



## APPENDIX B

# Deep Dive Case Studies

## DEEP DIVE CASE STUDY SUMMARY

### Arizona Department of Transportation

#### Introduction

This document summarizes the deep dive interview conducted with the Arizona Department of Transportation (ADOT) in support of Task 3 of NCHRP Project 08-129. An extended phone interview was held with Senior Program Manager on Thursday, May 27, 2021. In addition, follow-up emails were exchanged to obtain further information. The following topics were discussed: the incorporation of resilience approaches into plans and programs, policies, and concepts; leadership and institutional capacity; internal and external collaboration; resource availability; risk and resilience assessment (RnR); identification of resilience improvement strategies; professional training and development; and public outreach and communications.

ADOT's vision is "Moving Arizona to become the most reliable transportation system in the Nation."<sup>1</sup> ADOT is responsible for the construction, operation, management, and maintenance of the State Highway System, which comprises more than 21,000 lane miles and over 5,000 bridges, with a historical cost of more than \$22 billion.<sup>2</sup> Transportation planning is delivered under the offices of the Deputy Director, with services provided by the organizational structure as illustrated in Figure 30.

The main strategic areas of focus related to planning include (i) the development of the Statewide Transportation Improvement Plan (STIP) and, as a subset, the ADOT 5-year construction plan, (ii) the Long-Range Transportation Plan (LRTP), (iii) working with

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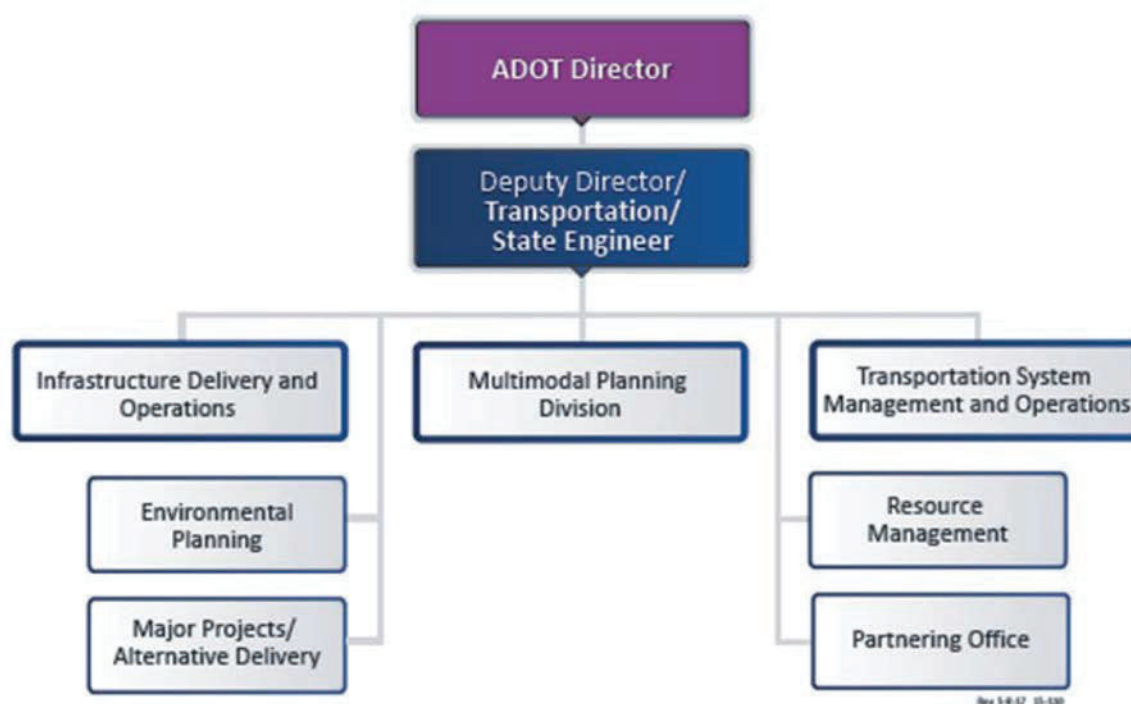
<sup>1</sup> ADOT, "Inside CDOT," [Online]. Available: <https://azdot.gov/about/inside-adot>. [Accessed June 7, 2021].

<sup>2</sup> ADOT, "Transportation Asset Management Plan" Arizona Department of Transportation, June 2019

representatives of individual tribes, MPOs and Council of Governments (COGs), (iv) Performance and (v) Asset Management.

### Key Findings

- A resilience program is established and in use.
- A formal definition for resilience has been established and communicated.
- Resilience definition is effective in ADOT planning efforts and inter-agency coordination.
- The management of the roadway system has now evolved from a decentralized, project-based focus to one that encompasses enterprise-wide endeavors: administration, asset management, technology adoption, planning, design, construction, operations, and maintenance.
- ADOT considers that long-range planning, planning outreach, and program development provide a natural foundation for applying/integrating resilience approaches.
- ADOT has developed and is developing tools for resilience quantification.
- ADOT has formally incorporated resilience into several significant efforts.
- ADOT recommends a 'bottom-up' approach to integrate resilience into planning.
- ADOT uses resilience tools to screen and prioritize activities from a planning perspective.



**Figure 30. ADOT organizational chart.**

ADOT seeks to combine risk, science, technology, and engineering to improve the understanding of risks to its transportation system and accomplish its mission, "Connecting Arizona. Everyone. Every Day. Everywhere."<sup>3</sup> A programmatic approach has been developed to address weather and natural hazards issues through a formal Resilience Program. The scope and goals of the program encompass risk-based asset management and life cycle planning approaches. In March 2020, ADOT published the results of its Asset Management, Extreme Weather, and Proxy Indicators Pilot Project.<sup>4</sup> The program identifies those stressors which pose the greatest threat to ADOT's transportation system, considering:

- Intense precipitation
- System flooding
- Wildfires
- Wildfire-Induced floods
- Drought-related dust storms
- Rockfall incidents
- Slope failures
- Increased surface temperatures

The outlined approach targeted extreme weather and climate stressors and prioritized asset classes susceptible to the considered stressors. It used GIS to advance how scientific evidence-driven decision-making informs transportation systems management and integrates with asset management processes. The project aimed to demonstrate how life cycle planning plays a crucial role in improving resilience to extreme weather and natural-hazard events by providing tools to link stressors, natural hazards, extreme weather, and measurable long-term climate-related risks to their impacts on transportation infrastructure in Figure 31. The developed methods are appropriate to serve ADOT in "identifying mitigation/adaptation options throughout the different stages of an asset life cycle, including planning, design/engineering, construction, maintenance, and operations. The purpose of the methods is to integrate information regarding current measures being used within ADOT and identify innovative ideas to mitigate risk through life cycle planning."

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<sup>3</sup> <https://azdot.gov/business/environmental-planning/programs/sustainable-transportation/resilience-program> [Accessed June 8, 2021]

<sup>4</sup> ADOT, "Asset Management, Extreme Weather and Proxy Indicators Pilot Project" Arizona Department of Transportation, March 2020. <https://azdot.gov/sites/default/files/media/2020/03/ADOT-Asset-Management-Infrastructure-Resilience-Study-Report%20Final-2020.pdf> [Accessed June 14, 2021].



Figure 31. Life cycle Planning Template Process to Link Extreme Weather Climate Adaptation, Asset Management, and Infrastructure Resilience<sup>5</sup>

5 ADOT, "Asset Management, Extreme Weather and Proxy Indicators Pilot Project" Arizona Department of Transportation, March 2020. <https://azdot.gov/sites/default/files/media/2020/03/ADOT-Asset-Management-Infrastructure-Resilience-Study-Report%20Final-2020.pdf> [Accessed June 14, 2021]

## Plans and Programs

ADOT incorporates resiliency concepts and approaches into its multimodal, long-range transportation plan (LRTP), statewide transportation improvement program (STIP), transportation improvement program (TIP), TAMP, and its 5-year, \$1.1 billion construction program.

The LRTP represents the 30,000-foot view and the entry point for resilience related to introducing the topic. It juxtaposes approximately \$100 billion in need in Arizona with circa \$30 billion in revenue over 30 years (2021 dollars). It represents an opportunity to craft what resilience means and introduce it to the planning partners internally and externally. An example is via interaction on the regional transportation plans developed by the two largest planning partners, the Maricopa Association of Governments and the Pima Association of Governments (PAG) out of Phoenix and Tucson, respectively.

By contrast, the STIP focus is on what can reasonably be afforded. Collaboration with local partners is vital as they bring to the table resilience-related issues associated with, for example, flooding and wildfires. In this regard, it is noted that:

'All highway and transit projects in the State, funded under Title 23 and the Federal Transit Act, must be included in a federally approved STIP. Projects in the STIP must be consistent with the statewide Long-Range Transportation Plan and Metropolitan Transportation Improvement Programs (TIPs). The program must reflect expected funding and priorities for programming, including transportation enhancements. Additionally, the Clean Air Act Amendments (CAAA) require MPOs within nonattainment areas to perform conformity determinations before approving their Regional Transportation Plans (RTPs) and Tips.<sup>6</sup>

The 5-year construction program provides for goals already being implemented in project-based resilience assessment. It contains not just the federally funded efforts but also the regional plans (RTPs). In addition, it has a public outreach component. ADOT's Planning to Programming (P2P) Guidebook<sup>7</sup> connects the LRTP to the 5-Year Construction Program through performance, as required by Arizona Revised Statutes (ARS) Title 28, Chapter 2, Article 7 (§ 28-501 through § 28-507), 23 USC Section 135(d)(2), and 49 USC Section 5304(d)(2).<sup>8</sup>

The P2P Guidebook is the key planning entry point for resilience at ADOT. Indeed, Section 2.0 Project Identification states, "Each May, the P2P Manager requests any new planning study recommendations from ADOT Planning staff, COGs, and MPOs, as well as any District project nominations."<sup>9</sup> Table 38, reproduced from Table 1, *ADOT Planning to Programming Scoring*

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<sup>6</sup> <https://azdot.gov/planning/transportation-programming/state-transportation-improvement-program-stip>. [Accessed June 7, 2021]

<sup>7</sup> [https://azdot.gov/sites/default/files/media/2020/09/FY20\\_P2P\\_Guidebook.pdf](https://azdot.gov/sites/default/files/media/2020/09/FY20_P2P_Guidebook.pdf) [Accessed June 10, 2021]

<sup>8</sup> <https://www.azleg.gov/arsDetail/?title=28> [Accessed June 10, 2021]

<sup>9</sup> [https://azdot.gov/sites/default/files/media/2020/09/FY20\\_P2P\\_Guidebook.pdf](https://azdot.gov/sites/default/files/media/2020/09/FY20_P2P_Guidebook.pdf) [Accessed June 10, 2021]

*Guidebook*, highlights resilience entry points from a strategic planning step and as a 'supplement and addition' to Section 4.0 Technical Score Criteria.<sup>10</sup>

**Table 38. ADOT Technical Groups.<sup>11</sup>**

Technical Group	Division
ADA/Civil Rights	Infrastructure Delivery & Operations (IDO)
Bridge	IDO
Geohazard / Rockfall	IDO
Railroad Coordination	IDO
Rest Area	IDO
Roadway	IDO
Stormwater & Erosion Control	IDO
Winter Operations Support	IDO
Pavement Management	Transportation Systems Management & Operations (TSMO)
Safety / Technology / TSMO	TSMO
Port of Entry	Enforcement & Compliance (ECD)

Another area flagged as a resilience planning entry point in the P2P Guidebook context relates to the Section 7.0 District Score.<sup>12</sup> The heavy weighting of this factor, in addition to the workshop component, was considered an 'additional point of resilience reinforcement.' It was believed that 'it could be utilized as an additional resilience project prioritization trigger because the final decision on what project to pursue comes with visiting the sites and getting the ground truth from the District folks who know the specific location and the weather and natural-hazard issues.'

By 2023, it is anticipated that the annual plan will be thoroughly screened for resilience in terms of the additional year adding to the 5-year program, with comprehensive coverage throughout planning documents expected by 2024. However, this will require partnership and collaboration with the regional planning entities. By developing such a process, it will be possible to identify

<sup>10</sup> [https://azdot.gov/sites/default/files/media/2020/09/FY20\\_P2P\\_Guidebook.pdf](https://azdot.gov/sites/default/files/media/2020/09/FY20_P2P_Guidebook.pdf) [Accessed June 10, 2021]

<sup>11</sup> *ibid.*

<sup>12</sup> *ibid.*

and prioritize projects where resilience-building is desirable early in the planning/preliminary engineering process. The result is that optimal early interventions can be placed in a root cause analysis and implemented more efficiently than later in the process. Effects can also enhance benefits which can be quantified in a life cycle analysis from an asset management perspective.

The key is identifying and understanding the nuances between planning, programming, and where preliminary engineering fits to capitalize on possible benefits before initiating the initial design. By screening, from a resilience perspective, the possibility exists all at once to extract as much benefit as possible.

In the initial stages of developing resilience policies and practices, the focus was on interacting with activities addressing weather-based natural-hazard risks. As a result, the entry point was at the project level instead of the planning level. From these activities, a toolbox was developed in a bottom-up approach, which facilitated screening at the planning level from an asset class perspective, e.g., drainage structures, roadways, bridges, etc. As a result, ADOT has become skilled in looking at a program from an asset class approach.

Based on their experience, ADOT would see the bottom-up approach, i.e., initial entry at the project level, with a focus on pilot studies considering asset classes, etc., as optimal in developing the competencies necessary to consider resilience assessment/incorporation at the planning level. It is simply regarded as infeasible to develop these competencies and critical mass from a top-down approach simply due to the inertia of the planning process. Project-level up provided the best route to success for ADOT as actionable resilience planning, assessment, and integration steps can occur daily, weekly, or monthly. However, ADOT recognizes that a mature resilience program is not fully validated without integration throughout planning and administration. Therefore, it is essential to note that scale cannot be achieved without other avenues also pressing the overall resilience planning and program need. Consequently, it was concluded that whether working bottom-up or top-down, it is preferable to have concurrent activities going on, i.e., if going top-down has some recent bottom-up activities going on and vice versa.

The main barriers which ADOT faced/faces in incorporating resilience into transportation planning relate to (i) a lack of a specific place for it to reside, i.e., in administration, planning, operations, or design engineering/project development, (ii) a lack of funding, (iii) a lack of staff, and (iv) a lack of metrics. Concerning funding, it is noted that the complexity associated with defining the case for funding resilience is difficult outside the areas related to emergency response funding. While top-level funding is made available at a congressional level for resilience funding/building efforts, it is often outside of areas related to design engineering activities. However, some recent positive moves have been made to address this apparent historical imbalance from a planning and design engineering perspective.

Concerning metrics, ADOT is currently focused on developing appropriate resilience metrics for agency-wide activities together with the Texas Transportation Institute Center for Advancing Research in Transportation Emissions, Energy, and Health (CARTEEH). CARTEEH is a Tier-1 center, funded by the U.S. Department of Transportation's Office of the Secretary for Research and Technology (OST-R), under the University Transportation Centers (UTC) program. Examples

include resilience return on investment, resilience benefit-cost analysis, number of resilience activities conducted, total lane mile assessed for resilience, number of structures assessed for resilience, etc. These were expected to be finalized by the end of 2021 with significant benefits from a planning perspective to define/quantify agency-focused resilience activities.

### *Policy & Concept*

ADOT defines resilience as found in FHWA Order 5520 – "anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions."<sup>13</sup>

ADOT's resilience program details may be accessed via the program's dedicated website. At a Resilience Program level, it is focused on the management of assets (e.g., bridges, culverts, pavements, and roadside vegetation/stabilization) concerning the extreme weather-climate risk of intense precipitation, system flooding, wildfires, wildfire-induced floods, drought-related dust storms, rockfall incidents, slope failures, and measurable climate trends (especially as it relates to precipitation and direct effects of increased surface temperatures) by regions or specific segments emphasized as critical to contribute to the safety of the traveling public, improve weather and natural-hazard risk management, and improve the long-term life cycle planning of transportation infrastructure.

ADOT considers that "incorporating natural-hazard, weather-related considerations, and resilience into how agencies plan and execute their Transportation System Management and Operations (TSMO) and maintenance programs helps the agency become more resilient to unanticipated shocks to the system. Adjustments to TSMO and maintenance programs - ranging from minor to major changes - can help minimize the current and future risks to TSMO and maintenance, and most importantly, safety to the traveling public."<sup>14</sup>

Policy implementation represents the 'holy grail.' ADOT planned to work with government relations groups comprehensively in 2021 to provide assistance and education on activities in resilience capacity building from a state legislative approach, but this will need a high-level champion. Often support is developed as opposed to the policy. For example, Arizona has no state resilience policy but a resilience definition and an "implementation of the TAMP."

### *Leadership and Institutional Capacity*

In some regards, barriers within ADOT implementation have arisen by underestimating the appetite to adopt resilience across the agency and underestimating the willingness for individual practitioners to help. However, there have been no leadership barriers. Indeed, champions for adoption exist across the agency, for example, with the state engineers' office eagerly awaiting

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<sup>13</sup> <https://www.fhwa.dot.gov/legisregs/directives/orders/5520.cfm> [Accessed June 16, 2021]

<sup>14</sup> <https://azdot.gov/business/environmental-planning/programs/sustainable-transportation/resilience-program/resilience> [Accessed June 16, 2021]



the 2021/22 resilience plan. For example, funding has been made available to upgrade the frame of an agency-level business case approach. In addition, there has been a willingness to champion and adopt new and advanced strategies where applicable, e.g., the case was made with leadership and approved by leadership for building asset class probabilistic risk-based methodologies. Overall, from the perspective of leadership and institutional capacity, there have been no barriers, whereby the agency recognized at an early stage from agency-level planning through project development that better identifying, understanding, mitigating weather and natural-hazard risks, and enhancing resilience were in its best interest in achieving the ADOT vision.

### *Collaboration*

ADOT communicates resilience approaches to develop consensus with both internal and external entities. The challenge in this regard is crafting a messaging structure that applies to a broad range of participants.

- **Internally**

Specific internal collaborations facilitate the process, including the Asset Management Working Group. Resilience-based activities are built into the asset management plan. The group "supports the implementation of the TAMP, including developing performance measures and state targets to be reviewed for approval by the steering committee; identifying and prioritizing risks to ADOT's transportation infrastructure; recommending changes to policies, procedures, and processes to improve transportation asset management at ADOT; ensuring together to accomplish the development and maintenance." Detailing the breadth of participation is the membership of the group, listed here<sup>15</sup>:

- Transportation Asset Management, Facilitator
- FHWA Arizona -Division Representative
- Assistant Director for Transportation Systems Management and Operations Division
- Assistant Director for Infrastructure Delivery and Operations Division
- Deputy State Engineer – Operations
- Deputy State Engineer – Design
- Federal Aid Administrator – Financial Management Services
- Chief Economist – Financial Management

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<sup>15</sup> ADOT. (2021). Arizona DOT Transportation Asset Management Plan, Phoenix, AZ. Accessed July 7, 2022, from, <https://azdot.gov/sites/default/files/2019/08/Transportation-Asset-Management-Plan.pdf>

Consensus building before initiation of the WG is a vital activity, so the participants are well versed in the arguments and ready/willing to participate in discussions around and promote resilience-related activities.

Participation includes the Deputy Senior State Engineer and group level and director level participation from planning, asset management, TSMO, etc. TSMO participation has facilitated the development of tools and protocols, e.g., incorporating resilience into district-level emergency operations plans.

Furthermore, the breadth of services offered by different DOTs was discussed. For example, ADOT has an aeronautics group; as a result, ADOT manages airports for the State and is the federal funding portal for 175 municipal airports in the State. The Director and Deputy Director of Aeronautics are starting this year on resilience activities purely as a planning activity in terms of funding authorization activities.

Systems Operation should also be considered a part of the discussion and a possible champion for resilience-based activities. Accordingly, ADOT is looking to focus on growing resilience-based planning activities from a systems operation perspective.

- **Externally**

ADOT interacts with external organizations in the context of resilience-related activities, such as MPOs and Councils of Government (COG). This interaction also includes bringing resilience to the State's counties and regional flood control entities, primarily through large-area drainage planning studies. Furthermore, ADOT plays an active role in collaborating with AASHTO, FHWA, and TRB. At a national level, ADOT led one of six pilot projects focused on "evaluating the linkage between asset management, LCP, risk, extreme weather, and measurable climate trends."<sup>16</sup> This project, built upon the ADOT Extreme Weather Vulnerability Assessment, assessed the vulnerability of transportation infrastructure to extreme weather and climate trends specific to Arizona.<sup>17</sup> ADOT developed a "multi-stakeholder decision-making framework – including planning, asset management, design, construction, maintenance, and operations – to cost-effectively enhance the resilience of Arizona's transportation system to extreme weather and climate risks."<sup>18</sup>

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<sup>16</sup> ADOT, "Asset Management, Extreme Weather and Proxy Indicators Pilot Project" Arizona Department of Transportation, March 2020. <https://azdot.gov/sites/default/files/media/2020/03/ADOT-Asset-Management-Infrastructure-Resilience-Study-Report%20Final-2020.pdf> [Accessed June 14, 2021]

<sup>17</sup> ADOT, "Extreme Weather Vulnerability Assessment" January 2015. [https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015\\_pilots/arizona/arizonafinal.pdf](https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015_pilots/arizona/arizonafinal.pdf) [Accessed June 13, 2021]

<sup>18</sup> *ibid.*

## Resource Availability

Recent scans of state DOTs and MPOs have revealed common challenges to incorporating resilience into planning, including a lack of tools and resources. ADOT has expressed a similar need for increasing some of these resources.

### ▪ Data

From a resilience perspective, ADOT has found the central warehousing of data to be a 'game changer' in the use of data and management. A resource compendium has been established by ADOT via a resilience GIS database using ArcGIS. This way, base layer mapping in the agency was combined with traffic data, and incident data in addition to the ADOT climate modeling mapping needs information, USGS, NOAA, National Weather Service, Forest Service, Dept. of Interior, etc. The platform developed applies to project development and consideration/analysis of over 30,000 lane miles in the system from a planning standpoint of 'areas of interest.' Such data sets must be regularly monitored, updated, and validated, all of which are discussed in the following sections. ADOT considers the TAMP, with its requirement for regular updating, to be an excellent facilitator in this regard.

ADOT is passionate about the 'elephant in the room' to better address life cycle planning and long-term management of available resources in considering/tackling climate change effects, which is data! Data and human resources must be made available to facilitate, for example, interactions between planners, academia, resource agencies, and state climatologists to develop climate-based data inventory for use in planning and design. But how can this best be done? It will require the necessary people/resources to do this.

ADOT has just started its 3rd climate data effort with North Carolina State University; however, data storage/management facilities are proving an issue. ADOT does not have computer resources to work with the data sets produced. ADOT did 2015 and 2018 studies on collecting and using climate data. All data was mapped in GIS, i.e., two time series from 19 different climate models were mapped in GIS.

One possible solution discussed is subdividing the country into manageable parts with similar climatic conditions. For example, ADOT already interacts with six states on advancing hydrology and hydraulic engineering, partnering with FHWA and USGS.

### ▪ Funding

ADOT considers that funding is easier to secure for resilience assessment at the project level. It is not as easy to define how the Federal Aid program can assist in planning. However, a part of the regional transportation planning budget mechanism can be assigned to facilitate resilience assessment from the Federal Aid program. A key issue is who has control over different developments and who has control over funding associated with those developments.

## Risk and Resilience Assessment (RnR)

ADOT follows the risk framework in the FHWA document titled *Incorporating Risk Management into TAMPs*.<sup>19</sup> It details the consideration of risk and risk management provided in the TAMP.<sup>20</sup> The applied framework includes five components, namely (i) Establish Context, (ii) Risk Identification, (iii) Risk Analysis, (iv) Risk Evaluation, and (v) Manage Risks. Risk types considered include Agency, Financial, Program, Asset, Project, and Activity. Risk registers are maintained whereby the likelihood and impact of various risks are assessed and ranked. At the same time, the TAMP focuses on bridges and pavements, and the risk analysis considered other families of assets on the National Highway System and State Highway System. In total, 27 risks were identified in the TAMP, of which 16 are very high in priority. In addition, the TAMP proposes mitigation actions for high-priority risks, including those due to extreme weather.

Furthermore, 6 of 27 risk register items are resilience-based and are connected to/correlated with six others. So, a significant portion of the risk register has some resilience as a contributing factor. Overall, resilience fits comfortably within the risk-based approach.

ADOT prepared a Preliminary Study of Climate Adaptation for the Statewide Transportation System in Arizona in 2013<sup>21</sup> and an Extreme Weather Vulnerability Assessment in 2015.<sup>22</sup>

Currently, quantitative probabilistic approaches to resilience quantification are under development by ADOT. They offer considerable promise for rational consideration of the effects of planning and design strategies and decisions. Fragility curves represent the system's functionality over time.<sup>23</sup> Functionality curves describe system performance before, during, and after a hazardous event. ADOT's probabilistic framework shows promise in facilitating quantification of the impact of planning and design decisions on the resilience of infrastructural elements or networks.

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<sup>19</sup> FHWA, 'Incorporating Risk Management Into Transportation Asset Management Plans', [https://www.fhwa.dot.gov/asset/pubs/incorporating\\_rm.pdf](https://www.fhwa.dot.gov/asset/pubs/incorporating_rm.pdf) [Accessed June 12, 2021]

<sup>20</sup> ADOT, "Transportation Asset Management Plan" Arizona Department of Transportation, June 2019

<sup>21</sup> ADOT, "Preliminary Study of Climate Adaptation for the Statewide Transportation System in Arizona", March 2013. [https://apps.azdot.gov/files/ADOTLibrary/publications/project\\_reports/pdf/az696.pdf](https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/az696.pdf) [Accessed June 15, 2021]

<sup>22</sup> ADOT, "Extreme Weather Vulnerability Assessment" January 2015. [https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015\\_pilots/arizona/arizonafinal.pdf](https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015_pilots/arizona/arizonafinal.pdf) [Accessed June 13, 2021]

<sup>23</sup> Solomos, G. and Caverzan, A. (2014) Review on resilience in literature and standards for critical built-infrastructure. doi: 10.2788/872668.

Currently, ADOT is conducting studies to assess planning and design options from a resilience enhancement perspective on projects such as the State Route 80 San Pedro River Bridge and the Interstate 10 Gila River Crossing, Figure 32.<sup>24</sup>



**Figure 32. San Pedro Bridge over the Gila River, SR-80, Arizona.**

Challenges to incorporating qualitative and quantitative methods related to the funding and building a programming level argument for what should be risk unit activity and who should perform risk and recovery activities within the state agency.

The main successes of having methodologies to incorporate RnR approaches include (i) having the ability to speak at the asset class level (which is a more comfortable planning level conversation) and (ii) for planners to make decisions on how funding should be spent, i.e., on what activity, e.g., future growth or preservation.

ADOT has protocols and procedures in place to monitor and track the impact of measures taken at a project level to enhance resilience. Protocols and procedures include monitoring instances where a risk-informed decision was taken not to incorporate resilience enhancement measures. ADOT stressed the importance of incorporating appropriate ongoing monitoring into developed frameworks to assess the efficacy of measures taken to enhance resilience.

- **Criticality and Hazard Assessment**

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<sup>24</sup> <https://i10bridgeproject.com> [Accessed June 16, 2021]

The purpose of ADOT's Asset Management Extreme Weather and Proxy Indicators Pilot Project, published in March 2020<sup>25</sup>, was to '(i) develop life cycle planning methods that consider the effects of natural hazards and extreme weather conditions on transportation assets, (ii) establish analytical procedures that provide a risk-based approach for identifying assets and locations with a high likelihood of being impacted, (iii) develop a flexible, scalable, risk-based GIS-based resilience database and real-time information dashboard that links transportation asset management, natural hazard and weather, climate impacts, and ADOT infrastructure resilience efforts, and (iv) identify actions to improve overall infrastructure resilience linkages, especially for the most vulnerable assets or classes of assets eligible for FHWA TAMP reporting.' The pilot integrated extensive internal and external data sources to identify and synthesize risks and hazards in the ADOT system. The approach adopted in the pilot is illustrated in Figure 33.

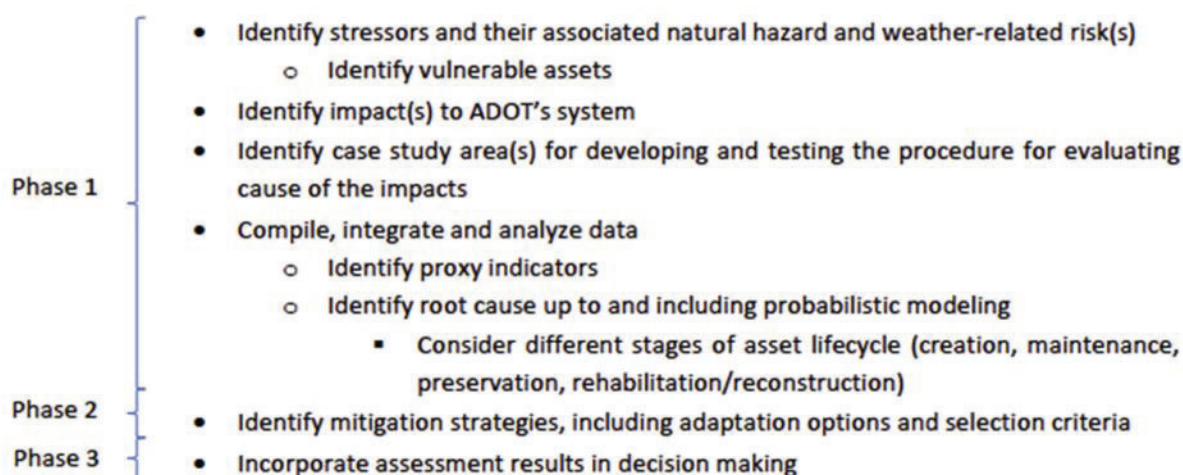


Figure 33. ADOT's Pilot Project Approach<sup>26</sup>

#### ■ Vulnerability Assessment

<sup>25</sup> ADOT. (2020). Asset Management, Extreme Weather, and Proxy Indicators Pilot Project. Retrieved from <https://azdot.gov/sites/default/files/media/2020/03/ADOT-Asset-Management-Infrastructure-Resilience-Study-Report%20Final-2020.pdf>

<sup>26</sup> ADOT. (2020). Asset Management, Extreme Weather, and Proxy Indicators Pilot Project. Retrieved from <https://azdot.gov/sites/default/files/media/2020/03/ADOT-Asset-Management-Infrastructure-Resilience-Study-Report%20Final-2020.pdf>

ADOT prepared a Preliminary Study of Climate Adaptation for the Statewide Transportation System in Arizona in 2013 and an Extreme Weather Vulnerability Assessment in 2015.<sup>27</sup> In the 2015 assessment, ADOT leveraged the FHWA Vulnerability Assessment Framework, Figure 34.<sup>28</sup>

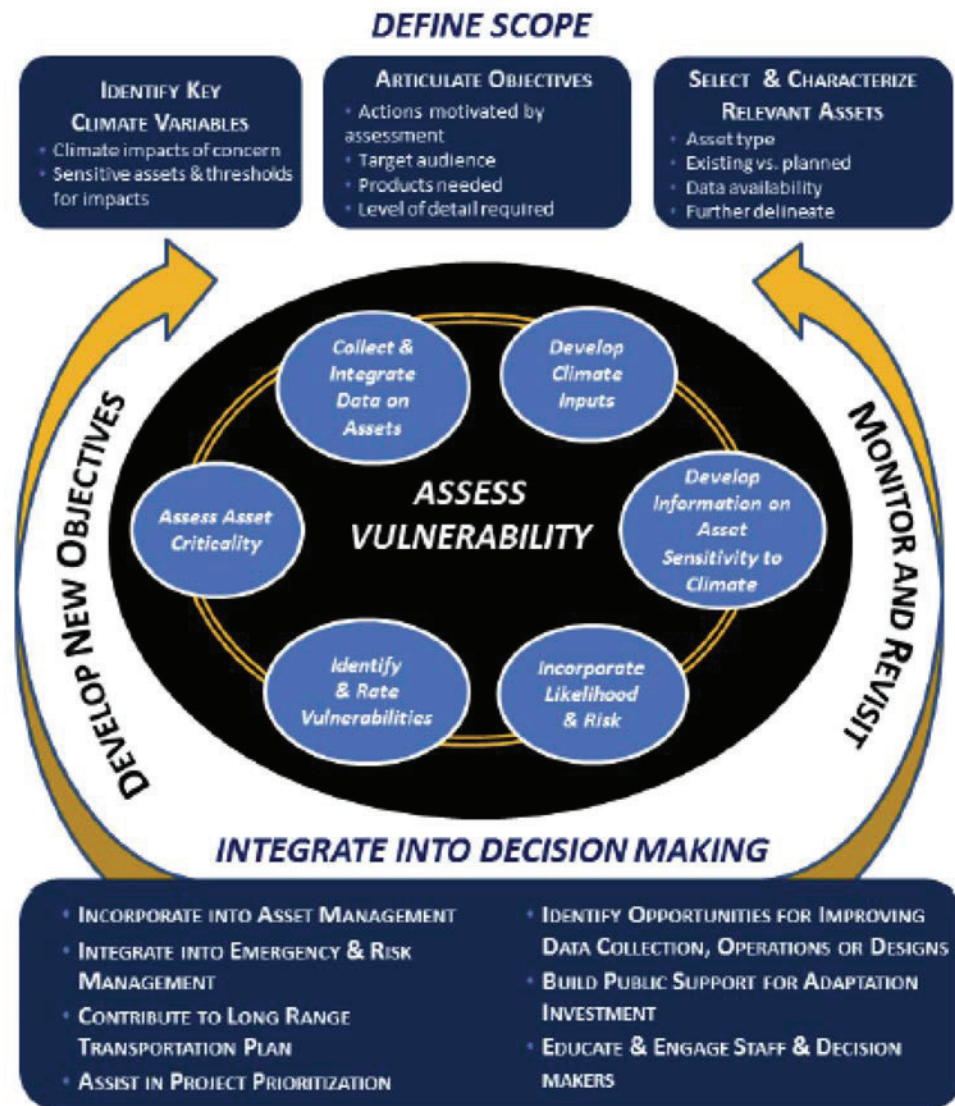


Figure 34. FHWA Vulnerability Assessment Framework<sup>29</sup>

<sup>27</sup> ADOT, "Extreme Weather Vulnerability Assessment" January 2015.

[https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015\\_pilots/arizona/arizonafinal.pdf](https://www.fhwa.dot.gov/environment/sustainability/resilience/pilots/2013-2015_pilots/arizona/arizonafinal.pdf) [Accessed June 13, 2021]

<sup>28</sup> <https://www.fhwa.dot.gov/environment/sustainability/resilience/index.cfm> [Accessed June 18, 2021]

<sup>29</sup> <https://www.fhwa.dot.gov/environment/sustainability/resilience/index.cfm> [Accessed June 18, 2021]

Information was gathered on potential extreme weather impacts, climate data, transportation assets, and land cover characteristics (e.g., watersheds, vegetation, etc.). The datasets were then integrated with conducting a high-level vulnerability assessment. Stakeholder input and feedback were central to the process. The study was a part of the FHWA Climate Change Resilience Pilot Program. ADOT's goal was/is "the development of a multi-stakeholder decision-making framework - including planning, asset management, design, construction, maintenance, and operations – to cost-effectively enhance the resilience of Arizona's transportation system to extreme weather risks."

- **Identification of Resilience Improvement Strategies**

Since 2013, ADOT has developed 8-10 tools, approximately 1 per year, to facilitate the assessment/quantification of resilience and the benefits of resilience enhancement from a planning perspective. Examples include tools to identify the necessary steps for resilience planning and include the benefits of incorporation into planning activities such as the 5-year plan. ADOT has, for example, (i) a resilience financial hierarchy model, (ii) a planning/screening tool, (iii) an end-to-end engineering process tool, (iv) a climate influence model, etc. Overall, an excellent 'toolbox' has been developed to be utilized in resilience assessment and planning, which facilitates the development of financial justification approaches and consideration of sustainability criteria in a 'total systems approach.'

In discussion, it was felt that long-proven program-level prioritization methodologies which provide for annual project prioritization could (and perhaps should) include resilience as a factor for consideration. It was felt that ADOT could, in some sense, serve as an intermediary (via the planning group) and offer resilience considerations to parties (external – municipalities, contributing authorities, etc.) involved in the planning exercise to develop prioritization strategies.

- **Resilience Metrics**

ADOT has established resilience metrics that are data-driven and tracked through resilience-building software tools, e.g., dollars spent, number of screened activities, asset types, State Route vs. Interstate, etc. For example, metrics are employed in the economic justification for project building. ADOT has to date, completed 10 resilience-building efforts. By way of example: the 24-hour precipitation design threshold and scour critical status were selected as sensitivity metrics in ADOT's Asset Management, Extreme Weather, and Proxy Indicators Pilot Project.<sup>30</sup>

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<sup>30</sup> ADOT, "Asset Management, Extreme Weather and Proxy Indicators Pilot Project" Arizona Department of Transportation, March 2020. <https://azdot.gov/sites/default/files/media/2020/03/ADOT-Asset-Management-Infrastructure-Resilience-Study-Report%20Final-2020.pdf> [Accessed June 14, 2021]



### **PROFESSIONAL TRAINING AND DEVELOPMENT**

ADOT does not offer specific training now. However, two initiatives were planned for the Fall of 2021: (i) an online/desktop training session for project managers on sustainable development for project development and (ii) a resilience training day.

### **PUBLIC OUTREACH & COMMUNICATION**

ADOT engages in extensive public outreach and communication via the ADOT News web page.<sup>31</sup> ADOT has a robust system to inform the public of all things related to natural hazards. In addition, the web page has been used to communicate several resilience-enhancing initiatives to the public, including relating awards for sustainable infrastructure and resilience-enhancing projects.

### **Final Thought**

We concluded our discussion by asking ADOT's NEPA Assignment, Innovative Programs, Major Studies Senior Project Manager, 'How long do you think it would take an agency to incorporate resilience into planning?' He felt that based on his experience and on the fact that the Transportation Bill in development would be a significant lever in the process, a period of 5-7 years seemed 'about right.' ADOT began the process in 2011 and, in 2015, had a Resilience Program. He was very optimistic about the future as he felt a plethora of federal guidelines, tools, and suggestions were available. He closed our discussion by suggesting, 'It is not complicated. It is very manageable.'

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<sup>31</sup> <https://azdot.gov/adot-news?page=1> [Accessed 18<sup>th</sup> June 2021]