climate adaptation Y/N? • Number of memoranda of understanding with partners • Number of other collaborations • does agency use utilize the same climate projections/ models as partners Y/N? • Has agency identified mechanism for inter-agency coordination in place for other purposes that could be expanded to target climate change adaptation Y/N	1, 4, 13
Design issues and standards Climate change will require building infrastructure beyond current specifications, as well as updating design standards. Transportation engineering must focus on how environmental conditions over a longer timeframe could affect engineering design should occur, and in particular, whether current design standards and principles are adequate for infrastructure that could potentially be exposed to a wider range of weather extremes.	
Infrastructure designs based on climate variables and impacts expected at date of implementation and beyond. • Percent of engineering standards that include tolerances for extreme weather events at the upper bounds of climate change projections • Percent of design and procurement standards for equipment and vehicles that require items to meet future climate conditions. • Has agency developed adaptation timeline for updating design and engineering standards Y/N?	4, 10, 12, 14, 15, 20, 25, 28
Infrastructure siting • Does agency utilize flood maps to determine facility design parameters such as drainage Y/N?.	7, 10,
*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *
Infrastructure adaptation Transportation Research Board (TRC, 2008, p 193): "state and local governments and private infrastructure providers should incorporate climate change into their long-term capital improvement plans, facility designs, maintenance practices, operations, and emergency response plans.'	

Asset management
• Does agency's asset management system measure heat and flood vulnerabilities for each asset Y/N?
  • Percent of assets considered to have significant vulnerability to heat
  • Percent of assets considered to have significant vulnerability to flooding
	4, 7, 17, 20

Reduce heat impacts on facilities, building materials, users and rolling stock:
• Has agency mapped urban heat islands across service area (or have access to map) Y/N?
  • Percent of above ground assets in urban heat islands
  • Percent of critical assets in urban heat islands
  • Percent of most vulnerable assets in urban heat islands
  • Percent of urban heat islands in service area with above average and majority transit dependent populations
• Percent of Metro facilities and vehicles utilizing cool roofs (roofs constructed with high-albedo materials that reflect and emit heat, thus reducing solar energy absorption).
• Percent foliage coverage at metro stations
• does agency have overheating standards for public transport facilities and rolling stock Y/N?
• Percent of bus stops with shade
• Percent of bus stops with seating
• Percent of stations and stops with drinking water source
• Does agency have timeline for adaptation efforts to reduce temperatures Y/N?
	3, 21, 23, 25, 29

Identify energy demands & generation opportunities • Percent increase in power and fuel consumption on hot days vs. normal days • Percent of Metro's power generated from onsite renewable energy production (solar, wind, geothermal, biomass etc) • Percent of metro properties with on site energy generation)	20, 24, 29
*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *
Reduce precipitation impacts on facilities, building materials and rolling stock, • Percent of stations with capacity and efficiency of pumping and drainage systems to cope with flooding scenarios based on future precipitation and sea level rise projections • Percent difference in frequency of stormwater management equipment maintenance at facilities with high flood risk vs typical facility. • Percent of facilities with bioswales or other natural stormwater management systems • Percent of stormwater managed by agency that is managed by natural systems	3, 8, 21, 24, 25
Emergency preparedness	
Procedures and plans • Does agency have emergency procedures for high heat days, significant rain/ flooding events, and service interruptions Y/N? • Have these procedures been evaluated based on their performance in a real world weather emergencies Y/N? • Are there communication channels to alert public about weather-related delays, cancellations, etc Y/N? • Have these communication channels been tested and evaluated Y/N? • Percent of critical and vulnerable facilities with site specific emergency plans. • Percent of rail stations, bus yards and other critical facilities with back- up generator capacity • Does agency have policies to modify construction schedules and labor practices to protect workers from high heat Y/N?	1, 2, 25
System capacity • Percent of rolling stock that is standing reserve available to cover broken down vehicles? • Percent of passengers who can be moved by alternative modes if one or more rail lines are closed by extreme weather? • Minimum level of back-up generator capacity to allow rail and bus operations for 24 and 48 hours. • Percent of stations and facilities with required level of back up generating capacity • Minimum level of compressed natural gas reserves to power 50% of bus fleet for one week • Percent of this reserve natural gas currently held and available by agency • Does agency have back up plan for failure of electric grid Y/N?	3
*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *
Transit's role in society-wide emergency preparedness • Does agency have designated evacuation routes for buses and emergency vehicles, including pick-up and drop-off points Y/N? • How many people can the agency evacuate in the event of a weather emergency • Have transit dependent and vulnerable populations been identified and/ or mapped using established methods Y/N? [see Los Angeles County Operational Area (LACOA) Specific Needs Awareness Plan (SNAP)] Y/N?	22, 26, 27,
Transit, land use and vulnerable populations	
Prioritize adaptation measures in high-use, high need areas. • Does agency have demographic analysis of its service area and ridership Y/N? • Has agency conducted a cumulative impact analysis of climate change on the public, especially on the most vulnerable populations Y/N? • Do agency's environmental impact assessments and/or related documents identify the potential for disproportionate impacts to impacts to minority, low income and disadvantaged populations from potential climate impacts Y/N • Has agency surveyed riders on how their travel patterns change during high heat or heavy rain Y/N? • Percent of increased service delays/ cancellations attributable to weather that occur in areas with above average transit-dependent populations.	8, 9, 11, 16, 27
Encourage land uses, joint use development and last mile access so that more residents live near transit • Percent of residents living within walking distance of transit stations and/or high quality bus corridors • Percent of transit-dependent service area population lives within convenient walk of train station or frequent bus route • Percentage of stations with clean mobility centers • Percent of stations with joint development plans, land use plans, and/or MOUs to increase density of housing and/or employment near station site	11, 24
Performance monitoring Measuring progress of climate adaptation efforts should happen at multiple levels and for multiple audiences, including the internal team as well as with partners and the public.	
*number corresponds to bibliography entry.	

Metric and/or adaptation action	Suggested by *
Assess the "mainstreaming" of climate adaptation into decision making in priority planning areas. • Existence of an ongoing and regularly convening team tasked with implementing climate adaptation plans. Y/N? • Number of staff tasked with implementing climate adaptation actions. • Percent of top priority climate adaptation recommendations/ actions from adopted plans implemented • Does agency have guidelines on how to integrate new or updated information on climate change vulnerability, risk and preparedness into decision making Y/N? • Are climate vulnerabilities and the adaptation of assets tracked in agency's Environmental Management System and/or Asset Management System Y/N? • Percent progress in reducing vulnerabilities based on meta-analysis of climate adaptation indicators in EMS and/or asset management system. • Does agency publish regular reports or updates on climate adaptation efforts Y/N?	2, 4, 8, 18, 28, 29
Financial feasibility—climate adaptation budgeting • Funding needed to implement priority adaptation efforts • Percent of this funding provided in annual budget. • Does agency capital and/or operating budget have category for climate adaptation or category into which adaptation funding can fit Y/N? • Amount of money saved based on implemented preparedness actio	1, 8, 29
Evaluate community partnerships and stakeholder engagements in climate adaptation process. • Participation rates of public or advisory members in its internal climate change adaptation team or committee meetings • Records kept of outreach and numbers of stakeholders/ members of public engaged on climate adaptation in person and on-line Y/N • Number of stakeholders/ members of public engaged per year • Does agency request, collect, analyze and publish recommendations from public on climate change adaptation? Y/N	1, 18, 22
Regularly review assumptions and performance measurements in regards to climate change preparedness and adaptation. • Does agency conduct regular planning updates to incorporate new climate change information and best practices into adaptation plans Y/N	1, 8, 9, 28
*number corresponds to bibliography entry.	

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The guidebook is intended to assist local, regional, or state governments prepare for climate change. It lays out a process that includes scoping potential impacts on important social and economic sectors; involving the public; creating a planning team; conducting vulnerability and risk assessments; developing a vision and tools for a climate resilient community; creating a climate change preparedness plan; and developing and tracking measures of resilience.

2. Jacob, Klaus, and Reginald Blake, Radley Horton, Daniel Bader, Megan O'Grady. "Chapter 7: Indicators and monitoring". *New York City Panel on Climate Change 2010 Report,* Annals of the New York Academy of Sciences. 1196:1 (2010). 127-142.

This chapter contains recommendations for tracking and monitoring indicators to help the New York City region more effectively adapt to climate change. It suggests indicators related to climatic conditions, climate science, climate impacts, and adaptation activities, based on policy relevance, analytical soundness and measurability.

3. "Adapting to climate change: Lessons for London". London Climate Change Partnership. Greater London Authority, London. 2006.

This review examines eighteen case studies of climate adaptation measures to understand how cities within Europe, the United States, Japan, China and Australia are addressing three climate risks—flooding, high temperatures and limited water resources—with a focus on how such measures could potentially benefit London. The general conclusions and key recommendations include identifying the need for city-wide planning, as well as partnerships between different organizations, and across geographic boundaries; that climate change needs to be considered in short, medium and long-range decision-making, recognizing the interactions between different measures; that holistic, integrated thinking is required to manage climate risks most effectively; and that the opportunities for "climate-proofing" new developments are easier to realize, and must be driven through the planning process.

4. "Mainstreaming Climate Change Adaptation Strategies Into New York State Department of Transportation's Operations: Final Report". Prepared for the New York State Department of Transportation by the Center for Climate Systems Research. 2011.

This study identifies climate change adaptation strategies and best practices, and recommends ways of mainstreaming them into planned actions, including legislation, policies, programs and projects in all areas and at all levels within the New York State Department of Transportation (NYSDOT) in light of climate change impacts and vulnerabilities in NYS. The study's recommendations are presented in eleven categories: planning policies and guidelines, organization and management, inter- and intra-agency coordination, regional aspects of adaptation planning, vulnerability inventories, design issues, infrastructure adaptations, monitoring and assessment, training needs, communications, and research needs.

5. "Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation". FTA Report No. 0001, Federal Transit Administration. 2011.

This report discusses potential climate change impacts on public transit and adaptation strategies to help transit adapt to climate change. It considers precipitation, temperature, sea level rise, severe weather and combined impacts. The report provides best practices and case studies from domestic and foreign transit agencies on how to assess vulnerabilities, develop adaptation strategies, and implement strategies.

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7. Walker, Lindsay, and Miguel A. Figliozzi, Ashley R, Haire, and John MacArthurt. "Identifying Surface Transportation Vulnerabilities and Risk Assessment Opportunities Under Climate Change". *Transportation Research Record: Journal of the Transportation Research Board, No. 244,* Transportation Research Board of the National Academies. (2011) 41-49.

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This strategic plan is a framework for King County's mitigation and adaptation plans and strategies. It includes emission reduction strategies, adaptation plans, and public outreach and collaboration plans.

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Zimmerman and Faris discuss the challenges to climate change adaptation in major urban infrastructure sectors, focusing on New York, and draw lessons from adaptation efforts underway in other large metropolitan regions. They argue that understanding the characteristics of a city's infrastructure that make it particularly vulnerable to the impacts of climate change is a critical foundation for understanding the severity of the impacts and the means for adaptation.

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This paper explores how transportation infrastructure could be impacted by climate change. It recommends an adaptive systems management approach to help anticipate likely climate changes, identify vulnerabilities in the transportation system, and assess different strategies for mitigating potential impacts.

11. California Environmental Health Tracking Program, "ASTHO Climate Change Population Vulnerability Screening Tool." California Department of Public Health. 2012.

This report used an Environmental Justice Screening Methodology (EJSM) to assess vulnerability to climate change impacts in different census tracts in Fresno and Los Angeles Counties. Indicators include access to transit. By describing the process, the report suggests how jurisdictions and agencies can identify populations and areas that are particularly vulnerable to the impacts of climate change.

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This report suggests managing weather and climate related natural hazards to avoid or minimize damage to railway infrastructure. It suggests a process consisting of gathering weather Information; documenting past weather events; mapping natural hazards; monitoring infrastructure status; mapping vulnerability; assessing risk; analyzing regional climate models and risks; and adopting adaptation strategies.

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This report evaluates the potential risks of climate change to London's transport systems and recommends how the risks identified can be incorporated into transport management strategies. The report includes case studies of station flooding, infrastructure damage from high temperatures, and customer comfort in underground stations.

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This plan includes strategies for reducing greenhouse gas emissions from Metro operations and for adapting to higher temperatures and more severe weather and precipitation. The climate adaptation section of the plan summarizes weather records and anticipated changes in climate for Los Angeles County; assesses the criticality and vulnerability of assets to climate change; and recommends adaptation actions.

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Special Report 294 was requested by Congress and funded by the Federal Transit Administration and the Transit Cooperative Research Program to investigate the role of transit in emergency planning and emergency operating procedures, in the wake of September 11 and Hurricane Katrina. It contains a literature review and assessment of publicly available emergency response and evacuation plans for 38 large urbanized areas, and five in-depth case studies, including the Los Angeles urban area. The report finds that the majority of such plans are only partially sufficient in describing in specific and measurable terms how a major evacuation could be conducted successfully, and even fewer focus on the vitally important role that transit can play in the four components of emergency planning: mitigation, preparedness (decision making structures), response, and recovery.

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This pilot project is analyzing a light rail line for historical impacts of extreme weather; projecting future impacts from a changing climate; and identifying and prioritizing adaptation actions for the agency and line.

28. Metropolitan Atlanta Rapid Transit Authority, Georgia Institute of Technology, Parsons Brinckerhoff. Transit Climate Adaptation Pilot. Presentation to FTA Peer Exchange Webinar. November 2012.

This pilot project is studying how a transit agency can use an enterprise asset management system to monitor climate changes and help identify response strategies.

29. Chicago Transit Authority and TransSystems Consulting. An Integrated Approach to Climate Adaptation for Transit Assets in Chicago. Presentation to FTA Peer Exchange Webinar. November 2012.

This update describes progress made on CTA's pilot project to survey vulnerabilities of twenty to thirty types of assets; analyze three types of risk in detail; and develop long-term strategies to mainstream climate adaptation into asset management, operations planning and other standard business practices.

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This report presents a framework for transit agencies to use for prioritizing capital asset rehabilitation and replacement decisions. The report includes equations and spreadsheets models for tracking and calculating state of good repair.

APPENDIX

D

Outreach Elements

CLIMATE RESOLVE

Messaging Strategy for Metro's Climate Change Adaptation Pilot Program
May 20, 2013
Prepared by Climate Resolve
for the Los Angeles County Metropolitan Transportation Authority (Metro)

Background

The Los Angeles County Metropolitan Transportation Authority (Metro) has emerged in recent years as a leader in climate adaptation planning in the transit sector. In June 2012, Metro adopted a Climate Action and Adaptation Plan (CAAP), which identifies greenhouse gas emissions and mitigation opportunities under Metro's operational control, as well as major climate-related vulnerabilities and options for targeted, cost-effective adaptation measures.

Shortly after adoption of the plan, Metro became one of seven metropolitan transit agencies selected to participate in a Federal Transportation Authority (FTA) pilot program on adaptation planning. Metro is now taking their adaptation planning to the next level by piloting integration of climate principles in transit maintenance and operations, starting first with the incorporation of key principles into their Environmental Management System (EMS) agency-wide framework. Metro has also begun to lay the groundwork for broader integration of climate principles into transit systems with the development of metrics and procedures to evaluate the effectiveness of these efforts. The final phase of the project includes conducting outreach to share the successes of the pilot with the public, other transit agencies, and Metro staff. As Metro continues to pursue further adaptation efforts in the future, especially in terms of messaging with external audiences, it will be important for Metro to identify their own accomplishments as well as clarify gaps and future needs for climate adaptation planning in the transit sector, including the need for additional work by other government agencies to ensure the region is adequately prepared.

Metro requested support from Climate Resolve for the development of an outreach plan and messaging strategies to communicate their efforts. Founded in 2011, Climate Resolve is the only organization in Los Angeles dedicated to telling the local climate story. Working alongside City of Los Angeles staff, top-rated universities, and a variety of regional coalitions and non-profits, Climate Resolve specializes in communicating local science to a diverse range of audiences while championing cost-effective adaptation strategies and policy measures. Climate Resolve worked closely with Metro's Environmental Compliance Services division and communications team to develop a messaging strategy for future outreach. This report was prepared for Metro by Climate Resolve to detail the recommended messaging strategy.

Overview of Audiences

As one of the nation's largest transit providers, it is Metro's responsibility to plan for potential climate-related impacts to facilities and operations. While the work completed thus far is

progressive, communicating these successes to a diverse range of audiences, both within the organization and outside, will be critical to continued support in the future.

Internally, Metro has the opportunity to connect with 9,200 employees within numerous departments and committees as well as a 13-member Board of Directors (including the sitting Mayor of Los Angeles). While Metro's pilot climate adaptation project is focused on strategies within the Operations Division, the ECS Department is interested in communicating the effort across other departments to share information about the pilot, sustain progress, and encourage future development of a climate adaptation strategy.

Externally, there are a number of regional parties that are leaders in climate change adaptation planning, many of whom are in the process of developing Sustainable Community Strategies (as required by SB 275). Within Los Angeles County, there are several Councils of Governments (COGs) that have made transit a priority; additionally, the Southern California Association of Governments (SCAG) considers public transportation and climate adaptation within their scope. Other crucial organizations to consider for external outreach include research institutions, local municipalities, including Los Angeles County and the City of Los Angeles, and relevant non-profits and organized networks, including the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC).

The Los Angeles region is home to several other transit providers, including LADOT, Long Beach Transit, Antelope Valley Transit Authority, Big Blue Bus and many others. While several of these providers are represented on subcommittees of Metro's Technical Advisory Committee, it is recommended that Metro develops targeted messaging for all regional transit providers. By reaching out to the above entities, Metro will not only promote progress in climate adaptation planning for transit in the LA region, but also open the lines of communication with regional experts who may be able to provide assistance as Metro moves forward.

Lastly, nearly 10 million individuals and potential riders live within Metro's service area and serve as a crucial audience and champion for efforts. In the past, Metro has done a skilled job of alerting customers to sustainability efforts – climate adaptation measures can certainly be weaved in to this established outreach.

Communication Goals

Climate Resolve, with input from Metro, developed the following communication goals as well as Key Concepts and Messages for the Climate Change Adaptation Pilot Outreach (details on the development process are provided in a "Key Concepts" report submitted to Metro on April 8, 2013).

- Show leadership by demonstrating Metro's commitment to climate adaptation planning to ensure the transit system is safe, effective, and prepared for a changing climate (G1)

- Share information on Metro's climate adaptation planning to inform and help others offer safe, cost effective, and dependable transit, and to identify and leverage natural co-benefits (G2)
- Address concerns and questions about whether Southern California transit will meet the areas needs in the face of a changing climate (G3)
- Call to action for others to also proactively mitigate and prepare for impacts of climate change (G4)

The next section associates key messages with specific target audiences and discusses recommended strategies for reaching the audience. Recommended strategies including:

- High-level briefings with Metro's Board of Directors
- Establishing an agency-wide Adaptation Task Force
- Adding a 1-page insert to the Environmental Management System (EMS) documentation
- Using a variety of print materials (brochures, memos, and posters)
- Publishing articles in *Metro People*, *The Source*, and *Metro Insider*
- Providing regular updates at BOS and LTSS quarterly meetings
- Participation by Metro in relevant regional organizational meetings
- Conducting cooperative outreach to local organizations
- Posting content on Metro.net
- Strategically posting content on social media sites (Twitter and Facebook)
- Publishing press releases
- Conducting outreach with local media, blogs, and at public events
- Develop a synthesis report on Metro's Climate Change Adaptation Program

In addition to audience-specific messaging strategies noted above and described below, we recommend Metro consider developing a "synthesis report" on their Climate Change Adaptation Pilot Program, essentially drawing together summary information from existing reports and the final report to FTA. The report can be used to communicate with any number of audiences and would cover background information on Metro's adopted Climate Change Action and Adaptation Plan as well as findings and efforts completed through the FTA pilot program. The content should stay at a high-level, focusing on key findings, developments or plans, and next steps. The brief should be less than 10 pages, including visually-rich graphics, images, and tables to reinforce and supplement prose, and geared toward an audience of sector-experts and professionals. A section of the summary report could outline next steps the agency will take in preparation for anticipated impacts on infrastructure and the organization in the wake of a changing climate. Factsheets and a FAQ document based on the content of the synthesis report could also be developed by Metro to provide easily accessible general highlights about the program, and a quick identification of key gaps and needs moving forward.

Metro could make the report, fact sheet, and FAQ document available on their website – perhaps featuring the release of the synthesis report on the front page of Metro.net, and at least under the auspices of the Sustainability portion of the site. Promotion of the report can be

done through established social media channels (including Twitter and Facebook) and Metro's online blog, *The Source.* In addition, it is recommended that this report be available in print and distributed at any relevant meetings or events.

Messaging Strategies by Key Audience

Board of Directors

Key Messages to Metro's Board of Directors

Metro is a national leader in transit climate adaptation. Out of the seven entities in the FTA program, Metro is the only one with a fully articulated climate action and adaptation plan, ready to ingrate adaptation planning into maintenance and operations procedures.

LA is being impacted by climate change – and Metro will meet the challenge.

LA is getting warmer; there will be more severe floods, dusty conditions, and weather-related flooding. Metro is proactively preparing for these climate impacts.

By acting now, Metro will avoid costly consequences such as fleet and equipment malfunctions and railway buckling during periods of extreme heat, and flooding of underground stations and tracks, at-grade railways and bus rapid transit right of ways. Metro will make their transit system better today, ensuring a safe and reliable transit system for the future.

Metro's 13-member Board of Directors provides agency oversight and high-level decision making for the agency's operations, image, finances, and direction. As recommendations from the Climate Change Adaptation Pilot Program will likely shape initiatives that Metro pursues in the future, informing the Board early and often on climate adaptation planning will be important for ensuring long-term support on this and other future climate change-related initiatives.

We recommend that Metro's Board of Directors receive a high-level briefing at the completion of the FTA pilot with regular progress reports of the adaptation program as it moves forward. The Synthesis Report noted above could also be distributed to Board members during the first briefing.

Metro may also consider asking the Board to establish an Agency-wide Adaptation Task Force. Preparing for climate change occurs within multiple departments of Metro, including planning, budgeting, and transit operations, and each department has unique but related needs and

responsibilities regarding climate change. An agency-wide Adaptation Task Force would enable coordination and communication across divisions, helping to reduce redundancies in expenditures and effort, allowing for cross-department information exchange and learning opportunities, and enabling streamlined direction from agency leaders. The task force membership could, for example, include one or more Board members as well as a representative from each of Metro's departments. External, non-Metro, representatives may also be considered for the task force.

Metro might be able to achieve similar objectives – coordination and efficiencies – by leveraging existing teaming structures. For example, during the Roundtable event it was noted that the EMS Administrative Team and Facility Core Teams are already beginning to include climate adaptation objectives as well.

Metro Departments

Key Messages to Metro Employees

Frontline employees are entrusted with protecting Metro assets and ensuring riders will get where they need to go in the face of severe weather conditions They will continue to do this in the future because Metro is planning ahead.

Metro is committed to ensuring that:

- *Severe weather will not disrupt their ability to provide timely and safe service to riders in their service area.*
- *Employees are informed and ready to respond to the severe weather challenges by serving as front line responders and readiness agents.*
- *The work environment is safe and comfortable for all Metro employees.*

Metro is starting to integrate climate adaptation and severe weather readiness into environmental management systems (operations and maintenance).

By acting now, Metro will avoid costly consequences such as fleet and equipment malfunctions and railway buckling during periods of extreme heat, and flooding of underground stations and tracks, at-grade railways and bus rapid transit right of ways, Metro will make their transit system better today, ensuring a safe and reliable transit system for the future.

Metro is a large organization with 9,200 employees distributed at locations across Los Angeles County. Internal communication is important for an organization of this size to remain inclusive, efficient, and functional. Fortunately, Metro already has many established lines of

communication that can be used for internal outreach. It is encouraged that these modes continue to be leveraged for communicating about climate adaptation internally. Identified below are several specific strategies for reaching internal audiences at Metro. Note that regular email communications and staff trainings may also provide opportunities for correspondence on these issues.

1-page Insert into EMS Documents

Metro has an Environmental Management System (EMS) agency-wide framework in place into which the climate adaptation measures are being incorporated. As recommendations and findings from the Climate Change Adaptation Pilot begin to emerge and get incorporated into the EMS framework, it may require targeted communication to ensure that all staff are knowledgeable of updates. One possible mechanism for expedient and flexible updates is to add a 1-page summary of changes to the EMS, inserted into the EMS documents already distributed throughout divisions. This insert can be revised and distributed as needed when new updates are made to the EMS framework.

Print Materials

Various print materials are displayed throughout the Metro workspace such as brochures, memos, and posters. These types of materials can readily be used to promote the work Metro is doing on climate change adaptation, highlighting key initiatives that are relevant to the day-to-day work of employees. These materials can answer any questions about why Metro decided to invest in this pilot and adaptation, while also featuring ways the program will positively affect the agency and employees. Print materials can also promote upcoming events and meetings that are particularly relevant to staff and adaptation efforts.

Article in *Metro People*

Metro People is a bi-weekly print publication for employees, which features the latest news from across the agency. As needed, Metro could feature work related to the Climate Change Adaptation Pilot and other relevant climate initiatives. These articles could be brief and serve a variety of purposes: to highlight ways adaptation planning is preparing Metro for expected changes in the climate, feature the work of a particular division, tout the relationships and connections made across the region through adaptation planning, and encourage employees to take part in climate change adaptation efforts.

Climate Resolve can assist Metro in creating the first article on climate change adaptation; it is recommended that Metro then create 2-3 articles a year to update staff on progress.

Blog posts in *The Source*

The Source blog, written by Metro staff, was created as a way to communicate with the riders, Metro staff, and taxpayers who support the third largest transit agency in the nation. The blog largely covers policy and planning within the agency - “projects that the agency is building, preparing to build and is dreaming of building.”

Although intended for readers outside of the agency, *The Source* is a great way to reach Metro staff, as well. Metro is one of the most progressive transit agencies in the nation in terms of climate change adaptation planning. This is a fact that agency staff and employees should be proud of. *The Source* is an excellent way to tout progress, and feature the work of particular departments or employees. Articles appearing in professional transit blogs, such as Railway Track & Structures, Streetwise, National Journal, and BusRide Maintenance, would also confirm the national significance of Metro's climate adaptation plan.

Communicating to riders through *The Source* is described in more detail below. When considering The Source as a method of communication to Metro staff, Metro should consider asking additional staff to serve as "guest writers" on the blog to highlight their work on climate change adaptation. This will not only engage the writer more fully, but may also encourage additional staff to take note of their peers' efforts.

External Audiences

Key Messages to External Audiences

Metro is a national leader in transit climate adaptation. Out of the seven entities in the FTA program, Metro is the only one with a fully articulated climate action and adaptation plan and ready to ingrate adaptation planning into maintenance and operations procedures.

LA is being impacted by climate change – and Metro will meet the challenge.

LA is getting warmer; there will be more severe floods, dusty conditions, and weather-related flooding. Metro is proactively preparing for these climate impacts.

By acting now, Metro will:

- *Avoid costly consequences such as fleet and equipment malfunctions and railway buckling during periods of extreme heat, and flooding of underground stations and tracks, at-grade railways and bus rapid transit right of ways, while making the transit system better today and ensuring a safe and reliable transit system for the future.*
- *Help California and Southern California Region meet its climate goals.*
- *Pave the way for other transit authorities and transportation planning groups to more rapidly integrate climate adaptation planning into their operations.*

Metro's work can inform and adapt to other local transit authorities and transit planning bodies in their efforts to prepare for climate change.

Regional Transit Agencies

Roundtable and Summary Report

On May 9, 2013, Metro hosted the L.A. Regional Transit Climate Adaptation Roundtable (Roundtable). Climate Resolve prepared a separate summary report of the Roundtable. This report describes the communications goals and strategy related to the Roundtable. The purpose of the Roundtable was to bring together the region's transit agency managers and other stakeholders to identify shared climate issues, discuss adaptive actions, and exchange ideas for adaptation planning.

The event was intended to serve as the start of an ongoing communications effort with regional transit agencies. As Metro is the largest transit provider in the region, and one of the only ones with a climate plan in place, this event allowed Metro to share successes and lessons learned so that other transit agencies may be able to follow their lead. The roundtable event also served as an opportunity to clarify the audience and methods of communication with regional transit agencies moving forward.

Regular Updates at BOS and LTSS Quarterly Meetings

Metro has several Advisory Committees that meet regularly. The Bus Operations Subcommittee (BOS) and the Local Transit Systems Subcommittee (LTSS) are two subcommittees of the Technical Advisory Committee. Both BOS and LTSS have a number of regional representatives from external transit agencies.

As these subcommittees are already established and meet regularly, Metro could begin updating all members at regularly scheduled meetings on the progress of climate change adaptation within Metro. BOS and LTSS members could also be encouraged to share their agency's progress in terms of adaptive planning.

Further, Metro could create a list-serv of all interested BOS and LTSS members to enhance regular communications on climate adaptation planning. This will help all members stay current on progress happening at transit agencies throughout the region in regards to adaptation planning.

Regional Climate Change Planning Leaders

Within the region, there are several parties that are leaders in climate change and adaptation planning. While their focus may not be exclusively on transit, their knowledge of the broader issues related to climate change and networks can help inform Metro on adaptation planning in the future. These include several Council of Governments (COGs), the Southern California Association of Governments (SCAG), the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC), regional municipalities, and several area non-profit organizations.

Roundtable Event

Several representatives from the above organizations were invited to the Roundtable. As with

external transit agencies, the Roundtable was an initial opportunity for Metro to engage with these industry experts and professionals from a diverse network of organizations across the region. Although the roundtable was a great way for outside organizations to understand the work of Metro, it also served as an opportunity for the agency to learn from regional experts on climate change and adaptation and identify next steps for communication moving forward.

Upcoming Organizational Meetings

Several of these organizations and networks hold regular monthly or quarterly meetings of their members. While not all meetings will be relevant to Metro planning, these meetings can serve as another venue of two-way communication for the agency and organizations moving forward.

Climate Resolve recommends that Metro consider presenting their adaptation program at one of LARC's monthly steering committee meetings or quarterly members meetings. LARC is a regional network of 25 members dedicated to sharing ideas, fostering partnerships, and developing system-wide strategies to address climate change–LARC members, including city governments, universities, and non-profits, are a highly relevant audience for the adaptation pilot and will certainly provide Metro with a fruitful opportunity to exchange ideas and share progress with climate-engaged organizations.

Cooperative Outreach to Local Organizations

There are many non-profit organizations that focus their efforts on improving transit, sustainability, and livability in Los Angeles and the surrounding region. These organizations have established means of communicating with their members – through social media, blog posts, their homepage, newsletters, and public events. Metro may consider requesting, through existing relationships, transit-oriented organizations to post information on social network sites related to the climate adaptation pilot program. This effort will extend the reach of Metro's outreach messaging by sharing progress with other organizations' established audiences.

As the region's largest transit provider with high visibility, many organizations and networks are already aware of Metro's role as a provider of public transportation. However, many may not realize the work that Metro is doing to be a leader in sustainability - continuing to provide excellent service while preparing for the future's climate uncertainties. By identifying leading organizations that share a similar interest, Metro has the opportunity to build new relationships and connections who can then share Metro's progress. We recommend such groups as MoveLA, Climate Plan, FAST, Green LA Coalition, The Transit Coalition, Coalition for Clean Air, Communities for a Better Environment, Community Health Councils, East Yard Communities for Environmental Justice, From Lot to Spot, Sierra Club, LAANE, SCOPE, Hollywood Beautification Team, Northeast Trees, Trust for Public Land, The Nature Conservancy, Union de Vecinos, Urban & Environmental Policy Institute at Occidental College, and Urban Semillas.

Metro Riders and the General Public

Key Messages to Metro Riders and the General Public

LA is being impacted by climate change – and Metro will meet the challenge.

LA is getting warmer; there will be more severe floods, dusty conditions, and weather-related flooding. Metro is proactively preparing for these climate impacts.

Metro is committed to ensuring that:

- *Climate change will not disrupt their ability to provide timely and safe service to riders in their service area.*
- *Implementation of large infrastructure projects (such as under Measure R) will not be disrupted by extreme heat or severe storms.*
- *Metro is being proactive about reducing environmental impacts from construction through the implementation of its Green Construction Policy*

Metro's work on climate readiness shows how important sustainability is to the agency. Metro is authentically and proactively a green institution.

Riders are part of the solution to climate change.

Metro.net

Metro has a user-friendly website filled with informative content on Metro's projects and programs. Metro should continue to use the website as a means to communicate directly to riders and web visitors on work completed through the Climate Change Adaptation Pilot Program and future initiatives.

After the completion of the pilot, Metro can raise awareness to its work by featuring the program and the Climate Action and Adaptation Report on the front-page of the website, much as they now feature new ad campaigns, agency initiatives, and public service announcements. Featuring climate adaptation work on the front-page will increase visibility for users that might not dig deep enough to find this content on their own.

In addition, regular updates should be included under the Sustainability (http://www.metro.net/projects/sustainability/) and Environmental Compliances Services (http://www.metro.net/projects/ecsd/) pages. On these pages, Metro can include the Summary Report from the Roundtable, Synthesis Report recommended above, links to any relevant *the Source* posts, and information regarding next steps for the agency.

Social Media

Metro has an established presence on both Twitter and Facebook, two of the most utilized channels of social media today. While both Twitter and Facebook are slightly different in their mechanics, both offer Metro an opportunity to connect and respond directly to their audiences, while sharing progress of the agency as it moves ahead with climate adaptation planning.

As Metro.net is updated with new reports and information, Metro should use established social media and outreach channels to draw new visitors to the website, for example, by using Facebook and Twitter posts to engage the audience.

Climate Resolve can assist Metro staff with creating content of a few Facebook posts and Twitter tweets promoting the work of the agency on adaptive planning in the weeks ahead. As future content is created, we recommended Metro engage users creatively by posting pictures, asking open-ended questions, promoting events, and leading with unique taglines.

Metro Insider

Intended to keep riders up-to-date with service changes, route delays, and relevant transit news, *Metro Insider* is found on all buses and train cars, within view of all passengers. While the publication has wide distribution on all buses and train cars, the content may not be an obvious match for messaging on climate adaptation. The publication tends to focus on logistics and other details and may not attract readers interested in general news about what Metro is doing on environmental issues or sustainability. However, providing a brief snapshot into the work completed (or to be completed) through the Climate Change Adaptation Pilot Program in terms of how it can help prevent or limit delays and route changes could provide an effective messaging frame for this particular publication; this approach uses a more subtle means of informing riders and conveying a sense that Metro is doing everything they can to make transit safe and reliable. Readers could also be directed to visit Metro.net to learn more about the program and related initiatives.

Press Release

As one of the largest transit providers in the nation, and one of only seven to complete this FTA Pilot Program, Metro deserves recognition for its initiative to prepare its fleet, its employees, and its infrastructure for the possibility of increasingly extreme weather. Metro's public relations and communications team could create a press release to alert local media and blogs of its work. It is recommended that these press releases come at a time of particular relevance – during anticipated extreme weather incidences, such as high heat or severe rainstorm events, or prior to the unveiling of high-visibility initiatives, procedures, or construction informed by the pilot program.

Outreach with Local Media, Blogs, and Public Events

In the same vein as the above press release, Metro may want to identify key media and blogs within its service area to report on the work Metro is doing to prepare for climate change. In addition to established media – television news networks, daily papers, and community newspapers – Metro can expand its reach by also contacting specialty blogs and relevant public

events to share their work on climate adaptation in Los Angeles County. We further suggest that information could be included in mayoral and city council newsletters throughout the county. Other specialty blogs include Streetsblog LA, Atlantic Cities, Curbed LA, LA Observed, LA as Subject, GOOD, BlogDowntown, LAist, and City Watch. Last, Metro can inform the public by including the factsheet described above at Metro-staffed kiosk booths during public events.

Summary of Southern California Transit Climate Adaptation Roundtable

Hosted by Los Angeles Country Metro Transportation Authority

May 9, 2013

The Los Angeles County Metropolitan Transportation Authority (Metro) has emerged in recent years as a leader in climate adaptation planning in the transit sector. In June 2012, Metro adopted a Climate Action and Adaptation Plan, which identifies greenhouse gas emissions and mitigation opportunities under Metro's operational control, as well as major climate-related vulnerabilities and options for targeted, cost-effective adaptation measures.

Shortly after adoption of the plan, Metro became one of seven metropolitan transit agencies selected to participate in a Federal Transportation Authority (FTA) pilot program on adaptation planning. Metro is now taking their adaptation planning to the next level by piloting integration of climate principles in transit maintenance and operations, starting first with the incorporation of key principles into their Environmental Management System (EMS) agency-wide framework. The final phase of the project includes conducting outreach to share the successes of the pilot with the public, other transit agencies, and Metro staff.

As part of their outreach plan, Metro hosted a one-day roundtable event for transit agencies and industry professionals in Southern California to begin exchanging information and strategies for climate adaptation within the transit sector. Presentations throughout the morning set the groundwork for the day – with presentations highlighting the work already being done on the local and national level in transit planning and an explanation of the current best science for climate change in the Los Angeles region. An interactive panel and lively discussion followed in the afternoon.

Participants

Metro**:** Matthew Egge, Shannon Walker, Cris Liban, K.N. Murphy, Nathan Maddox, Niraj Vora, John Roberts, Michael Harris-Gifford, Randy Lamm, Aliya Popatia, Julia Salinas, Brian Rydell, Evan Rosenberg, Rohini Banskota, Collins Kalu, Carley Markovitz, John Drayton

Climate Resolve: Katie Goldman, David Fink, Heather Kachel, Jonathan Parfrey

Others:

Fernando Castro, CalTrans
Gail Davis, Metrolink
Michelle Garcia, USC
Cheryl Laskowski, AECOM
Sabrina Bornstein, SBC COG
Mark Valliantos, Occidental
Detrich B. Allen, LADOT
Bob Gottieb, Occidental College
Chris Phillips, TRC

AGENDA
Southern California Transit Climate Adaptation Roundtable

- Introduction to Metro's work on Climate Action and Adaptation
  Art Leahy, *CEO, Metro*
  K.N. Murthy, *Executive Director Transit Project Delivery, Metro*

- Roundtable Purpose and Structure
  Katie Goldman, *Director of Programs, Climate Resolve*

- Setting the Stage: Potential Climate Impacts in Los Angeles
  Jonathan Parfrey, *Executive Director, Climate Resolve*

- Climate Change Planning and Implementation Principles
  Cris Liban, *Deputy Executive Officer of the Environment, Metro*
  Ray Tellis, *Senior Transportation Program Specialist, Federal Transit Administration*

- Overview of Metro Climate Action and Adaptation Plan and FTA Pilot Project
  Cris Liban, *Deputy Executive Officer of the Environment, Metro*

- Metrics for Tracking Climate Change Adaptation
  Mark Vallianatos, *Policy Director*, *Urban & Environmental Policy Institute, Occidental College*

- Panel: Planning for Impacts to Operations
  Bryan Rydell, *Rail Fleet Services Manager – Blue Line, Metro*
  John Drayton, *Vehicle Acquisition Manager, Vehicle Technology and Support, Metro*
  John Roberts, *Deputy Executive Officer Operations, Metro*
  Michael Harris-Gifford, *Executive Officer Rail Wayside Systems, Metro*

- Wrap up discussion and Concluding Remarks

Throughout the day, attendees were encouraged to actively participate, asking questions and providing input as they considered how their organizations can move forward with climate adaptation planning in the future.

Meeting Summary

Introductory Remarks by Art Leahy and K.N. Murthy: Metro's Role and Commitment to Sustainability

The demand for transit is growing throughout the region, as Angelenos are stepping away from their cars and relying increasingly on buses, subways, and trains to travel. Union Station in downtown Los Angeles is representative of this transition, as thousands now bustle through the historic transit hub on a daily basis.

In response, Metro is growing - expanding rail lines, bus service and connections throughout the region. Metro is committed to reducing its greenhouse gas emissions and prioritizing clean air, clean water, and clean and renewable energy technologies within the agency. With a ridership of over a million people a day, Metro recognizes its critical role in the city and in the region, striving to create livable communities for all Angelenos.

To meet its sustainability goals, Metro recognizes that operations are a key component to success, with bus and rail operations as the crucial on-the-ground support to complete initiatives moving forward. One of the biggest questions the agency faces is how to best use new and emerging technology to reduce emissions and prepare for climate change in the years to come.

Climate Impacts in Los Angeles, Jonathan Parfrey, Climate Resolve

Los Angeles is a city envied by many. On a given day, Angelenos can start their day in the mountains hitting the slopes and finish at the beach to catch some waves in the setting sun. The climate – lots of sunshine and warm temperatures – is one of the things that draw visitors from across the globe. Local science, however, shows that the climate in Los Angeles is changing. Across the globe, climate change is linked to increasingly severe weather – and the LA region will be no different.

Groundbreaking science out of UCLA's Department of Atmospheric and Oceanic Sciences indicates that big changes to the region's climate are coming by mid-century. More specifically, these impacts will not be the same throughout the Los Angeles region; with this highly-precise research, scientists can, for the first time, forecast the difference between one side of the Santa Monica Mountains and the other.

The first climate analysis, focusing on temperature, revealed that the Los Angeles region will be warmer by mid-century, with average annual temperatures rising 4-5 °F, with coastal regions warming more slowly than the surrounding deserts and mountains. In addition, the occurrence of "extreme heat days", days when temperatures exceed 95°F, is expected to increase substantially – threefold on the coast and up to 5-6 times in the desert and mountain areas.

Further analysis will consider snow fall, precipitation, and Santa Ana winds. While the details are not yet known, it is certain that Los Angeles will see increasingly extreme weather in the years to come. With this information in tow, planners throughout the region may begin considering risk management – given the high probability of increasingly extreme weather, agencies and communities must act now to prepare and move forward in the face of extreme heat, increased flooding, droughts, and wildfires.

Across the region, agencies and communities will feel the impacts of a changing climate. If Metro, and other transit agencies, is to continue to provide excellent service in a safe manner, the agency will need to prepare for coming operational threats.

Climate Change Planning and Implementation Principles at Metro, Cris Liban

Greenhouse gas emissions are the biggest contributor to global climate change. While emissions come from a variety of sources, private single-user vehicles are the largest contributor to a household's

carbon footprint. Public transportation is a viable alternative for many – especially in Los Angeles – who wish to reduce their footprint and do their own small part in reducing the impact of climate change. Metro provides alternatives – not only through public transit access, but also through public electric vehicle charging stations across the region.

Increased use of public transit means more than fewer cars on the road. More transit often means traffic congestion relief (which leads to increased fuel efficiency and less greenhouse gas emissions for the cars on the road) and a transition to multi-modal "complete" streets, where buses and trains often share nearby space with more pedestrians and bicyclists.

Despite the fact that public transit is less-dirty alternative for single-users, transit still comes at a cost for the environment, producing more emissions as ridership increases. In response, Metro is taking big steps to reduce emissions and prepare for climate change with the help of the American Public Transportation Association (APTA) and the Federal Transit Administration.

APTA, a nonprofit organization serving as an advocate for the advancement of public transportation programs and initiatives in the United States, has created a Recommended Practice Document to assist transit agencies in developing a Climate Action Plan. In exchange for being a member, APTA provides agencies with support for internal sustainability efforts and information for improving cost-effectiveness while offering support as agencies prepare for the effects of climate change.

Metro has utilized APTA recommendations in the development of their own climate action plan. In addition, the agency has adopted a Plan-Do-Check-Act Cycle within operations' Environmental Management System (EMS) documentation to strive for continual improvement in reducing Metro's impact on the environment. This cycle encourages strategic planning, options analysis and Climate Action Plan development, implementation of the plan, and continuous monitoring and improvement.

FTA Climate Change Adaptation Initiative, Ray Tellis

In 2012, the Federal Transit Administration (FTA) announced its Climate Change Adaptation Initiative. As part of the program, FTA distributed just over $1 million of research funding to seven pilot projects completed by transit agencies across the nation to conduct climate change adaptation assessments. Intended to "advance the state of practice for adapting transit systems to the impacts of climate change" the effort is in keeping with broader long-term FTA goals to address state-of-good repair needs and enhance transit safety.

Metro, one of seven agencies to be awarded funds, remains one of the most progressive agencies when it comes to climate adaptation planning. Throughout the FTA pilot, Metro and all other participants will go through a similar internal process to begin implementing climate adaptation strategies within the agencies: identifying climate hazards and potential climactic events; characterize risk on transit assets and operations; develop initial adaptation strategies; link strategies to organizational structures; and complete a final summary report.

Upon completion of the FTA pilot projects, lessons learned will be shared with the public and transit agencies across the nation to ensure that mobility will be protected for all transit users – especially vulnerable populations – in the face of sea level rise, extreme heat, flooding, and winter storms. Further objectives include: increased knowledge of how transit agencies can adapt to climate change and extreme weather; advancement of the state of practice for climate adaptation with concrete examples; development of strategic partnerships; and an increased visibility of climate adaptation work, at both the regional and national level.

Extreme weather events across the country have already had big impacts on transit – when Hurricane Sandy hit the east coast in 2012, flooding greatly impacted subway and bus service in New York City. As transit was seen as a crucial component to ensure individuals could return to work and back home, streamlining of the environmental review process was prioritized by FTA to get transit back online in a

timely manner. While it is too early to report back on lessons learned from this streamlining, there is great interest in the ability of FTA to streamline transit processes in the future to move projects forward more efficiently.

As FTA moves forward with its Climate Change Adaptation Initiative, roundtable attendees recommend that the agency invests more money in research and pilot projects to provide more real-world case studies across the nation. In conjunction, FTA must fully develop a method for participating transit agencies to share successes, recommendations, and constructive feedback. By allowing agencies to communicate with one another, FTA may be better able to develop a summary of standards and recommendations for all transit agencies to follow as they invest time and resources into preparing their systems for climate change.

Metro's Climate Action and Adaptation Plan, Cris Liban

California is often considered a leader in climate change policy and planning. The state has implemented a number of policies in recent years to ensure agencies and communities are doing their part to both mitigate emissions and prepare for climate change impacts. The California Global Warming Solutions Act of 2006 (AB32) is one notable example. The law requires the state to reduce its greenhouse gas emissions down to 1990 levels by 2020. Other relevant laws and regulations include the Sustainable Communities and Climate Protection Act of 2008 (SB375), amendments to the California Environmental Quality Act in 2007, and the adoption of the California Climate Adaptation Strategy.

In addition to the above drivers, Metro has other reasons to consider climate adaptation within operations. While the exact nature and magnitude of climate impacts is not yet known, the agency must consider the risks of potential extreme weather events. Across the region, service disruptions have already occurred during periods of extreme heat and heavy precipitation; these incidences are only likely to increase in the future if Metro does not adequately prepare. Identifying portions of the transit system that are already vulnerable, or that may become vulnerable, will help guide planning, and prevent disruptions in the future.

Critical assets and services to be considered in climate adaptation planning include any infrastructure, equipment, and property currently owned and operated by Metro, including bus operations, light and heavy rail, and equipment yards. The agency also has several large infrastructure projects in progress that will remain a cornerstone to their service for decades to come. Throughout the building process, Metro must consider future climate impacts if they are to ensure optimal performance and safety in new and existing development.

Given the fairly mild climate of Southern California, regional transit agencies do not need to worry about extreme winter snowstorms and cold, as many others across the nation do. However, Metro's transit operations still may be threatened by extreme weather events throughout the year: sea-level rise, high winds, heavy precipitation and flooding, and extreme heat. Only one rail location (the Blue Line in Long Beach) is expected to become vulnerable to expected sea-level rise; however, the Expo Line and the Purple Line extension may also become vulnerable as they expand westward in the years to come. Heavy rains and flooding may impact underground stations on the Red Line and negatively affect infrastructure above-ground, although none has yet been reported. Extreme heat is believed to have the farthest-reaching potential effects to the operations of the agency, potentially leading to equipment malfunction, railway buckling, fleet breakdown, and labor interruptions. Strong-blowing Santa Ana winds have also threatened service in the past, although largely due to external power outages, rather than internal complications.

As a result of expected impacts of climate change and extreme weather, Metro is actively considering options for adaptation. Metro has completed a Climate Action and Adaptation Plan, but the plan is largely fluid as the agency considers the best way to integrate adaptation into management, operations, and planning. Financial costs of new technologies and anticipated negative impacts from

extreme weather are now being considered on all current and future projects.

As a one of seven pilot projects with FTA's Climate Change Adaptation Initiative, Metro is currently concentrating on increased outreach with local transit agencies and relevant organizations to share its progress in climate adaptation. Moving forward, the agency hopes to continue coordination with FTA on future projects and continue its work on adaptation-complimentary programs – including EMS integration and sustainability projects. In the long-term, Metro would like to asses all of its fixed-asset vulnerabilities and implement criteria to prioritize asset management, develop GIS-based tools to incorporate climate impacts, integrate research that considers extreme weather impacts to vulnerable populations, and possibly participate in the budding carbon market.

Across the region, Metro is not the only transit agency considering the impacts of climate on operations. Of those groups in attendance, a majority have already begun thinking about climate adaptation strategies within their organization, with many already taking steps towards adaptive planning.

Metrics for Tracking Climate Change Adaptation, Mark Vallianatos

In order to move forward with climate adaptation within the agency, Metro worked alongside the Urban & Environmental Policy Institute at Occidental College (UEPI) to determine key metrics that the agency could use to track its progress. The final report, while targeted specifically to Metro, is intended to be informative for other transit agencies.

To determine key metrics, UEPI completed an extensive literature review on metrics and indicators for climate change adaptation by transit operators. Additional metrics were identified through surveys and discussions with Metro frontline staff and employees. Next, six core criteria were established (severity, equity, feasibility, cost, and best practice) along with five multiple-benefic criteria (climate, visibility, participation and governance, design, and mitigation). Out of 109 determined metrics, 20 rose to the top through a points-based ranking system. These top-ranked metrics consider impacts on riders, vulnerability assessments, vulnerable populations, and operations failures. Metrics can be binary (yes or no questions), quantitative, and qualitative in nature.

The top twenty metrics are:

- Have impacts on riders been analyzed?
- Has vulnerability assessment been conducted?
- Mean distance between failure (MDBF) for buses by temperature and geography
- Have adaptation actions been prioritized?
- Have vulnerable assets been mapped with transit dependent and low-income populations?
- Number of injuries/medical emergencies to workers and riders by temperature and rainfall
- Does agency have overheating standards for public transport facilities and rolling stock?
- Does agency have an ongoing and regularly convening tem tasked with implementing climate adaptation plans
- Percent of climate adaptation recommendations/actions from adopted plans implemented
- Capacity to monitor weather and temperature conditions in real time at key locations in service areas
- Extreme weather impacts on service delays and cancellations
- Percent of Metro facilities and vehicles with cool roofs
- Does agency conduct regular climate planning updates
- Are climate adaptation indicators tracked in agency's Environmental Management System and/or Asset Management System?
- Number of rail kinks/buckling by temperature and by heat island areas

- Number of technical advisors and members of the broader community included in climate adaptation team
- Do agency design standards consider climate adaptation?
- Has agency designated evacuation routes?
- Progress in reducing vulnerabilities based on meta-analysis of climate adaptation indicators
- Funding needed and provided to implement climate adaptation

For a full list of metrics and a description of the top 20, please see UEPI's April 2013 report *Metrics for Tracking Climate Change Adaptation*. UEPI recommends that transit agencies across the region consider these metrics as they begin to consider climate adaptation in management and planning. Agencies can track metrics that make the most sense for their operations and provide feedback to UEPI on their utility. Moving forward, UEPI would like to conduct more research on user experience, equity, and climate response.

Internally, Metro has already begun to consider the initial 20 metrics recommended by UEPI. Each metric has been given a level of prioritization within the agency, with the intent to adopt an initial set of metrics with more to be added in the years to come.

Planning for Impacts to Operations: An Interactive Panel

Everyday, front-line employees are on the ground grappling with the impacts of extreme weather and actively working to make the Metro system safe, efficient, and reliable. A discussion on climate adaptation within the agency would be incomplete without their unique perspective. Four such front-line representatives shared their perspective and thoughts on extreme weather impacts, integration of new technologies, and general operations management.

Panel participants included:

- Bryan Rydell, *Rail Fleet Services Manager – Blue Line*
- John Drayton, *Vehicle Acquisition Manager, Vehicle Technology and Support*
- John Roberts, *Deputy Executive Officer Operations*
- Michael Harris-Gifford, *Executive Officer Rail Wayside Systems*
- Katie Goldman (moderator), Climate Resolve

Summary of Panel Discussion

As mentioned above, Metro has experienced the effects of extreme weather in the past – oftentimes on its rail fleet and service. Extreme heat has led to two major chronic issues: disruption in propulsion services, and failure of on-board HVAC systems. Additionally, heavy precipitation actively encourages rust in the steel frames of rail cars, causing accelerated wear to vehicles. In response to all of the above issues, Metro has instituted regular preventative maintenance for all systems. With 171 light rail vehicles at varying life stages, this is no easy task, but Metro remains committed to in order to enhance the life and operations of its fleet.

High winds have also posed a threat to operations in the past – specifically in Pasadena in 2011. While Metro infrastructure withstood high winds, several regional electricity providers suffered outages. The Gold Line, a light rail line dependent on electricity to continue service, was forced to reduce and even shut down service until power could be restored. Unexpected events of this nature can be expected well into the future; fortunately the agency is experienced with severe weather and will take lessons learned into preparation for future events.

In an effort to combat to further combat negative weather impacts, Metro is willing to test out new and emerging technologies within their fleet. Quite often, these technologies reduce emissions, improve safety, and provide top-notch service. Some technologies are small – updated windshield wipers – while others require a commitment to an entire fleet – buses run entirely on natural gas. New technologies to withstand extreme heat – including heat-resistant track materials and white "cooling" boxes for equipment – are also being tested for effectiveness and efficiency. By consistently evaluation new technologies, Metro will sure to be a reliable leader while solidifying its commitment to a more livable city.

Moderated Panel Q&A (in detail)

John Drayton, *Vehicle Acquisition Manager, Vehicle Technology and Support, Metro*

1. How does Metro evaluate the risks, costs, and potential benefits of vehicles with new or emerging technologies, and what tools does Metro use to do this?

- Have to pass regulatory requirements, and follow internal guidelines for purchasing new equipment, best industry practices, and procurement guidelines.
- Metro's experience is also important (Metro is a leading operator of alternative fuel vehicles)

2. Do Metro vehicles currently employ any material, design, or technology elements that aid operation or maintenance during severe weather-related events like heavy rain, high heat, or high winds? What technologies in general exist or are under development that could prove useful in severe weather events?

- Metro is willing to try new technologies within their fleet to reduce emissions, improve safety, and provide top-notch service.
- Types of technologies employed or in consideration include all composite vehicle structures (to avoid rusting), tinted windows to help with cooling vehicles, cameras, updated curbside lighting technologies, windshield wipers, even automatic vehicle operators.
- Constantly evaluating new technologies

Michael Harris-Gifford, *Executive Officer Rail Wayside Systems, Metro*

1. What are the most frequently occurring impacts to wayside systems as a result of severe weather? What about the most detrimental?

Three types of extreme weather events that cause wayside issues: Rain, heat, wind.

- High temperatures impacts overhead track and wire systems. During high heat, wires can sag, causing a loss of service. When this happens currently, speed restrictions are put in place to reduce impacts; longer wires are at greater risk of sagging
- Track buckling has not yet occurred, but it is expected in the future
- Equipment malfunction may occur, especially batteries. Persistent high temperatures reduce the life of a battery. Air conditioned storage of equipment could help.
- Rain (both the absence and extreme presence); extreme rain can lead to flooding and washout; absence of rain causes stress in trees, leading to branches dying off. Once the rain returns, limbs often break off, falling along the trackway, potentially causing a disruption in service. Possible solution is cutting branches in advance of rainy season

2. In looking at a specific instance—the high winds in Pasadena that left thousands of homes without power in Fall 2011—what impacts did you observe to Metro's assets as a result? What was Metro's response and lessons learned from this event?

- Metro infrastructure, e.g., overhead rail line equipment, withstood the wind well.
- Fallen branches had to be removed from tracks
- Threshold temperature (at which Metro starts to anticipate problems) is 100 degrees F
- Biggest effects were outside the control of Metro and related to power outages from local utilities. Electrified rail lines were impacted by outages experienced by Pasadena Water and Power. Even with generators, there was not enough energy to power the system. Related effect of outages, crossing signals were down, passenger stations lost power, and road-rail crossings were closed (which happens when there's not enough power to operate them as a safety mechanism). Metro could continue some operations, but greatly impacted.
- Lessons learned: more generators purchased to be prepared in the future; reducing number of connection points to power systems

John Roberts, *Deputy Executive Officer Operations, Metro*

1. Engineering and design is a powerful tool to prepare for powerful weather events; can you explain your view on the relationship between new vehicle technologies and maintenance of those vehicles.

- Metro collaborates across the agency, across divisions, to learn from each other
- Metro has a diverse fleet, in terms of the age of vehicles, ranging from 15 years to 15 minutes old.
- In 1974 busses did not have air conditioning; today Metro operates busses on 100% CNG carrying 1.1 mil people a day – technology has advanced and Metro is keeping up
- Bus service area covers a wide diversity of locations and weather conditions throughout the year (even within one city, Chatsworth, temperatures range from 30 – 114 degrees F throughout the year)
- Reliability across these dimensions always has to be considered
- Huge improvements have already occurred – cleaner air, leader in alternative fuels and new technologies, decrease in use of fuel
- Technology has helped Metro provide consistent and reliable service, but it is challenging to keep the workforce trained as new technologies emerge

Bryan Rydell, *Rail Fleet Services Manager – Blue Line, Metro*

1. Metro operates some relatively old vehicles; could you list some of the chronic issues you see on these older vehicles and explain if any of these issues are exacerbated by heat or other weather impacts?

- Propulsion issues, caused by high heat impacts on cooling systems. Remedy: regular preventative maintenance.
- HVAC issues, in terms of maintaining internal temperatures of rail cars, is a challenge largely due to opening/closing of doors with passenger loading and unloading. When there is a threat of high heat days, the HVAC systems are checked regularly
- Precipitation encourages rust in steel frames. Remedy: spot check of each car/vehicle to prevent rust prior to rain events.
- Metro maintains 171 light rail vehicles ranging in age from 27yrs – 5yrs old

Audience Q&A (in detail)

Are buses taken offline immediately when AC goes out?

- Daily checks avoid this problem 99.9% of the time for buses.
- Rail: Employees will try to solve the problem immediately, if not successful train will be pulled offline

How is historical data utilized?

- Every time service is required, this information is stored in electronic records
- No detailed data on temperature or precipitation is recorded (but that can be gotten from other sources); primarily it is the number of service orders that are recorded.

What % of your vehicles is out of service on a monthly basis?

- 78 cars are required to be available for Blue and Expo – 14 cars will be offline for preventative maintenance, upgrades, unscheduled maintenance
- Mandated to do regular inspections. This can be done more frequently if failure rates are too high.

In the event of high flooding, would the rail system be at high-risk? If there is such a risk, will Metro consider mitigation of this risk moving forward?

- Certainly some vulnerability, but not to the same degree as New York or New Orleans, for example
- Biggest concern for LA and flooding risk is the Blue line in downtown Long Beach, sub-stations in the region

Has there been an effort to quantify, financially, impacts from the Pasadena event for future reference?

- Actual equipment damage was next to zero for Metro. Real cost comes, not in terms of finances, but when considering disruption in service – people couldn't get to where they need to go, via train or through rail crossings.
- As a result, Metro has purchased extra generators to avoid this problem in the future.
- Gold Line has many more distributed power connections (rather than more centralized), which resulted in many portions of the line losing power

Do those entities that set regulations and enforcement agencies consult with Metro (and others) before they implement new regulations?

- Communication lines are established, but there remains some contention about the best way to get to goals.
- Biggest concern is stringent rules on how to get to goals.

What are Metro's concerns with increased extreme weather? What are the opportunities to meet these challenges?

- In its tenure, Metro has had an opportunity to deal with many extremes in weather. This experience will help guide Metro's response to extreme events in the future.
- Thermal Management in general a big topic for improvements
- Self-Containment for AC units – not embedded into the engine using waste heat to power other systems.
- All trains on rail have regenerative breaking. There is room to capture and reuse more waste heat and Metro is working on options, for example, by establishing electrical substations along the track

system to supply power back to the grid. Regenerative braking also reduces stress on brakes, increases efficiency. Capture heat produced from braking to be used in propulsion (similar to a Prius).

- Paint technologies to help keep equipment cases cool. Passive alternative.
- Light replacement in Red Line tunnel to LEDs. Uses half the electricity, longer-lasting (8yr warranty). Less maintenance, less waste, less work.

Concluding Remarks

The Southern California Transit Climate Adaptation Roundtable served as an opportunity for Metro to share its climate adaptation progress with colleagues from across the region, while opening doors for dialogue between agencies moving forward. There was interest in developing ways to continue moving the conversation forward, for instance by opening more internal lines of communication across Metro departments, recognizing that the roundtable event itself was successful at accomplishing this objective. Other suggestions noted were to establish an adaptation task force or use the EMS integration core team to coordinate across departments on climate adaptation issues.

While many transit agencies have expressed interest and begun preparing for climate impacts, two concerns seemed to rise to the top of the list of many. Agencies, including Metro, must consider cost-effectiveness as they begin thinking about climate adaptation. While acting now may save money in the long run, often this comes at a higher upfront cost. Fortunately, transit agencies often think in the long-term, constantly preparing for large infrastructure projects and expansion well into the future. Given this perspective, Metro may find that a higher cost now means investing in a better service decades from now; to better understand this trade-off and the true value of investments requires life cycle asset analysis.

Many climate issues can be better understood when phrased in terms of weather extremes and risk management. By utilizing the language of front-line employees and keeping them involved in the conversation through standing committees or task forces, environmental managers may have an easier time moving initiatives for adaptation forward within the agency and identifying readily available, practical strategies for adaptation. This methodology also allows employees to see the multiple benefits of adaptation – overall cost savings, improved service, and reduced failure rates of equipment. Training employees to keep up with operating and maintaining newer (computer driven) technologies is a perceived challenge.

Finally, as Metro and other transit agencies begin to consider climate adaptation in their operations planning, it's important to remember to share this work with ridership. Often, the general public can be the biggest supporter of these initiatives. Touting not only the environmental benefits, agencies are reminded to also consider the increased livability and social well-being transit provides to communities. Messaging to a variety of audiences through several channels, including social media, blogs, websites, posters, advertisements, and events, will ensure that riders will remain informed of positive efforts the agency is pursuing.

Recommendations for the FTA were also discussed and include:

- Continued and expanded investment in research and pilot projects to move climate adaptation within transit further ahead
- Analysis of real-life case studies
- Developing recommendations/standards for all transit agencies on climate adaptation
- Facilitating the exchange of experiences, including successes, recommendations, and constructive feedback
- Make climate adaptation a priority at the national level inside FTA

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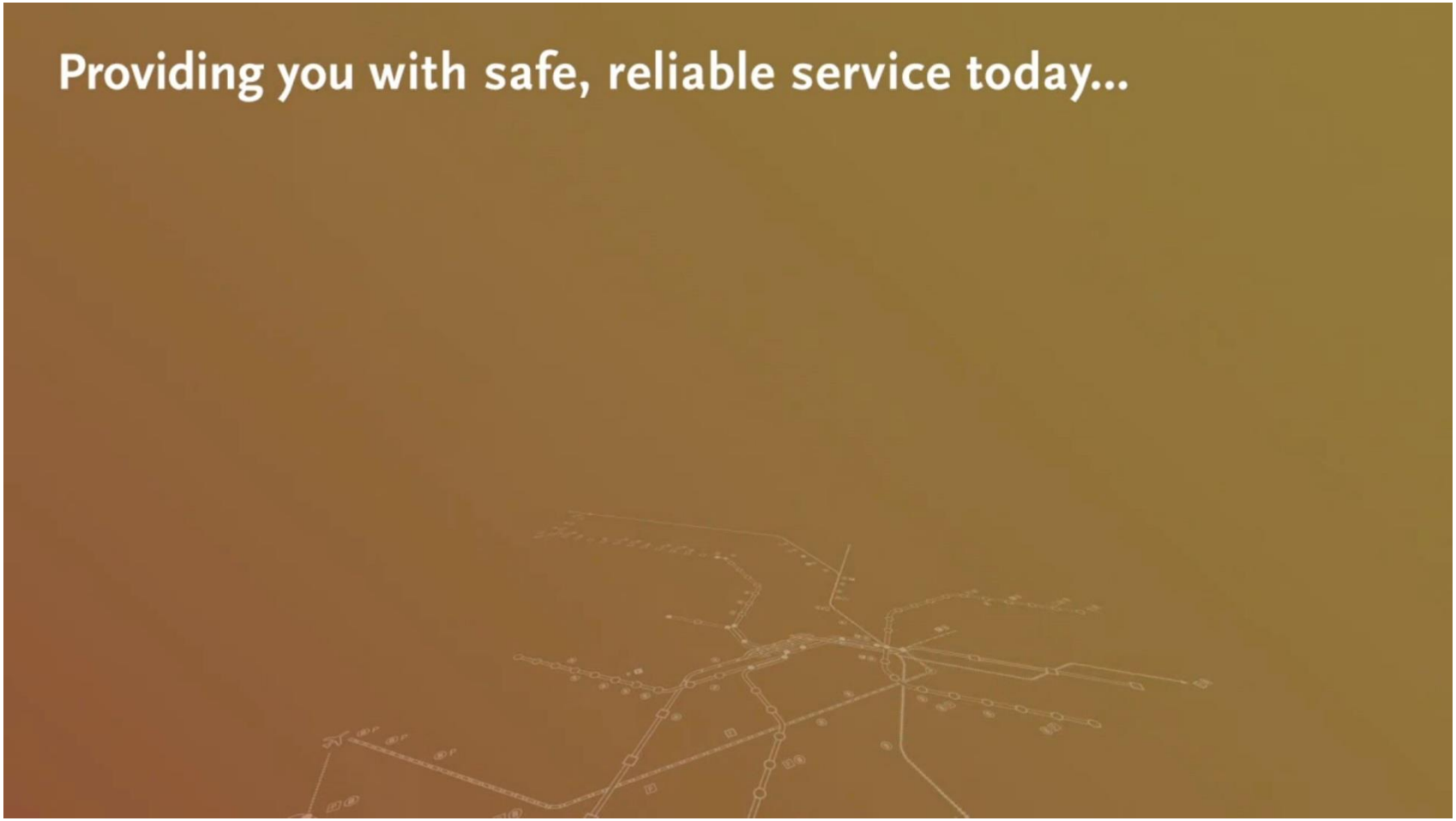
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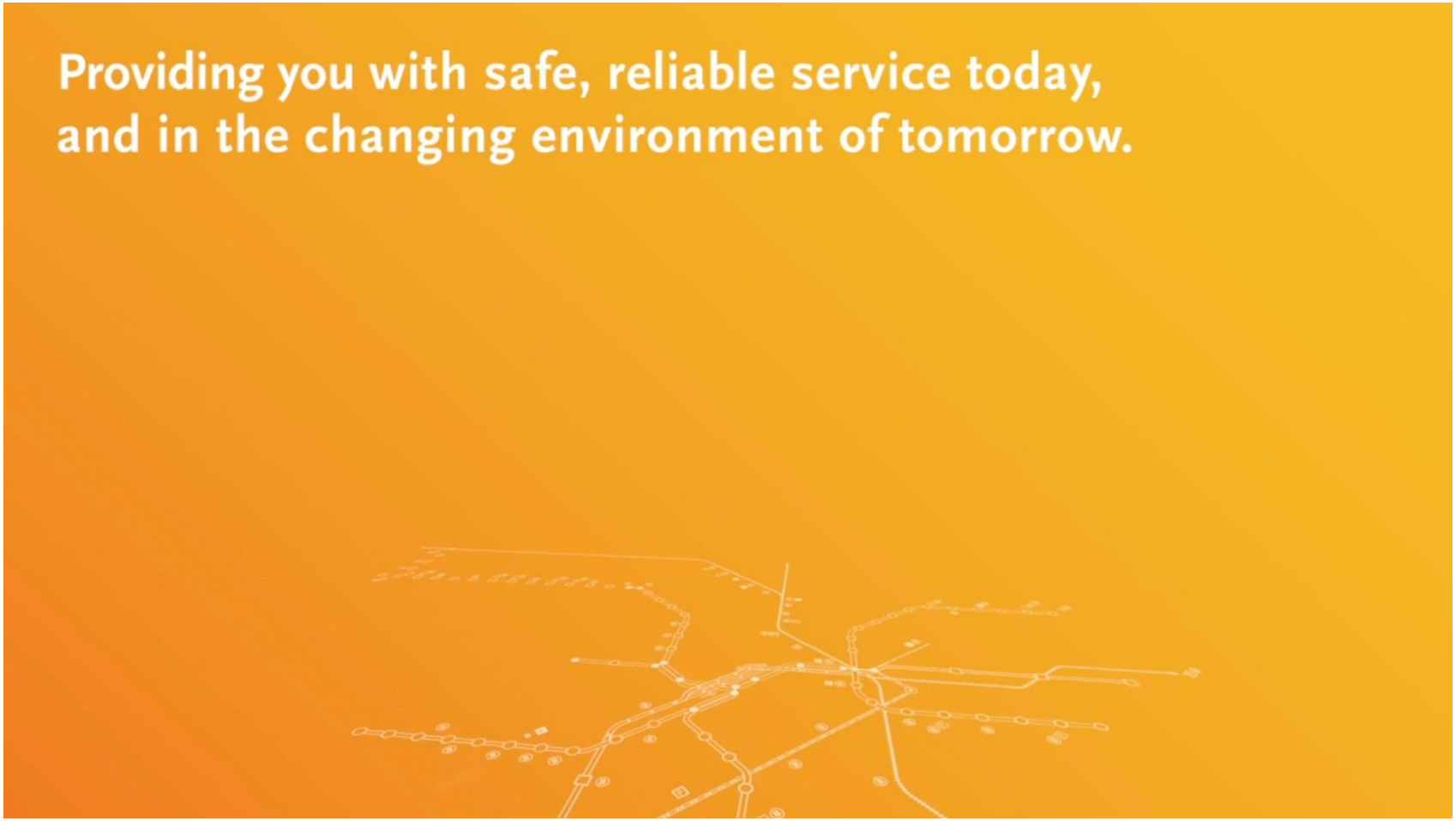
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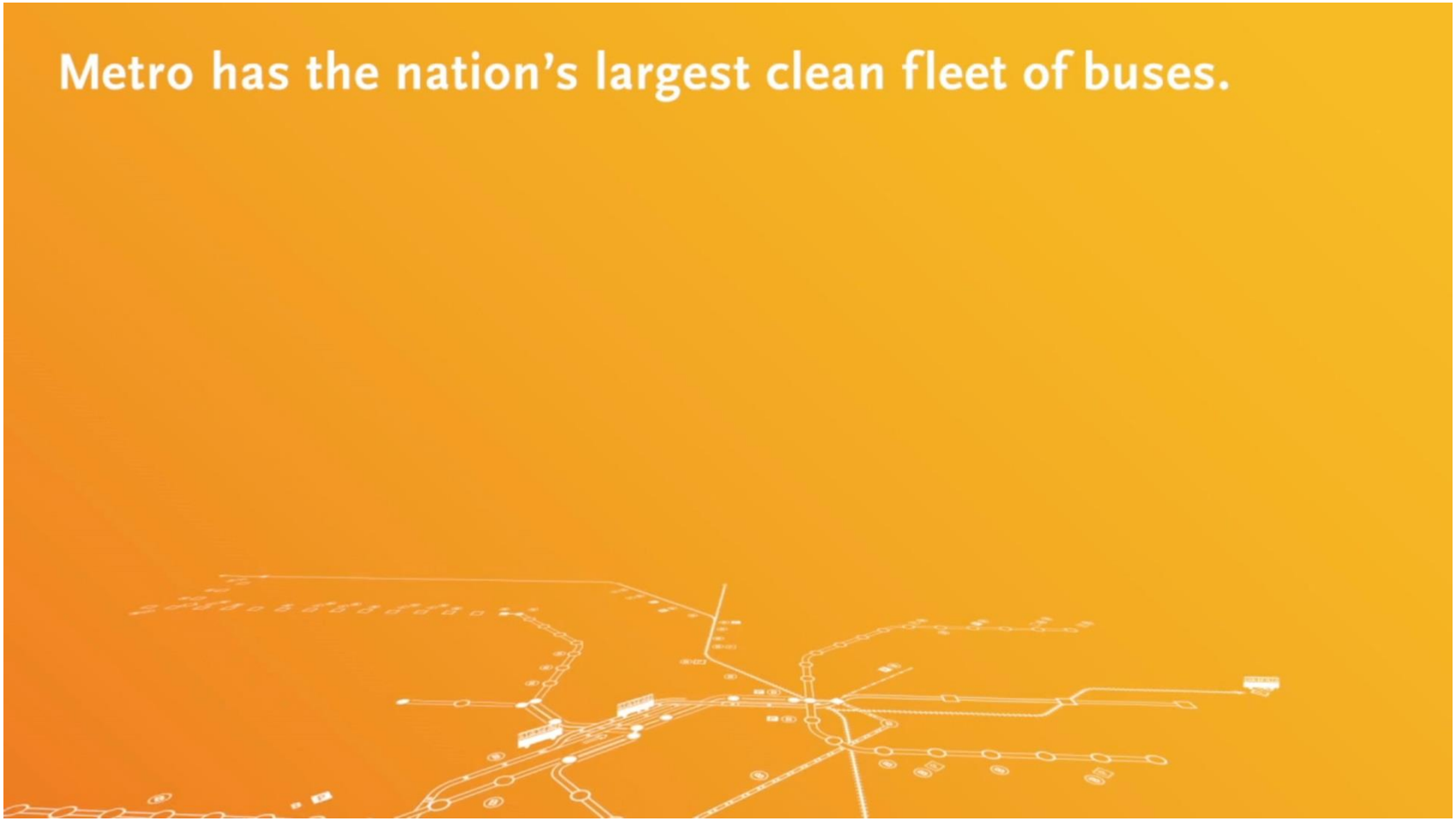
Metro has the nation's largest clean fleet of buses.


That's like removing...
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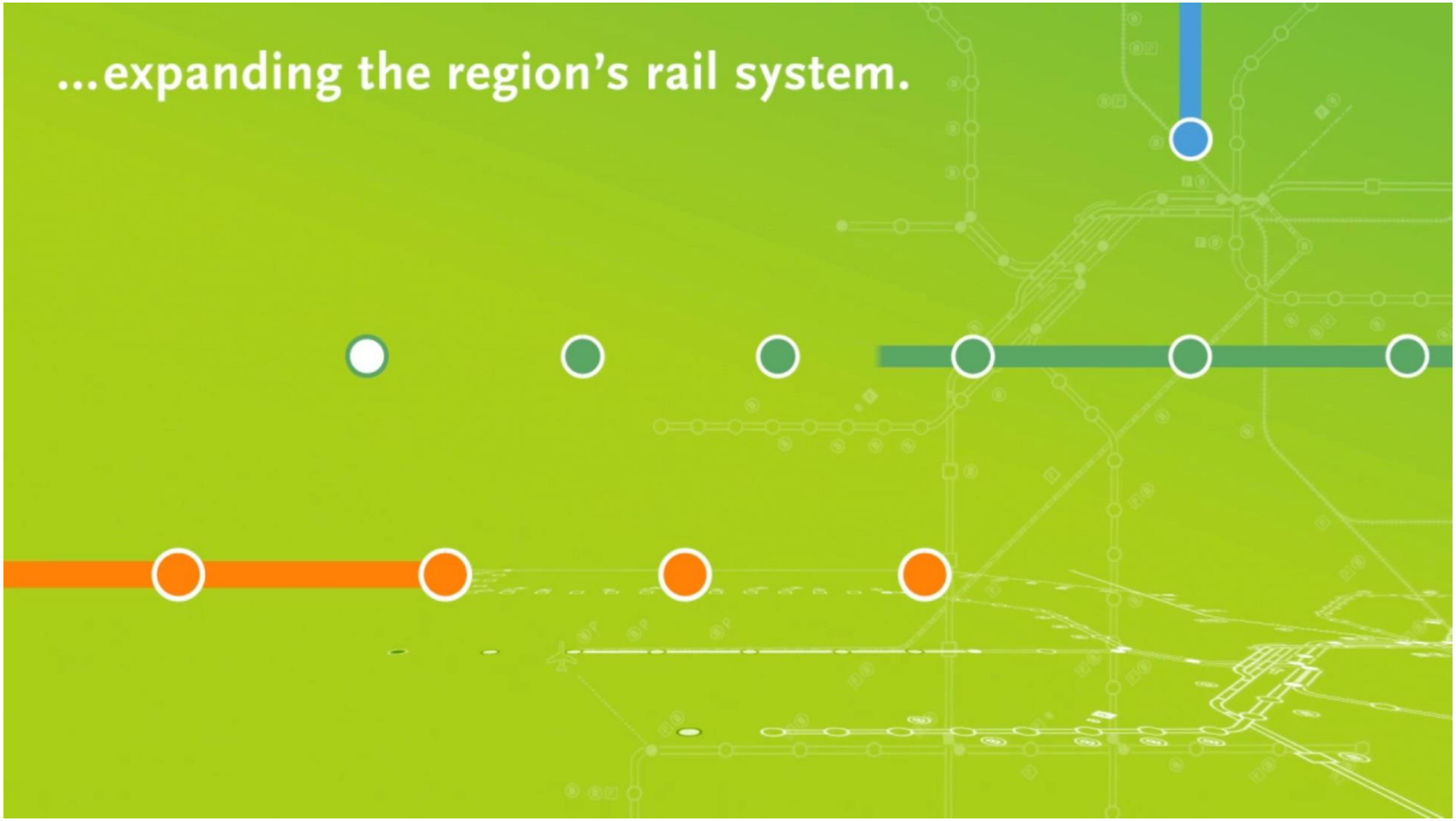
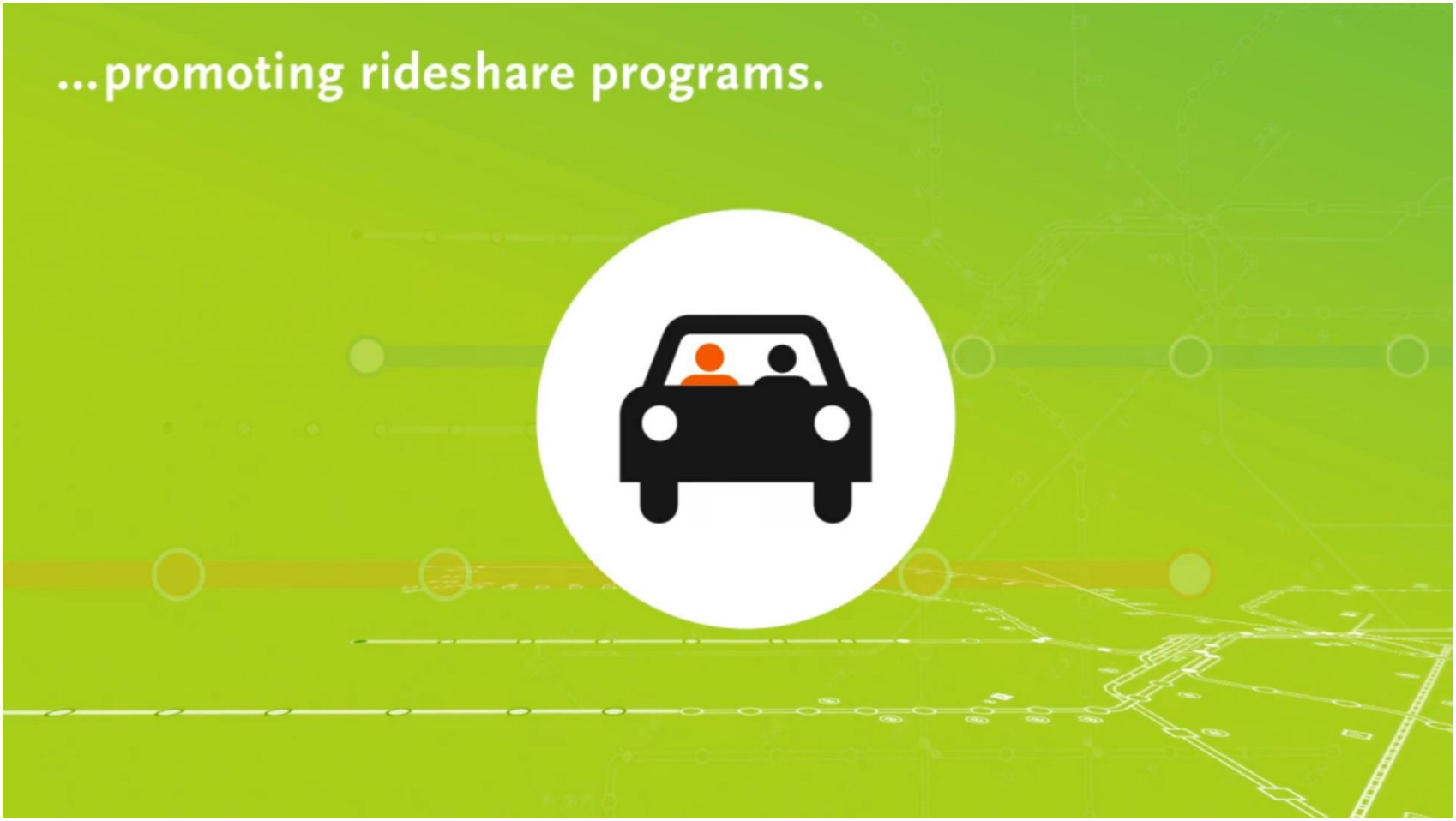
Over the last decade, we've reduced
toxic air pollutants by 93%.
LOWER EMISSIONS


We're continuing to reduce congestion and
lower emissions by...


...expanding the region's rail system.


...promoting rideshare programs.


...introducing innovative projects.
METRO
EXPRESS
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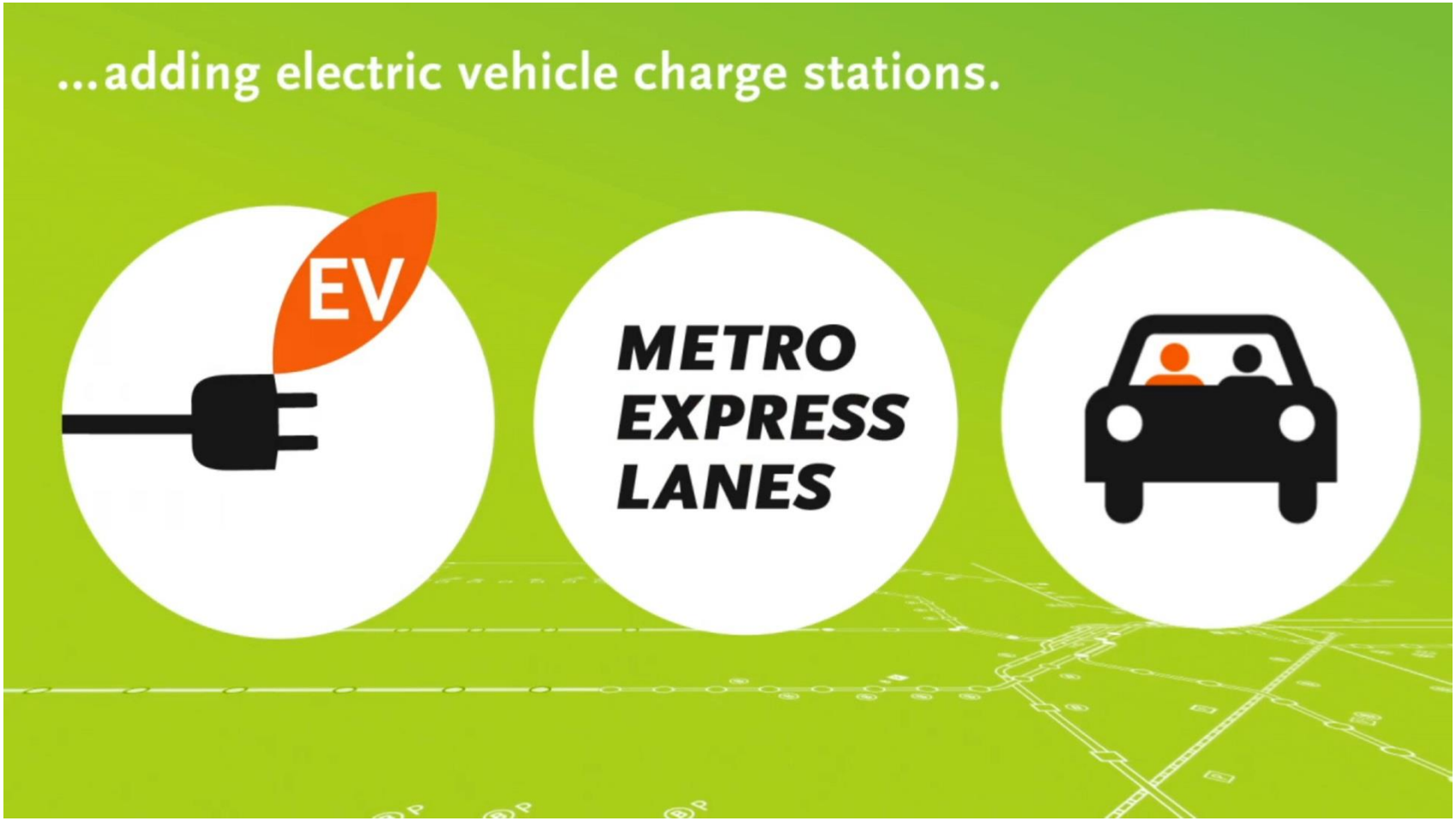
...adding electric vehicle charge stations.
EV
METRO
EXPRESS
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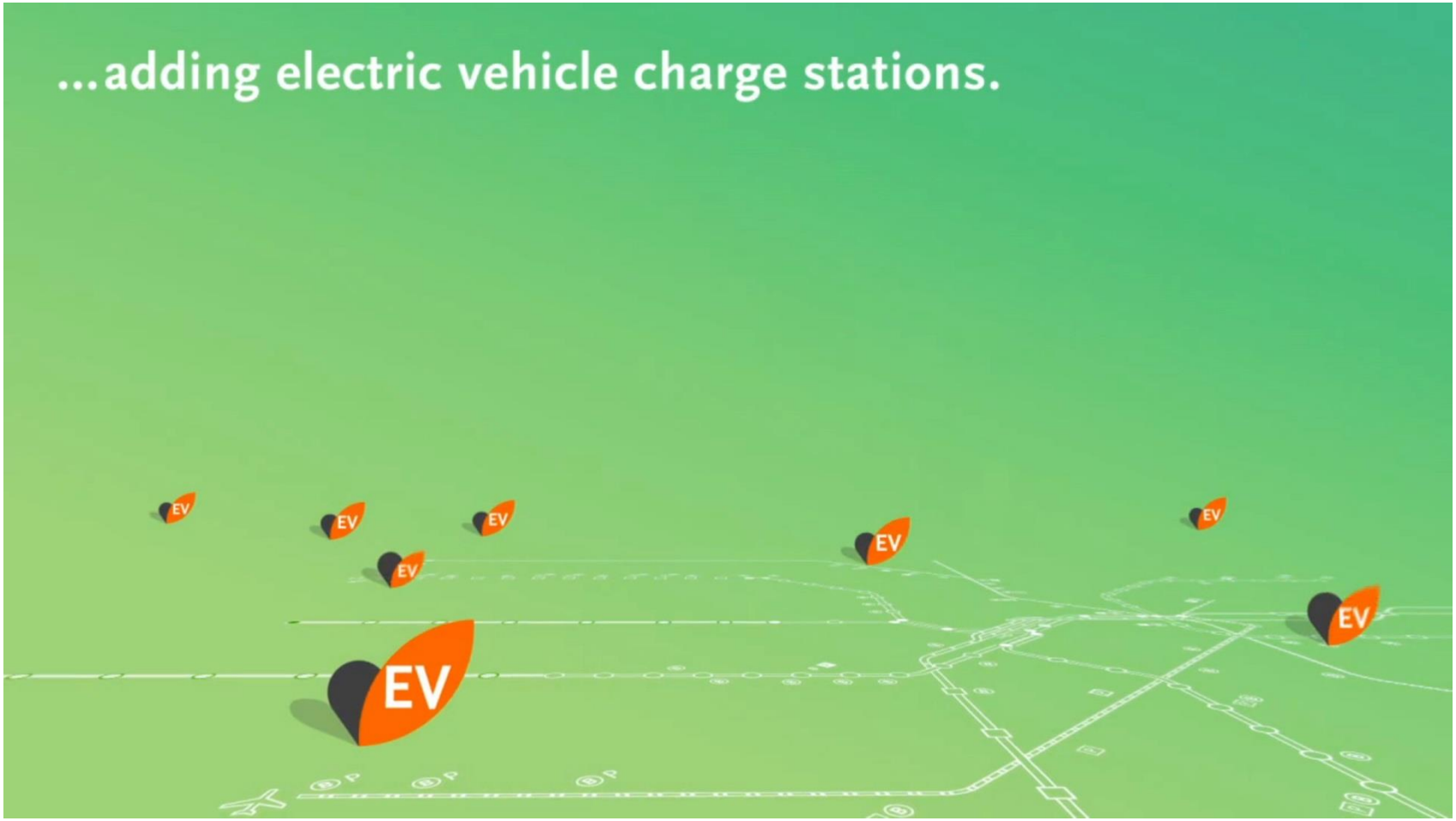
...adding electric vehicle charge stations.
EV
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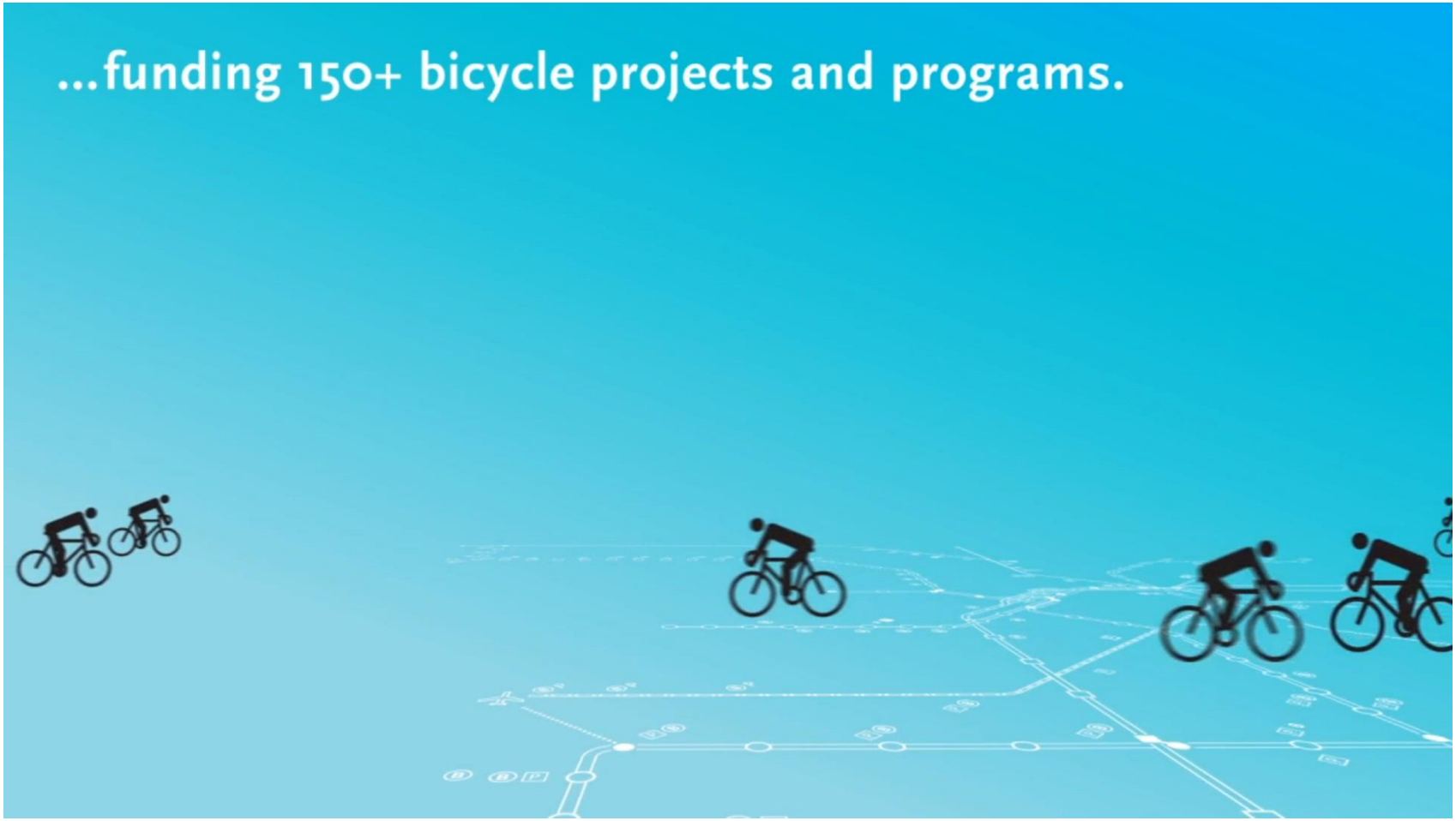
We follow a green approach to planning
and construction by...
Building with renewable materials.....


We follow a green approach to planning
and construction by...
.. Ensuring sustainable
practices with regional partners


...funding 150+ bicycle projects and programs.

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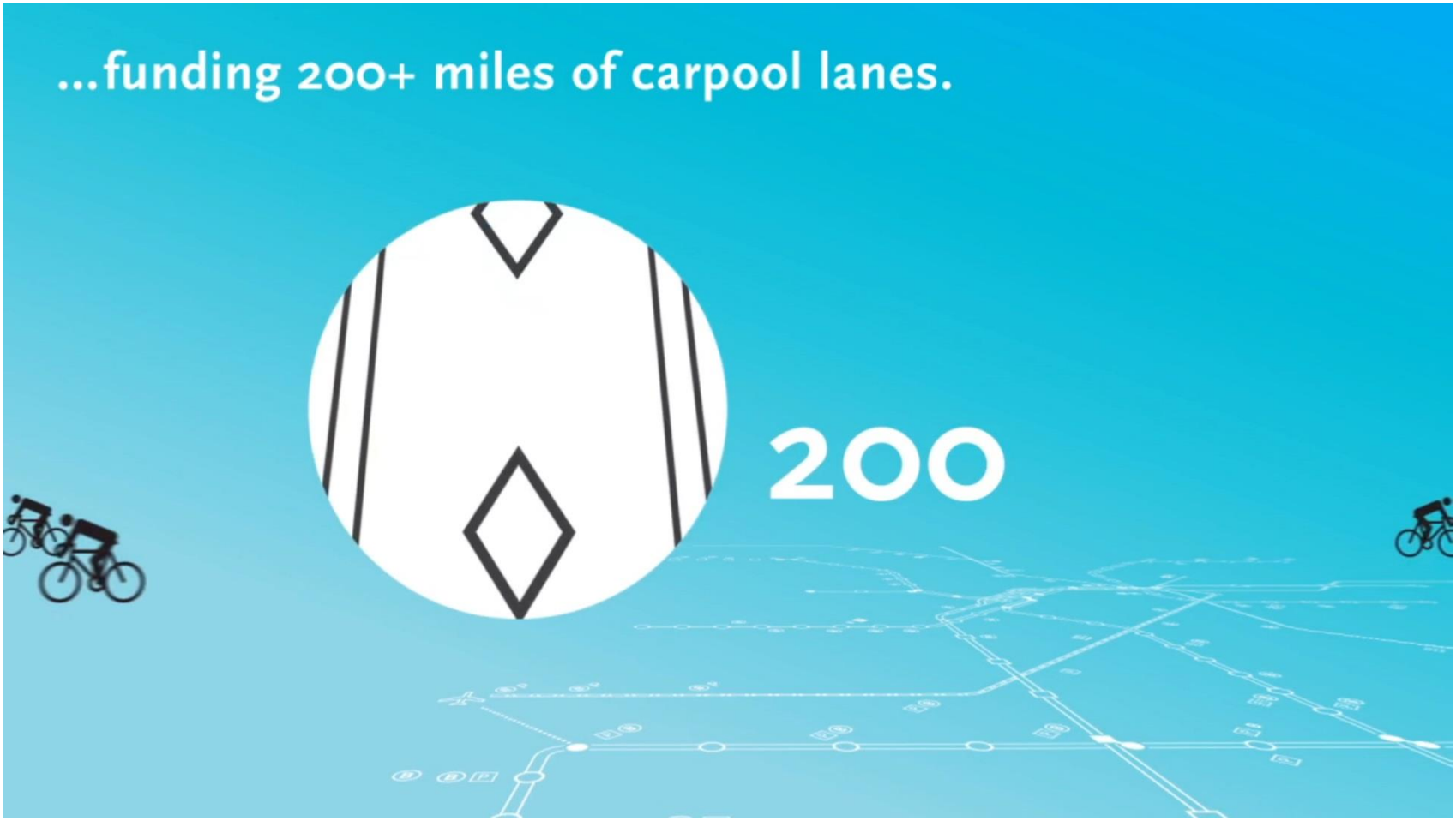


...funding street improvements which
support walking and better access to transit.

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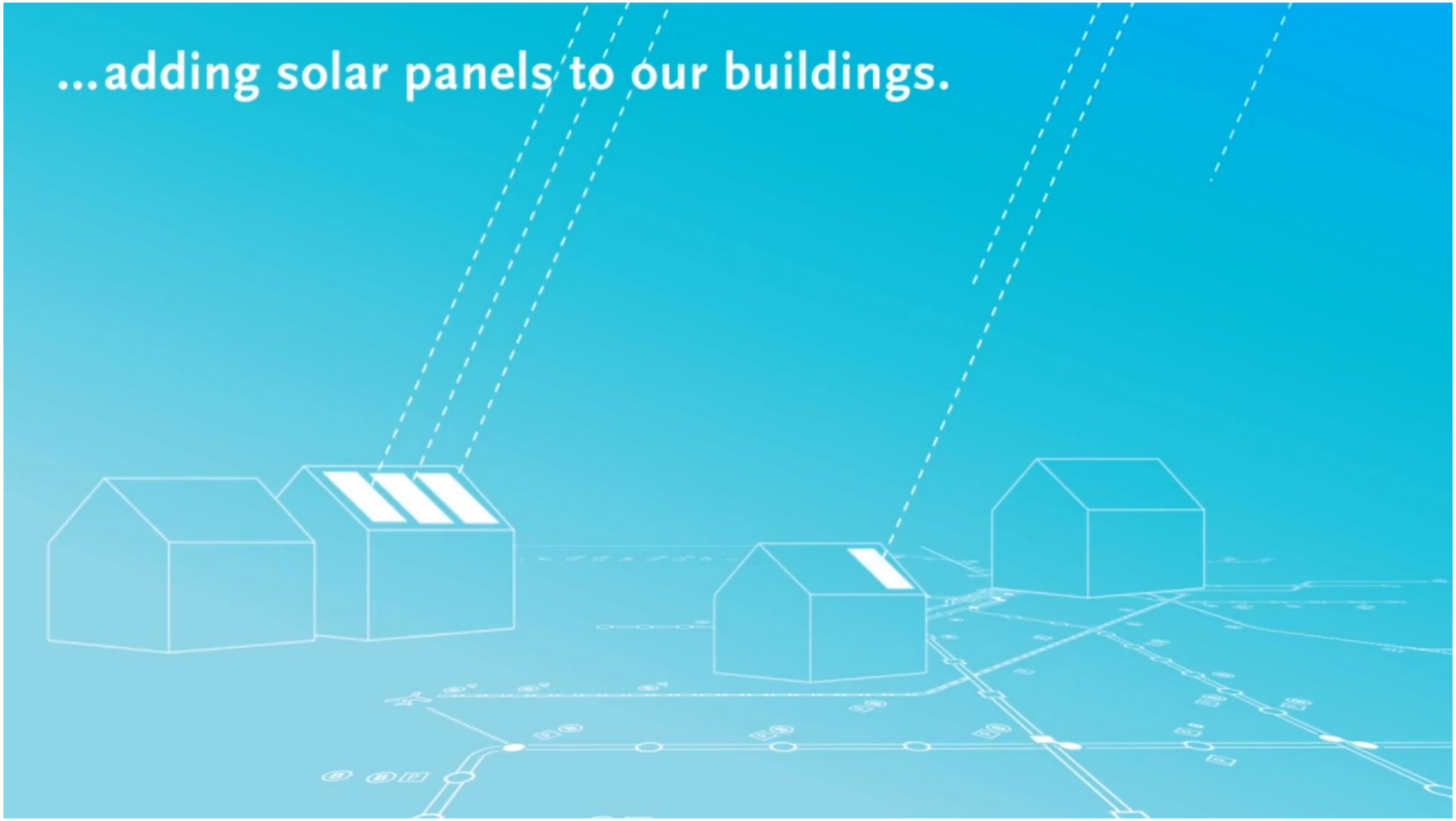

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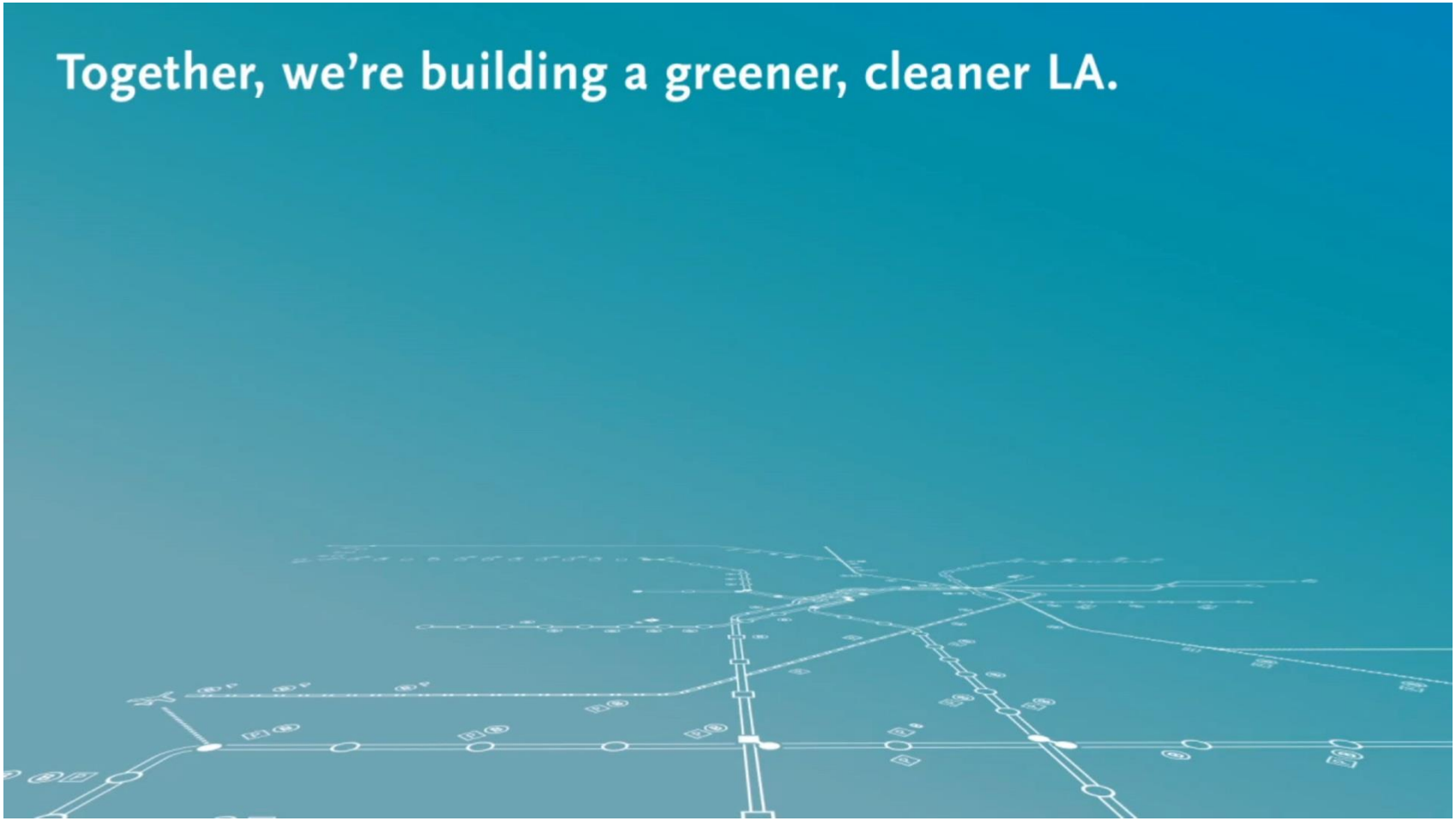

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