# Ohio Department of Transportation Research Project Fact Sheet

## Cost Effective Alternatives for Mitigating Debris and Environmental Impacts Around Bridge Piers

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### The Problem

Floating debris in rivers, such as tree trunks and branches, can catch on bridge piers and accumulate leaves, trash, and sediments that impede flow. Some debris accumulations may become extensive and block a portion of the bridge opening thus leading to increased potential for overtopping the roadway and flooding of adjacent properties. Debris piles can redirect and misalign flow causing bank erosion in the vicinity of the bridge with potential impacts to roadway embankments. Debris accumulations can also cause scour around piers and abutments undermining the bridge foundation. Furthermore, flowing water exerts horizontal forces on the debris pile and piers that the bridge was not designed to withstand. Debris accumulations are a threat to the structural integrity of bridges and the safety of motorists. Addressing these problems requires costly and dangerous maintenance, highlighting the importance of effective debris management and preventive measures to ensure the safety and longevity of bridges.

*Figure 1. A large debris accumulation at State Route 122 over the Great Miami River in Butler County.*

While catastrophic failure of bridges due to debris is rare, debris removal is often dangerous and expensive. Small debris is often ignored because of the difficulties in removing the debris. When it continues to accumulate and removal is necessary, it is typically removed manually or mechanically using tools like chainsaws, excavators, and cranes. Unfortunately, these approaches are often slow, imprecise, not feasible or safe, and may not fully remove debris. Bigger jobs are often sold to contractors, costing between $25,200 and $68,900 per site and taking around a year or more to complete. Cost-effective, safe, and practical solutions are needed to quickly and safely remove debris accumulations. Practices that mitigate debris may be a viable alternative when debris removal is challenging or not possible due to lack of access. In addition, tools and methods to inspect bridges for submerged debris, pier scour, and incremental changes to the streambed are needed to effectively manage the effects of debris.

### Research Approach

The overall goals of the research study were to identify and evaluate approaches to 1) remove debris from bridge piers, 2) prevent or mitigate debris accumulations, and 3) detect scour and streambed changes at bridges with characteristics that are difficult to inspect through conventional methods. Industry surveys and literature review were used to document current state-of-the-art debris removal techniques. Potential solutions were vetted by ODOT engineers, environmental scientists, and district and county staff to identify a suitable solution for debris removal. An equipment solution was identified and modified to meet the operational requirements of the project and subsequently field tested. Debris mitigation measures were designed, modeled, and presented to ODOT engineers for consideration. Ultimately, two projects were designed, implemented and monitored following construction. Lastly, a combination of literature review and outreach to industry representatives was undertaken to identify tools and methods to inspect bridges over large rivers that were impacted by debris. Three equipment solutions were identified and evaluated through on-site demonstrations.

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*This research was sponsored by the Ohio Department of Transportation and the Federal Highway Administration.*

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## Findings

**Debris Removal** – A counterweighted, knuckleboom crane (Figure 2) with grapple and saw attachments was developed and tested for debris removal. In total, 60 debris removal projects and 18 other projects (e.g. rip rap placement, etc.) were completed. Labor needs for small projects completed internally were reduced by 43% on average. Larger projects typically completed by contractors over many months could now be completed in weeks by ODOT forces with ~80-90% reduction in cost. The equipment was able to reduce environmental permitting requirements and minimize road closures to a single lane and better maintain traffic. Worker safety and work quality were improved over previous methods.

*Figure 2. A counterweighted knuckleboom crane with grapple attachment capable of reaching beneath the bridge deck on hammerhead piers.*

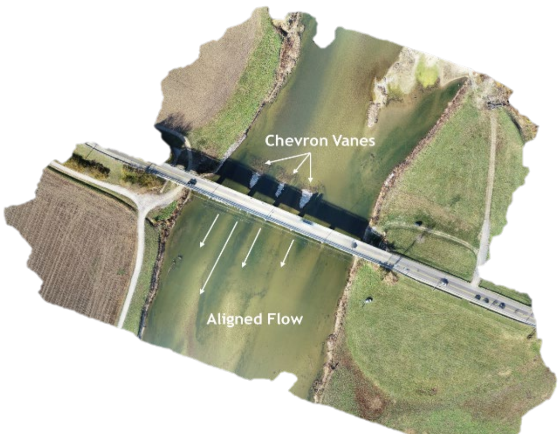


*Figure 3. Three chevron vanes were implemented at State Route 122 over the Great Miami River.*

**Debris and Scour Mitigation** – Numerous methods and materials to prevent debris accumulation and scour were designed, modeled, and implemented at two sites. Three chevron vanes (Figure 3) were implemented at State Route 122 over the Great Miami River to divert debris from catching on piers. The chevron vanes improved alignment and promoted deeper, faster flowing water through the clear spans between piers. Debris on piers has been greatly reduced, but not eliminated. A cross-vane structure was constructed at State Route 52 over Ray's Run in Clermont County. The vane was constructed beneath the bridge deck due to limited right-of-way and has effectively mitigated scour. An exposed pipeline downstream of the bridge has since been filled in and remains protected from damage.

**Scour Mitigation and Bridge Inspection** – Three remote-control (RC) uncrewed surface vehicles and sonar sensors were evaluated to aid in bridge inspections at sites with deep water where visual inspections and manual probing were ineffective. The Seafloor EchoBoat 160 (Figure 4A) was selected due to size, operational characteristics, software usability, and cost. The integrated SeaRay sonar produced the best image quality and allowed detection of submerged debris and scour and voids at piers and abutments (Figure 4B). Additionally, the bathymetric survey capabilities of the platform will allow for change detection of the streambed between successive surveys and to collect survey data needed for hydraulic modeling studies.

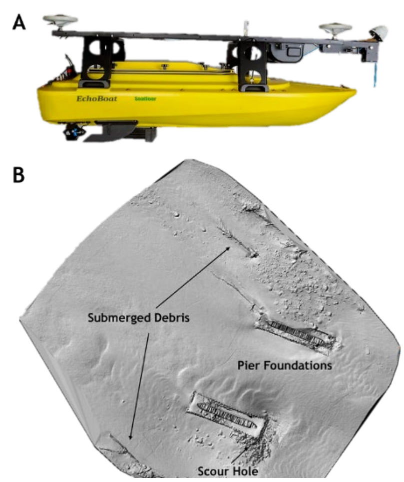


*Figure 4. A) The Seafloor EchoBoat 160 platform with integrated sonar sensor, and B) bathymetry maps generated from sonar data at State Route 122 over the Great Miami River showing pier scour, bedforms, and submerged debris.*

## Recommendations

The research suggests debris removal via the knuckleboom crane is highly effective. Results also indicate the approach is economical with return-on-investment <1-year. Where debris is problematic, the equipment should be utilized broadly. Debris mitigation measures were effective; however, implementation is likely best at small sites due to complexity and costs associated with working in large rivers. Scour detection and bathymetric surveys can be completed effectively with sonar. A single unit likely meets statewide needs.

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