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## North Carolina's Geodatabase for Statewide Stream and Wetland Mitigation

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### ABSTRACT

In 2003, North Carolina instituted an innovative statewide program to provide stream and wetland mitigation called the North Carolina Ecosystem Enhancement Program (EEP). From its inception, this award winning program relied heavily upon GIS as a tool to assist in watershed planning, project implementation, and site monitoring. As a new state program, the EEP needed to build a complex GIS from scratch that would allow tracking of spatial features associated with stream and wetland mitigation sites from planning through monitoring and could interface with other databases within the agency. The result is a geodatabase that is used throughout EEP in every stage of the mitigation process. GIS has assisted staff in the restoration, enhancement, and protection of more than 2.7 million feet of stream and 41,000 acres of wetlands.



Figure 1 – Stone Mountain Stream Mitigation Project



## PROGRAM HISTORY

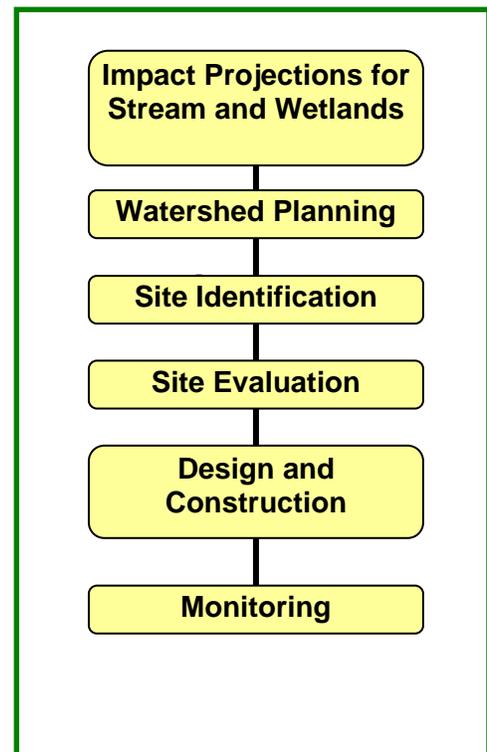
EEP is partnership between the North Carolina Department of Transportation (NCDOT), the U.S. Army Corps of Engineers (USACE), and North Carolina Department of Environment and Natural Resources (NCDENR). Prior to the creation of EEP, North Carolina operated the Wetlands Restoration Program (WRP) under NCDENR to provide compensatory mitigation for unavoidable impacts to wetlands and streams of the State from development projects. NCDOT also operated its own mitigation program which was unable to keep up with the number of impacts from road projects resulting in transportation project delays. The two programs operated independently, with NCDOT often purchasing credits from WRP to meet its mitigation needs. Federal and state regulatory agencies and environmental interest groups were not satisfied with the two organization system.

A task force composed of 10 state and federal environmental agencies convened in 2001 to recommend a new solution to meet North Carolina's compensatory mitigation needs. The solution was to form the North Carolina Ecosystem Enhancement Program which was signed into agreement on July 22, 2003, by NCDENR, NCDOT, and USACE. The program is designed to provide mitigation in advance of environmental impacts, to ensure no net loss of natural resources, and to eliminate delays to transportation projects. Mitigation is based on watershed planning. Mitigation sites are chosen based on need in the watershed and the site's potential to provide environmental uplift to the watershed.

The WRP was dissolved as a state program and merged into the newly created EEP. NCDOT transferred its mitigation projects to EEP to complete and monitor. Since its inception, EEP has restored, enhanced or protected more than 2.7 million feet of stream and more than 41,000 acres of wetland, and has avoided transportation project delays from lack of compensatory mitigation.

### THE LIFECYCLE OF A MITIGATION PROJECT

In order to effectively manage GIS resources for a program like EEP, it is important to understand the workflow of the organization. Mitigation projects are planned only when there is a projected mitigation need in an eight-digit hydrologic cataloging unit (CU). EEP receives impact estimates from NCDOT and from public and private entities paying into its in-lieu-fee program. The EEP watershed planning section analyzes smaller watersheds within a CU to initiate a watershed plan. Sites are located in watershed planning areas where they can provide the most beneficial environmental results. Sites are





also located through landowner referrals and professional proposals in other watersheds that would benefit from a mitigation site within the CU. Once the site is identified, it is evaluated for cost, beneficial uplift, owner interest, and feasibility. If EEP decides to pursue a site, it contracts with a design firm to design a wetland or stream mitigation project, contracts with a construction firm, and builds the site. Finally, the site is monitored for at least five years to ensure its success. At each stage of this process, EEP must make decisions that are helped by the availability of GIS data. Compiling the GIS data for these decisions was a major hurdle for the organization.

### GEODATABASE IMPLEMENTATION

As late as the fall of 2004, EEP had no GIS locations for its projects. The watershed planning section of EEP was using GIS as a tool to site watershed plans and evaluate watershed characteristics, so the program relied heavily on GIS to start the mitigation process. However, once a watershed plan was initiated, project features were usually not captured in GIS.

EEP began a slow process of mapping its mitigation sites. Initially, because there were many different formats for existing site data ranging from hand drawn maps in project files to CAD drawings to an occasional shapefile, EEP chose to map its sites as points. The goal of the initial project was to provide a general location for over 500 projects from three programs (NCDOT, WRP, and EEP). Simply mapping sites as points allowed the program to begin looking at mitigation management in different ways. EEP was able to assign project managers to sites by county and region, illustrate through maps where mitigation sites are concentrated, and estimate impacts on the program for changes in regional mitigation policies.

Points were not sufficient to meet the needs of the program, so in 2006, EEP began to design a geodatabase to hold important GIS features for all of its sites. Objectives for the geodatabase included the following:

- Provide one central location for storing GIS project data
- Provide a common format for GIS project data to promote program analysis
- Ensure that data can be easily used with GPS for field verification
- Store in a format that will allow for web mapping applications and data sharing with consultants
- Reduce time project managers spend manipulating GIS data

The ArcHydro model<sup>1</sup> was used as a starting point for the database design. The model contained features such as streams, monitoring points, and waterbodies that EEP planned to collect within its GIS. Additional features were added to the model, and new relationships were defined for model features. A series of meetings were held with EEP staff to evaluate the model and refine it. Staff recommended changes to some domains and subclasses, and testing began in early 2007.

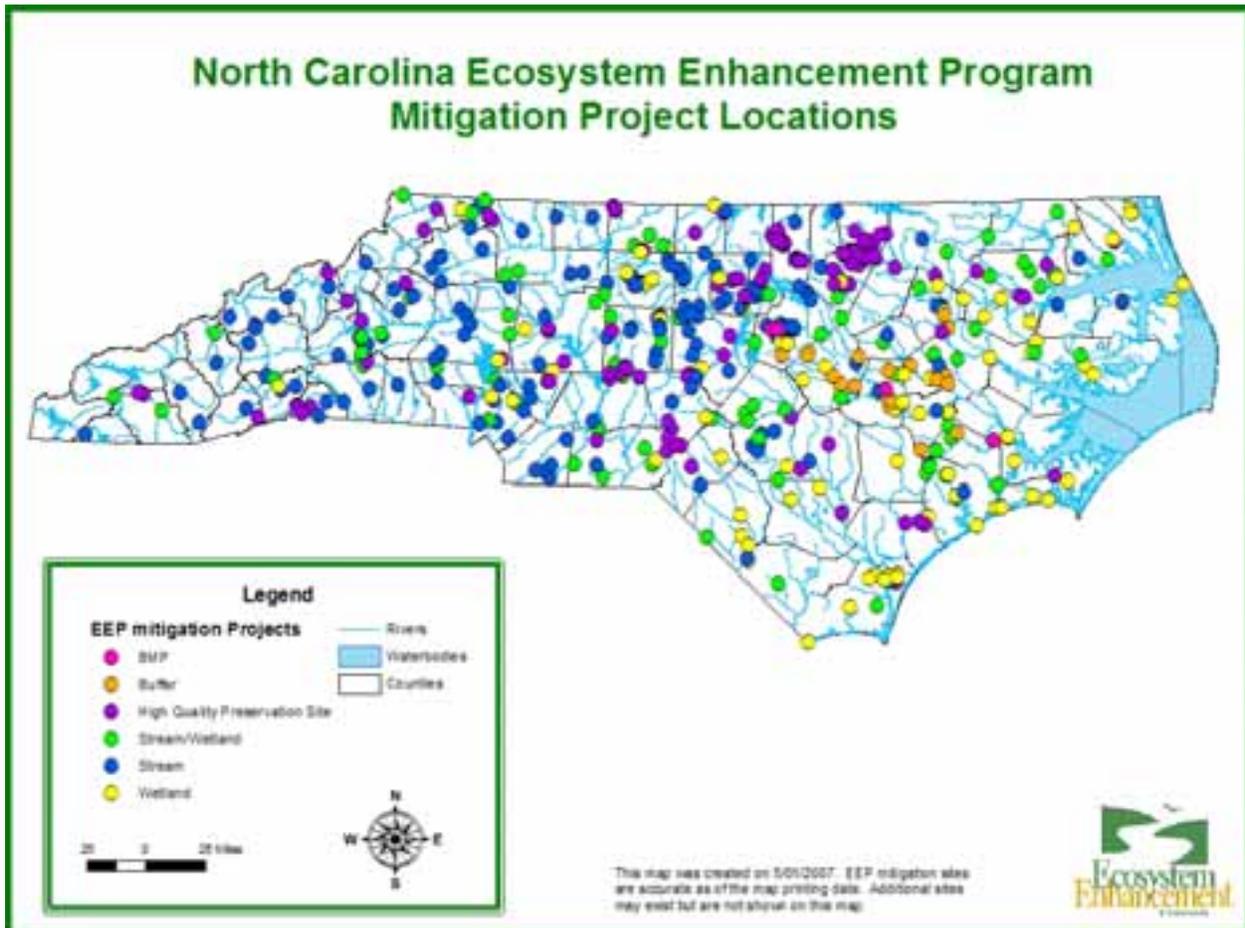


Figure 3- EEP Project Sites

### A STREAM AND WETLAND MITIGATION GEODATABASE

Figure 4 is a diagram illustrating the EEP mitigation geodatabase. Three datasets were used to contain the features, similar to the ArcHydro model. The model contains a network features dataset that includes stream centerlines and network junctions. A second dataset contains watershed layers used in the watershed planning section of the program. The third dataset contains layers that define site features including parcel boundaries, easements, stream structures, vegetation plots, wetland areas, wells and features that might constrain the mitigation process. Attributes have been modified from the ArcHydro model to customize the database for the mitigation program. Additional attributes were added to allow the data to be networked to the National Hydrologic Dataset in the short term, and to North Carolina's Streambed Mapping Program in the long term. EEP is a partner in the Streambed Mapping Program and will be sharing new stream locations with the program to maintain the state dataset.

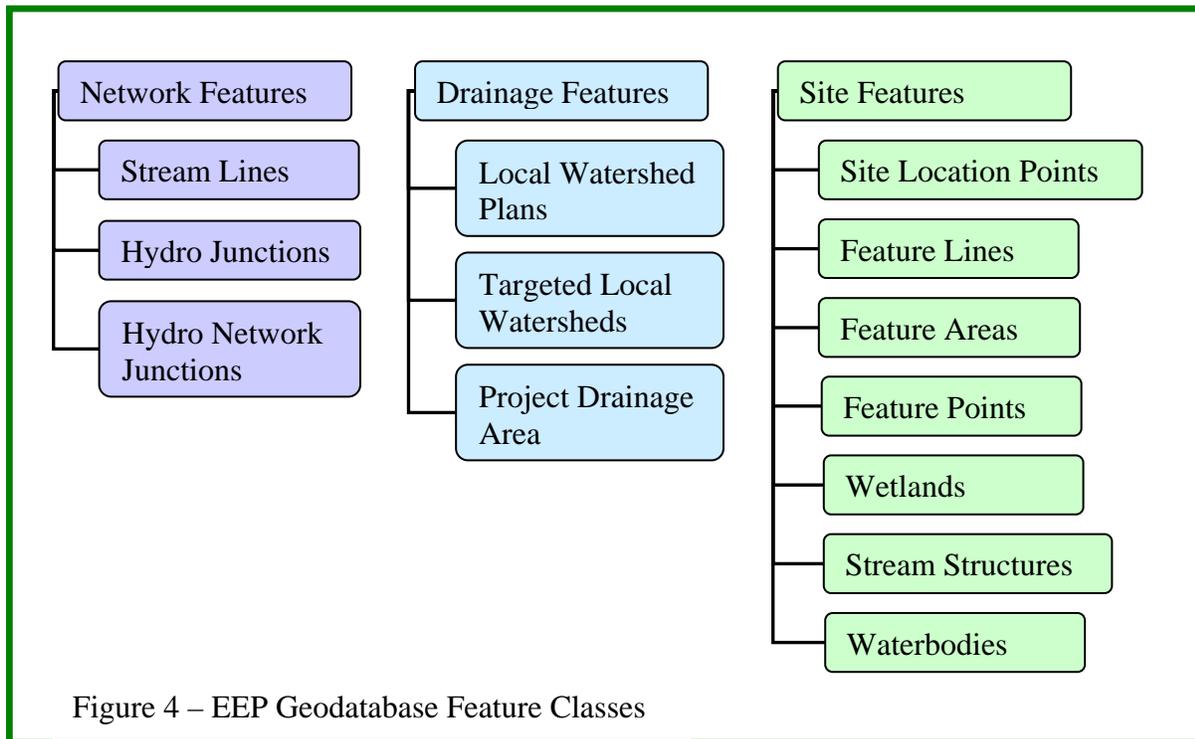


Figure 4 – EEP Geodatabase Feature Classes

The mitigation geodatabase allows EEP's staff to store data from every stage of the mitigation process. During the watershed planning process, new watershed plans and revised targeted local watersheds are stored in the drainage features dataset. These are shared with consultants and other state agencies interested in watershed planning and restoration. As new potential mitigation sites are identified, points are entered into the site feature dataset. Constraints to mitigation such as sewer crossings, wells, or livestock facilities are added as site investigation continues. Proposed easements, property lines, and proposed stream centerlines and wetland areas are also added prior to the decision to pursue the site. Once a decision is made to pursue a site, construction plans and surveys are converted from CAD to constructed stream center lines, wetland boundaries, vegetation plots, and other real features. Watersheds are created for stream reaches, and the registered easement is obtained from the State Property Office (SPO). As the site moves from construction to monitoring, point locations of stream structures and monitoring locations are added. These points, as well as vegetation plot locations, and other sites within the mitigation site, are visited yearly for at least five years to collect data for monitoring purposes.

The geodatabase format has been useful in field work, as EEP has been using ArcPad on Trimble GPS units to collect data. The geodatabase is loaded into the data logger and taken to the field in the feasibility stage to mark the locations of visible constraints or to outline a proposed easement area. As work continues, the location of the proposed easement may need to be adjusted, and this modification can also be

facilitated using the GPS units. Finally, the GPS units are heavily used during monitoring to locate features that have been obscured by vegetation or washed away during bank-full events.

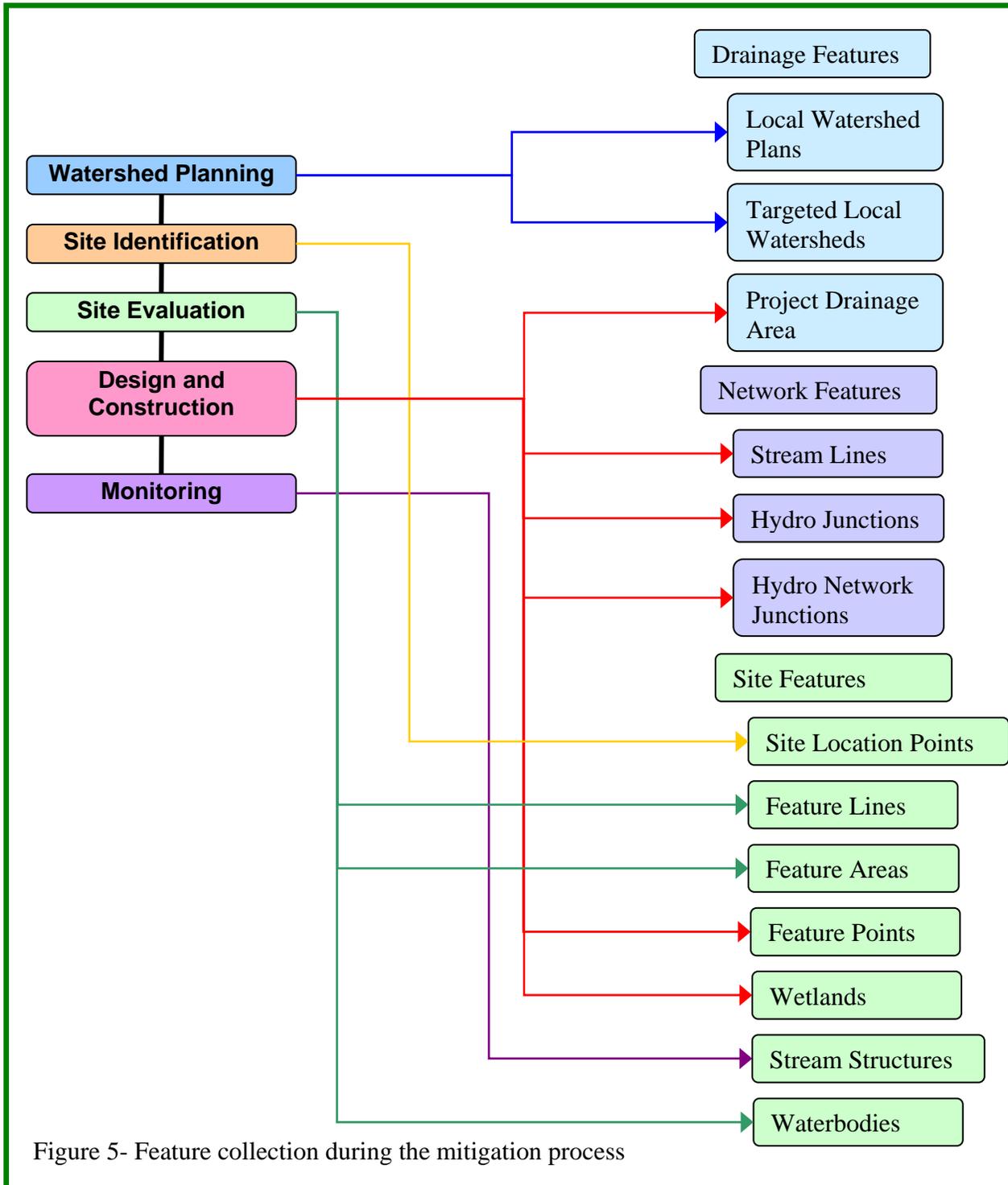


Figure 5- Feature collection during the mitigation process



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## CHALLENGES

EEP implements projects within a tight timeframe of less than three years from project identification to the completion of construction. Project Managers have little extra time to devote to data collection and organization. One goal for the geodatabase was to reduce staff time needed to map GIS features. The geodatabase did not meet this goal. Staff time devoted to GIS is the same now as it was prior to geodatabase implementation. However, data is now stored in format that reduces analysis time and allows for more effective program management. EEP receives much of its data from consultants in the form of CAD drawings. The consultants work in this format as they design construction plans for the restoration sites. EEP staff must then pull out important features from the CAD drawings, import them into the geodatabase, and attribute them. The program has implemented CAD standards that include standards for line attribution and distributes the ESRI white paper "Creating Compatible CAD Data for ArcGIS Software<sup>2</sup>" to its consultants. EEP hopes that proper line attribution and CAD standards will reduce the amount of time its staff devote to manipulating CAD data in order to convert it to GIS layers.

Various formats and attribution of CAD data are only two of the challenges facing EEP staff as they attempt to consolidate GIS data. Lack of data is another major hurdle. EEP inherited many mitigation sites from NCDOT. NCDOT did not map mitigation easements digitally. Instead, they were recorded in paper files by the Right of Way division of NCDOT. The easement area defines the boundaries of the mitigation site, and is a crucial piece of information that must be included in the geodatabase. Without a digitally mapped easement, it is difficult to accurately define the location and extent of each mitigation site. EEP has been working closely with NCDOT to define an action plan to convert the paper files into digital boundaries.

EEP's easements are mapped by the SPO. New policies have been adopted to require that digital easements are provided to the state for recording. Easements for WRP were in paper form, and the SPO had to create digital boundary files using metes and bounds. The results were often less accurate than the product of digital files. The new policies for digital files has greatly reduced staff time needed to record easement boundaries.

## NEW OPPORTUNITIES

Organization of GIS data into a central geodatabase has provided EEP with new opportunities for data analysis, field work, and project management. EEP has been successfully using the geodatabase with its GPS units running ArcPad to locate site features that are obscured by vegetation, mark easement boundaries, and record monitoring information. Often, one consulting firm will set up monitoring locations, but another firm will complete the monitoring over a multi-year period. Mitigation sites are planted prior to the installation of monitoring sites (typically marked using rebar rods driven into the ground). By the time monitoring is required the following year, the vegetation has grown significantly, and the rods are often very difficult to locate. EEP



and its consultants use GPS and ArcPad to locate the monitoring sites hidden in vegetation and attribute the site for the first monitoring year. Problem areas can be quickly identified on maps using the field data, and a maintenance plan can be quickly implemented.

By networking its data, EEP can now look at the location of its mitigation sites in relation to its other sites up and down stream, and begin to evaluate the effect of the mitigation site using monitoring site data from other state agencies. It can also look at its sites in relation to occurrences of endangered or threatened species. It may now demonstrate that water quality has improved upstream of an endangered mussel population, thus providing an opportunity for the mussel population to move into an area where it once would not have moved. Networking its sites provides the program with countless opportunities for analysis and new visions for the future of the program.

Finally, as a contributor to the N.C. Stream Mapping Program, EEP can provide accurate stream centerlines to update the State database. Stream restoration often involves changing the location of a stream, or introducing a meandering pattern to a straightened stream. These new locations will be shared with the state to maintain the Streambed Mapping Program database.

## CONCLUSION

The Ecosystem Enhancement Program has successfully implemented a program wide geodatabase for stream and wetland restoration. Despite many challenges in data collection, the overall database has been an asset to the program and has met most of the goals of the project. The geodatabase will make future analysis more robust and will allow the program to share its data with other state agencies.

## REFERENCES

1. Maidment, D. R.(2002) Arc Hydro: GIS for Water Resources. ESRI Press. Redlands, CA. 203p
2. ESRI (2003) Creating Compatible CAD Data for ArcGIS Software. An ESRI Technical Paper. 15p.

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