NEVADA DEPARTMENT OF TRANSPORTATION

FY 2014 RESEARCH PROBLEM STATEMENTS **(INTERNAL SUBMISSION FORM)**

I. PROBLEM TITLE: Streamlining hydrologic prediction processes using new and more accurate techniques and methods.

II. PROBLEM DESCRIPTION: The current edition of the NDOT Drainage Manual was published in December of 2006; however, new methods and technologies have emerged that have made hydrometeorological and hydrologic analyses more accurate. NDOT is proposing to use these new tools and methods that have not been used previously, as they have been shown to significantly improve accuracy and reliability. The new tools/methods are shown in Section IV below along with the methods NDOT currently employs. The proposed work satisfies the following critical research clusters:

- Infrastructure (Sizing of culverts, smaller bridge substructure components due to reduced scour depths from the anticipated reduced design flows)
- Economics (Smaller and cheaper culverts and bridge substructure components)
- Policy Analysis (Revision to NDOT Drainage Manual Chapter 3 - Hydrology Section)
- Energy/Sustainability (Smaller culverts and bridge substructure components requiring less materials, labor, and maintenance)

III. OBJECTIVE: More accurate representation of storms in Nevada is required in order to more accurately predict hydrologic runoff, particularly the components of storm size/shape/duration. NDOT is proposing to retain a meteorological consultant to more accurately analyze storm events in Nevada on a county-wide and/or a regional basis. Clark County would not be included in this effort as they have developed their own "Hydrologic and Drainage Design Manual" that uses storm durations, Depth-Area Reduction Factors (DARFs), and NOAA Atlas 2 for point rainfall values, all specific to Clark County.

The final results of the proposed research would be more accurate and efficient prediction of rainfall and runoff, which has been shown to lead to smaller-sized structures and reduced predicted scour depths at bridges and culverts.

IV. CURRENT PRACTICE AND RELATED RESEARCH: NOAA Atlas 14, Volume 1 and its predecessor, NOAA Atlas 2 both cover the semiarid Southwestern United States. Both publications recommend the use of National Weather Service (NWS) Publication TP-40 for depth-area relations, which is also currently used by NDOT. The Nevada Division of Water Resources (NDWR), whose State Engineer is responsible for dam safety, currently uses the 1977 NWS publication "Hydrometeorological Report (HMR) 49" which includes its own DARFs for Probable Maximum Precipitation (PMP) studies, and the HMR 49 DARFs are different from TP-40. NDOT and NDWR typically do not coordinate on meteorological methods, and it is hoped that a future joint PMP and DARF meteorology study can be funded jointly by NDOT, NDWR, and other agencies. Reductions of point rainfalls based on area (DARFs) in the semiarid Southwest are greater than the previously published TP-40 values because TP-40 was developed from storm data in the more humid Eastern United States that grossly overestimate values for

storms in the Western United States that are significantly smaller in size. Nearby states such as Utah and Arizona use newer NOAA Technical Memoranda and have developed their own DARFs and, as previously mentioned, Clark County, Nevada uses their own "Hydrologic Criteria and Drainage Design Manual" published in 1999. NDOT should follow suit with an update to their techniques and methods.

Radar-rainfall data (NEXRAD/Rain Gage) provide significant improvements in analyzing rainfall spatial distributions and have been used to analyze Depth-Area relationships (DARFs). This has been done by the Texas DOT, FHWA and others:

- Olivera, F., D. Kim, J. Choi, and M. Li, "Calculation of Areal Reduction Factors using NEXRAD Precipitation Estimates," Research Report FHWA/TX-05/0-4642-3, submitted to the Texas Department of Transportation, Texas Transportation Institute, Texas A&M University, 2005.
- Durrans, S.R., Lesly, T.J., and Yekta, M., "Estimation of Depth-Area Relationships Using Radar-Rainfall Data," ASCE Journal of Hydrologic Engineering, 7(5): 356-367, 2002.
- Parzybok, T.W., and E.M. Tomlinson, "A New System for Analyzing Precipitation from Storms", Hydro Review, Vol. XXV, No. 3, 58-65, 2006.

V. RESEARCH METHODOLOGY:

TASK 1: REVIEW PREVIOUS WORK. Review previous storm analysis, design storms, and rainfall frequency data in the region for data/techniques/procedures applicable to Nevada; provide discussions on previously implemented and proposed data/techniques/procedures.

TASK 2: STORM SEARCH AND STORM LIST DEVELOPMENT. Identify storm events to use in developing new DARF information (generally 2-yr to 100-yr storms); use previous storms used to develop PMP data and hydrologic studies; evaluate climatic regions throughout Nevada to identify regions of similar climatic characteristics' provide a comprehensive list of significant storm events and their relevancy to each region.

TASK 3: STORM ANALYSES. Utilize some number of new storm events with computer analysis using radar-rainfall data analysis (provided that NEXRAD data is available); determine storm shape/size/duration to develop explicit timing and DARF information; utilize historic NEXRAD data to analyze previous storms and determine their shape/size/duration; determine appropriate hydrologic parameters for each region based on storm analysis results.

TASK 4: DEVELOP DARF VALUES STATEWIDE. Using the results of Tasks 1-3, derive storm-based DARFs by storm type and climatic region with the results in several formats, including GIS gridded files; NDOT will determine the data format most useful.

TASK 5: QUALITY CONTROL AND SENSITIVITY. Perform quality control analyses to ensure continuity with adjacent regions and in time/space (where such comparisons can be made); compare derived DARFs with previous work in the region and against existing climatological data for reasonableness; discuss any differences.

TASK 6: DRAFT AND FINAL REPORT. A draft report will be developed to present and discuss the approach used and the results; respond to any questions from NDOT and incorporate any changes requested within reason; include as an Appendix detailed information on storm analyses.

VI. IMPLEMENTATION POTENTIAL: The proposed research is Stage V Specification & Standards with Full Deployment Stage and once completed, the new techniques would require revisions to the NDOT Drainage Manual. All drainage and bridge scour mitigation projects must be designed to provide an appropriate level of safety for the traveling public and adjacent land owners without being "overdesigned." (meaning that facilities are designed to provide an extra factor of safety up to a point that raises the project cost). Updated and more reliable analyses will provide more appropriately sized structures; provide an appropriate level of safety for the traveling public and adjacent land owners; and result in smaller cost due to the use of more realistic local hydrology.

The caveat with the proposed changes to the methods of hydrologic analysis is that they should NOT be predicated solely on cost savings. If more frequent or more severe flooding results, or adjacent landowners or the traveling public will be adversely affected, then either some mitigation should be considered, or the proposed changes should be rejected. The public will perceive a benefit with projects being constructed under smaller budgets, but that is a perception. If the reality of more frequent or more severe flooding occurs, the public will, of course, react negatively to the proposed changes. However, it should be noted that more accurate analysis could actually increase structure cost. In that case, the public is still receiving the appropriate level of safety.

VII. URGENCY AND PAYOFF POTENTIAL: This project can be completed within one calendar year and then be immediately available for design purposes. As highway budgets become more and more tight, projects must be examined more closely for ways to cut costs. In Nevada, drainage work on a project consumes roughly 10% of the budget, so anything that can be done to cut this cost while still providing safe, effective, and maintainable drainage facilities will help the state highway budget. Revising the methods used for hydrologic analysis should result in more realistic intensities based on detailed analyses of recent storm events which are often lower than those provided by current methods. Lower runoff values will result in smaller drainage facilities and smaller bridge substructure units due to reduced predicted scour, but even though the facilities may be smaller, they will still be safe and adequate for highway drainage purposes. In addition, oversized drainage structures could potentially result in increased maintenance costs as they are more readily silted in due to the lower velocities dropping out the sediment bed load. Quick implementation will result in immediate construction cost savings in approximately one year after completion of the project.

VIII. ESTIMATED BUDGET: $300,000 for Meteorology Consultant for Tasks 1-6. The cost for an Engineering Consultant to perform the other workflow changes would be an additional $100,000.

IX. DATE AND SUBMITTED BY: Brian Wilson, PE, NDOT Senior Engineer, Hydraulics Section (Roadway Design), 1263 S. Stewart St., Carson City, NV 89712. (775) 888-7604, bwilson@dot.state.nv.us.

X. ADDITIONAL 10 POINTS FOR MULTIPLE CHAMPIONS FROM MORE THAN ONE SECTION: Todd Stefonowicz, Structures Division Manager; Mike Griswold, Assistant Materials Engineer (Geotechnical Division).