

## JWRP&M's Reproducibility Review Program: Accomplishments, Lessons, and Next Steps

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### Introduction

In November of 2020, the editors of the Journal of Water Resources Planning and Management (JWRP&M) launched a Reproducibility Review Program (Rosenberg *et al.*, 2021). This initiative was inspired by studies showing a lack of reproducibility in water-related journals (Stagge *et al.*, 2019), calls for better reviews of claims of reproducibility (Goodman *et al.*, 2016), and similar review programs at journals in other domains (Rosenberg *et al.*, 2021). JWRP&M's voluntary program incentivizes authors to publish data, models, code, and directions with their articles so that an independent reviewer can replicate part or all of the authors' work. The goal of the JWRP&M Reproducibility Review Program is to promote a cultural shift toward making research more accessible and reproducible, thereby accelerating science and increasing impact. The program has 5 objectives (Rosenberg *et al.*, 2021):

1. Encourage authors to make their results more reproducible.
2. Allow scientists and practitioners to more easily find and use reproducible work.
3. Encourage further sharing and interaction between authors and readers.
4. Recognize and reward authors who make their work more reproducible.
5. Increase the impact of work published in the Journal.

For more details, visit the Reproducibility Hub (<https://ascelibrary.org/reprod>) for products of the Reproducibility Review Program, including a:

- 28 ● Description of the program philosophy and process,
- 29 ● Special collection of all successfully reproduced manuscripts,
- 30 ● List of annual reproducibility award recipients,
- 31 ● Description of Silver and Bronze badges awarded to papers with reproduced results and papers
- 32 that share all data, models, code, and directions to use, and an
- 33 ● Online form where people can sign up to be reproducibility reviewers to help reproduce results
- 34 of papers submitted to the program.

35 In this editorial, we – JWRP&M’s Associate Editors for Reproducibility (AERs) – share program  
36 accomplishments, challenges and lessons learned, and next steps to expand the pilot program to other  
37 American Society of Civil Engineering (ASCE) journals. We also share our experience as a potential model  
38 to foster more reproducible and open research products, set forth as a goal by research sponsors and  
39 government agencies (Burgelman et al., 2019, European Commission et al., 2020, Nelson, 2022, The  
40 National Science Foundation & The Institute of Education Sciences, U.S. Department of Education,  
41 2018).

## 42 **Accomplishments**

43 JWRP&M’s Reproducibility Review Program is already successfully addressing its five initial objectives  
44 outlined above, and the program continues to build momentum. Motivating authors to make their work  
45 more reproducible (Objective 1) can be measured by participation in the program. Since its inception,  
46 approximately 3 years ago in November 2020, the program has awarded 10 Silver badges for  
47 manuscripts where the reviewers could reproduce all or part of the study’s results, and 3 Bronze badges  
48 for manuscripts that provided research artifacts (Table 1). An additional 11 manuscripts are currently in  
49 various stages of reproducibility review. Furthermore, 7 manuscripts were published, but ultimately  
50 withdrew from the Reproducibility Review Program. Excluding manuscripts still in review or declined for

51 technical reasons, 65% (13 of 20 manuscripts) were successfully reproduced by reviewers. These  
52 manuscripts are not representative of all JWRP&M manuscripts, as the authors self-selected by applying  
53 to the voluntary program. From 2020 to July 2023, 557 articles were published by JWRP&M, making the  
54 13 reproduced articles an exclusive group (Bastidas Pacheco et al. 2023; Cordeiro et al. 2022;  
55 Hadjimichael et al. 2023; Jander et al. 2023; Jaramillo and Saldarriaga 2023; Morgan and Lane 2022;  
56 Obringer et al. 2022; Rasmussen et al. 2023; Rodríguez-Martínez et al. 2023; Thomas and Sela 2023;  
57 Tran et al. 2023; Vrachimis et al. 2022; Wang and Rosenberg 2023). We intend to further increase the  
58 proportion of JWRP&M articles successfully handled by the JWRP&M Reproducibility Review Program.

59

60 A major motivator for authors to participate in the program is the offer of Free Open Access without  
61 author publishing charges (APCs) for papers receiving the Silver reproducibility badge. ASCE Publishing  
62 and the Environmental Water Resources Institute (EWRI) donated \$40,000 and \$20,000, respectively, to  
63 support free Open Access publishing. The 11 papers that met the Silver badge reproducibility criteria  
64 were awarded Free Open Access publication. Offering Open Access publication with no APCs helps meet  
65 Objective 4: Recognize and reward authors who make their work more reproducible. Furthermore,  
66 JWRP&M implemented annual awards to recognize and reward authors (Outstanding Effort to Make  
67 Results More Reproducible) as well as editors (Outstanding Effort to Reproduce Results). Papers that  
68 meet the Silver and Bronze criteria are awarded reproducibility badges, and JWRP&M created a special  
69 issue page designed to drive readers to reproduced papers. Increased research visibility helps to reward  
70 authors who make additional efforts for reproducibility.

71

72 Objectives 2, 3, and 5 all describe increased research impact in various forms. Three years is too soon to  
73 detect an increase in impact in citations or whether new research is building upon successfully

74 reproduced manuscripts. In the coming years, we foresee an increased impact by publishing reproduced  
75 papers as Open Access because papers published Open Access are downloaded and cited at higher rates  
76 across multiple fields (McCabe & Snyder, 2014, Ottaviani, 2016, H. Piwowar *et al.*, 2018, H. A. Piwowar  
77 *et al.*, 2007).

## 78 Challenges and Lessons Learned

79 ASCE intends to expand the JWRP&M Reproducibility Review Program to other ASCE journals. This  
80 section presents some challenges and lessons learned from JWRP&M's experience to demonstrate how  
81 other journals could implement similar programs.

82 **Challenge 1: Better Incorporate Reproducibility into the Article Submission and Review Workflow.** A  
83 technical challenge with the Reproducibility Review Program was incorporating reproducibility reviews  
84 into the existing paper submission and review process. Reproducibility reviews are handled in parallel  
85 with traditional technical and content reviews. This setup allows reproducibility reviews to be  
86 independent of technical reviews, and the reproducibility review does not affect a decision to publish.  
87 Most editorial management software is not designed to support two co-editors (one for content and  
88 one for reproducibility) and two parallel reviews. For JWRP&M, this challenge was addressed by making  
89 the AER more senior in the editorial management software. In this workflow, the AER assigns a content  
90 editor based on the editor-in-chief's instruction and then acts as a pass-through once the content  
91 reviews and editor decisions are made. This additional step requires coordination between editors and  
92 some additional training for AERs and associate editors. If the Reproducibility Review Program grows, it  
93 may become feasible to redesign online journal submission and review tools to accommodate parallel  
94 reproducibility reviews.

95 **Challenge 2: Educate Authors about the Program.** Because the Reproducibility Review Program is new,  
96 there has been a learning curve for authors regarding what the program entails and the journal's

97 expectations. Publications such as the original policy description (Rosenberg et al., 2021) and this  
98 editorial help to clarify the process. We also established a Reproducibility Hub  
99 (<https://ascelibrary.org/reprod>) on the ASCE webpage, including resources and short videos created by  
100 the AERs and journal staff (Rosenberg et al. 2023). The AERs have given presentations about the  
101 Reproducibility Review Program at academic conferences. We expect the requirements and process of  
102 the Reproducibility Review program to become clearer as it grows in popularity and expands to other  
103 ASCE journals.

104 **Challenge 3: Concern about Publication Delays.** Despite broadly positive responses from authors, the  
105 most common concern has been that opting into a reproducibility review may delay publication. Our  
106 goal has been to parallelize reproducibility reviews to not affect the time to a publication decision based  
107 on technical merit. Since inception, the JWRP&M staff have iteratively revised the process to streamline  
108 reproducibility reviews. More recently, we have shifted the timing of reproducibility reviews to lessen  
109 reviewer burden and make the process more efficient. When the program began, reproducibility  
110 reviews were assigned when a manuscript was first sent for content review. We are currently piloting a  
111 change to begin reproducibility reviews only after receiving a positive first technical review. We are also  
112 evaluating publishing online manuscripts accepted on technical merit while the reproducibility review is  
113 finalized. These efforts can speed up the reproducibility review process, while also ensuring that  
114 reproducibility review effort is not expended for manuscripts that are unlikely to be published.

115 **Challenge 4: Recruiting Reproducibility Editors and Reviewers.** The program relies on volunteers to  
116 perform reproducibility reviews. JWRP&M initially recruited 10 AERs, and these editors have actively  
117 solicited volunteers to act as reproducibility reviewers through conference presentations and an online  
118 signup program (<https://ascelibrary.org/reprod>). The journal created a new position of Section Editor for  
119 Reproducibility to manage the program and AERs. The journal has also created a new role for people  
120 who review manuscripts with the aim to reproduce results. Further, if the reviewer chooses, their name

121 can be included with the published article as the reproducibility reviewer for recognition. In response to  
122 concerns about reviewer time, the new approach to perform reproducibility reviews after initial  
123 technical review decreases the burden on reproducibility reviewers.

124 **Challenge 5: Not All Papers Can Be Reproduced.** The decision to make the program voluntary was  
125 predicated on an understanding that not all papers can be made reproducible due to restrictions on  
126 data privacy, computational requirements, the embargoing of sensitive data, or other reasons.  
127 Embargoing was a major concern within the paleoclimate community, particularly with regards to early  
128 career researchers publishing portions of their research with data before graduation or project  
129 completion (Kaufman & PAGES 2k special-issue editorial team, 2017). Other potential barriers to  
130 reproduce results include time-intensive simulations or random number generation. Some of this issue  
131 with random number generation can be addressed by authors setting and publishing the random  
132 number seed within their code. Making the reproducibility program optional can motivate a cultural  
133 shift towards reproducibility without being unnecessarily prescriptive or onerous.

134 **Challenge 6: Follow the format for papers with reproduced results.** The Journal set up the  
135 Reproducibility Review program with requirements for how to format papers to submit to the program.  
136 First, articles with reproduced results must include a Data Availability section. Within the Data  
137 Availability Statement, authors must cite a permanent digital object identifier (DOI) and public locator  
138 for the data, model, code, and directions used in the work. Second, articles must include a Reproducible  
139 Results section. The Reproducible Results section must list the name of a person not affiliated with the  
140 study who reproduced results prior to submission. The reproduced results section must also state which  
141 results were reproduced. For example:

142 Ashlynn Stillwell (University of Illinois at Urbana-Champaign) downloaded all materials, ran the  
143 simulation model for low, medium, and high scenarios, and reproduced results in Tables 1 and 2.

144 These steps are important to help authors identify bugs, unclear directions, or other errors that prevent  
145 others from reproducing results prior to submission. Some papers submitted to the program did not  
146 have sections for data availability and/or reproduced results. Other papers failed to list a person not  
147 affiliated with the study who reproduced results prior to submission to the journal. Authors can now  
148 follow the examples of papers with reproduced results (e.g., Wang and Rosenberg (2023); Rodríguez-  
149 Martínez et. al (2023); Thomas and Sela (2022)). We also created a checklist for steps to submit a  
150 manuscript to the reproducible results program (see <https://ascelibrary.org/reprod>).

151 **Challenge 7. Difficulty to Reproduce Results for Work with Numerous Scripts or Manual Inputs.**

152 Journal AERs and Reproducibility Reviewers found it difficult to reproduce results for work that required  
153 a large number of different scripts to execute and/or workflows that required lots of manual input.  
154 Human error challenged the reproducibility of these works. We now request authors follow a best  
155 practice of providing a single master script or “run-all” button that executes all code needed to  
156 reproduce figures and tables in the manuscript. A master script will reduce human error and better  
157 document the workflow in reproducible code. For an example, see Bastidas Pacheco et al (2022).

158 **Challenge 8. Difficulty to Recreate Run Time Environments.** Journal AERs and Reproducibility Reviewers  
159 sometimes found it difficult to recreate the exact run-time environment used by the authors. The run-  
160 time environment includes the versions of the software programming language, libraries, packages,  
161 models, and other dependencies. Use of different versions may break dependencies, or potentially  
162 generate different results. This is commonly caused by ongoing updates after an author posts their code  
163 to a repository. Two best practices are:

164 a) List the exact versions of all software, libraries, or packages the authors used. Then provide  
165 links and directions to where readers can find, download, and install the required version of  
166 each component.

167           b) Bundle all required materials in a binding unit such as MyDocker or a web-hosted notebook.

168 See Bastidas Pacheco et al (2022) for an example of both methods.

## 169 **Next Steps**

170 The JWRP&M intends to proceed with the Reproducibility Review Program, and editors will continue to  
171 advocate for the program. We aim to expand the number of published papers recognized for  
172 reproducibility. We also plan to hold training workshops to educate both potential reviewers and  
173 authors.

174 Currently, JWRP&M is using external funding to publish successfully reproduced manuscripts as Open  
175 Access without author publishing charges. We hope to develop new funding sources and funding models  
176 to support this popular motivator. To our knowledge, JWRP&M is the only journal with a business model  
177 that offers free Open Access as an incentive for successfully reproduced manuscripts. The journals  
178 ReScienceC and ReScienceX also offer Open Access and fully reproduced research, but they do not  
179 publish new research with an internal reproducibility review, instead publishing computational  
180 reproductions of studies published elsewhere. We commend ASCE for supporting this initiative and for  
181 plans to expand to other journals in the ASCE portfolio. We encourage other academic journals and  
182 supporting organizations to adopt similar practices.

183 Our goal with this program continues to be to improve reproducibility within the water resources field.  
184 We have set and are achieving clear and attainable benchmarks. We are highlighting and rewarding  
185 authors that rise to the challenge to make their work reproducible. Papers with reproduced results are  
186 patterning best practices and helping shift our science and engineering culture towards reproducibility  
187 as the default when conducting analyses and submitting a manuscript.



## 188 Data Availability Statement

189 All data for this editorial is included in a Zenodo repository (Stagge et al. 2023)

## 190 Reproducible Results

191 The code used to generate Fig. 1 is available in a Github repository (Stagge et al. 2023). Kyungmin Sung  
192 and Irene Muneyjuru (Ohio State University) downloaded the repository, ran the code, and successfully  
193 reproduced Fig. 1 as presented here.

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308  
309

## 1 Tables

### 2 *Table 1 Number of articles handled by the JWRP&M Reproducibility Review Program.*

Article Status	Number of Articles (11/2020-11/2023)
Published, Silver Reproducibility	10
Published, Bronze Reproducibility	3
In Review or Revision	11
Published, but withdrew from Reproducibility	7
Declined for Technical Review	31
Total	62

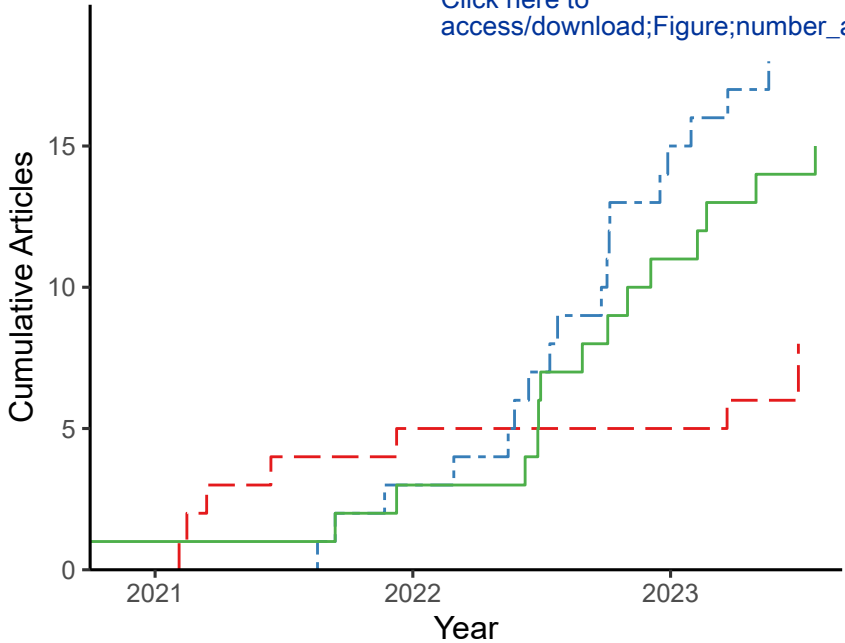
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4

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Fig. 1

[Click here to access/download;Figure;number\\_articles\\_singl](#) 



 Withdrawn Still Published       Under Review       Reproducible & Published (Bronze or Silver)

1 **Figure Caption List**

2 Figure 1. Number of manuscripts handled by the JWRP&M Reproducibility Review Program.

3 The number of reproduced and published articles includes one 2017 article (Di Matteo et al.,

4 2017) that was successfully reproduced prior to the start of the reproducible results program

5 (Stagge et al., 2019).

6