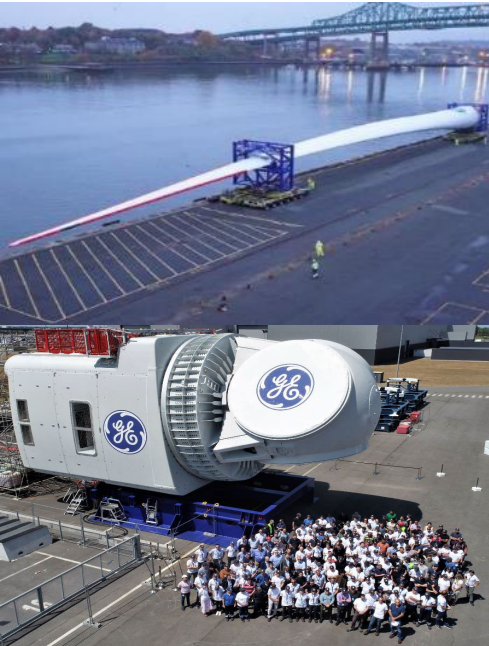# E19 - National Wind Turbine Database and Location Impacts R&D

Environmental, Siting, Workforce, and Grid – Stakeholder Engagement & Workforce Development

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FY21 Peer Review - Project Overview

Project Summary:
- US wind development interacts with radar for air defense and weather, as well as human uses
- if not handled properly, they can add costs to, and delay or derail wind energy deployment.
- Accurate assessments require proper input data and unbiased analysis.

Project Objective:

Provide broad-based, unbiased and scientifically defensible information about historical or potential U.S. wind development locational impacts on radar operations, the surrounding landscape, human populations, and economies.

Key project tasks:
1. U.S. Wind Turbine Database (USWTDB)
2. Turbine Scaling and Sound Perception Modeling (Figure 1)
3. Turbine Shadow Flicker (SF) Perception and Annoyance Modeling (Figure 2)
4. School Revenue and Student Outcomes in High Wind Energy Districts

Project partners: RSG, Vermont Energy Resource Associates (VERA); University of Connecticut; Amherst College; U.S. Geological Survey (USGS); and, American Clean Power (ACP) Association (formerly the American Wind Energy Association)

Project Start Year: FY19
Expected Completion Year: FY20 + ongoing
Total expected duration: 2 years + ongoing
FY19-FY20 Budget: $974,230

Key LBNL Project Personnel: Ben Hoen (PI), Joe Rand, Sydny Fujita, Salma Elmallah.
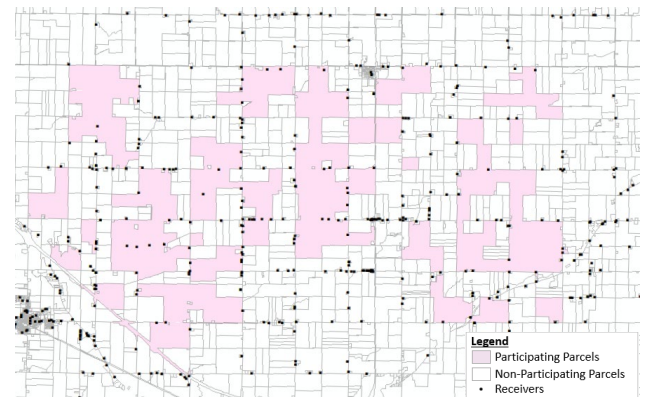
Key DOE Personnel: Maggie Yancy

Legend
Participating Parcels
Non-Participating Parcels
• Receivers

Figure 1: Prototypical site for multiple turbine configurations
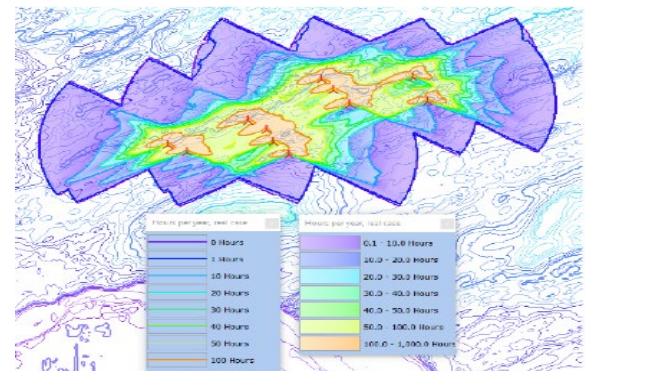
Figure 2: Shadow flicker pattern for >1 turbines

Project Scope & Impact

Wind Project Location Impacts

- Military and Weather Radar
- Community Attitudes
- Sound and Shadow Flicker Perception & Annoyance
- Other Location Impacts (e.g., School Finances)
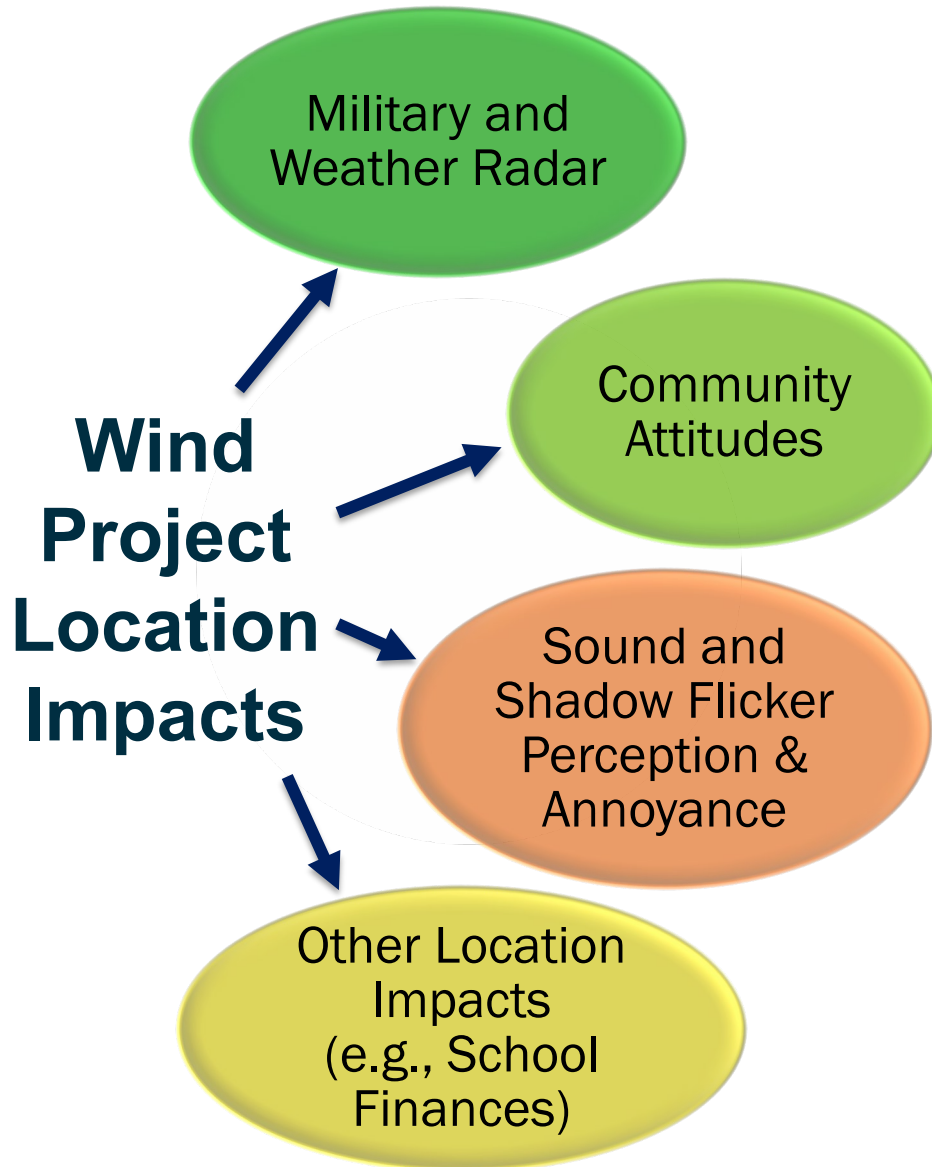
- **Provide tools and information to siting/permitting stakeholders**
  - U.S. Wind Neighbor Survey:
    - **Highly Cited:** Six papers, last ones completed in FY19, have been already cited 330 times
  - U.S. Wind Turbine Database (USWTDB):
    - **Mission Critical:** DOD Clearinghouse consistently cites the USWTDB as solving a significant problem of inaccurate and confusing turbine location data
    - **Widely Used:** the online version has been viewed almost 5 million times
  - Sound and Shadow Flicker Impacts:
    - **New:** Provide baseline impacts data not previously available
    - **Sought Out As Industry Experts:** Team members gave technical assistance to ACP board members as they tried to craft industry-wide sound and shadow flicker standards

Project Performance: Accomplishments, Progress, Impact
U.S. Wind Turbine Database (USWTDB)

- **Goal:** Provide high-resolution U.S. turbine location and characteristics data to allow government-wide mission critical assessments of radar impacts

- **Process:** Under a 10-year Cooperative Research and Development Agreement (CRADA) with USGS and ACP, LBNL produces a consolidated quarterly-updated dataset that is shared with federal agencies and the public

- **FY19 & 20 Results:**
  - **Massive Usage:** Almost 5 Million online views since launch (see figure)
  - **Allowed access to data in real time:** Added application protocol interface (API) capabilities
  - **Expanded data reach:** Appended an Energy Information Administration (EIA) ID
  - **Improved characterization of to-be-built turbines:** Created a "Development Pipeline" dataset for the Wind Turbine Radar Interference Mitigation Working Group (WTRIM)
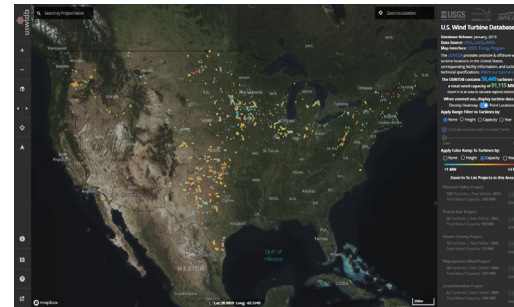 - **Extended cooperative agreement with partners:** The LBNL, USGS, ACP CRADA was extended through FY2026
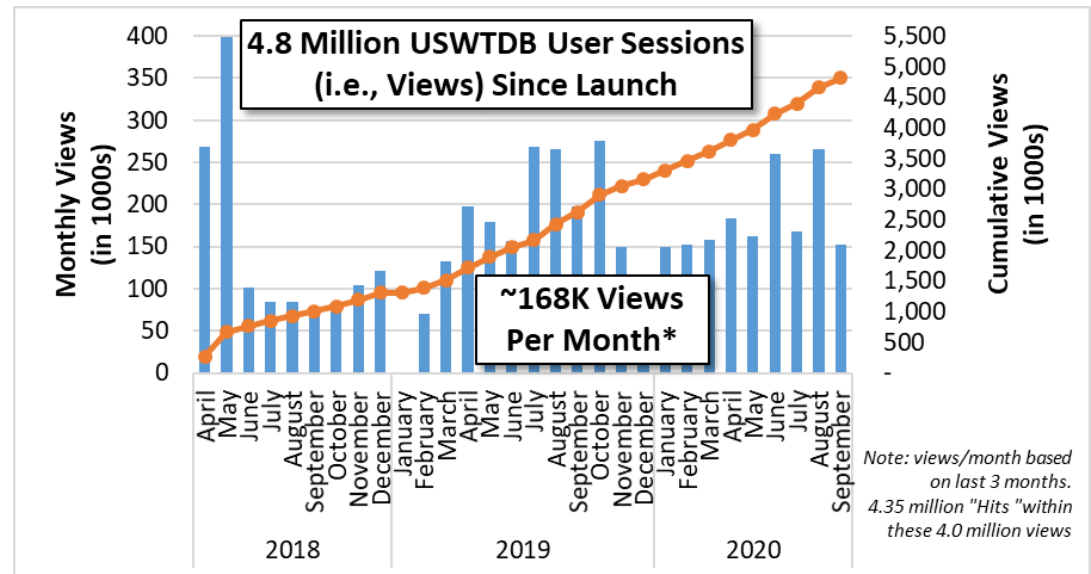

Figure 1: Screenshot of USWTDB Viewer

Partners

4.8 Million USWTDB User Sessions (i.e., Views) Since Launch

~168K Views Per Month*

Note: views/month based on last 3 months. 4.35 million "Hits" within these 4.0 million views

Project Performance: Accomplishments, Progress, Impact
Turbine Scaling and Sound Perception Modeling

- **Goal:** Examine the effect of turbine scaling on key community metrics: the number of turbines, nameplate capacity, annual energy output (AEP), and community sound levels (dBA)

- **Process: Using a prototypical site of participating parcels (see pink in figure) and "develop" desktop projects to examine scaling:**
  - older ("Then") turbines <u>and</u> modern ("Now") turbines
  - for each of GE, Vestas and SGRE
  - estimate sound levels at all homes (see dots in figure).

- **FY19 & 20 results:**
  - **Found operational and community benefits of larger turbines:** Lower sound levels on average and higher AEP when moving from *Then* to *Now* turbines
  - **But <u>lower</u> installed capacity:** for most, but not all, *Now* projects
  - Proved need to look at "Future" turbines

- **FY21 Plans:**
  - add additional site and include "Future" turbines (to-be-installed in the 3-5 years)
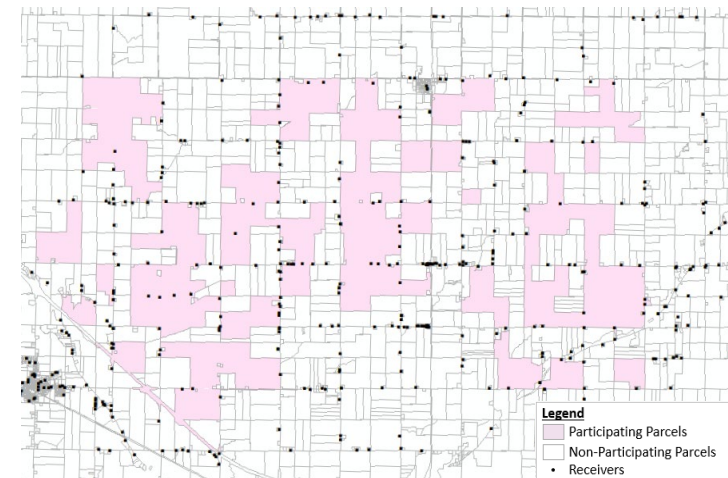

Figure 1: Prototypical Site with participating parcels (pink) and wind project neighbors (receivers, black dots)

Project Performance: Accomplishments, Progress, Impact
## Turbine Shadow Flicker (SF) Perception and Annoyance Modeling

- **Goal:** Characterize community SF levels and determine if modeled SF predicts perception and annoyance to SF, a common deployment barrier

- **Process:**
  - create shadow-flicker (SF) modeling estimates for 34,000 wind neighbors across 60 projects
  - Match with 750 Wind Neighbor Survey responses
  - test if modeled SF predicts respondent perception and annoyance
  - examine SF regulations in 50 communities

- **FY19 & 20 Results:**
  - **Modeled SF accurately predicts SF perception but not SF annoyance:** see bottom figure
  - **Annoyance is subjective:** closely associated with subjective aspects of respondents.
  - **Spotty regulations in U.S.:** Found either no or very sporadic and varying SF regulations/guidelines across 30 counties

- **FY21 plans:**
  - Submit this work for publication and release to broader audiences

SF Pattern for >1 Turbines

Shadow Flicker (Hours/year)
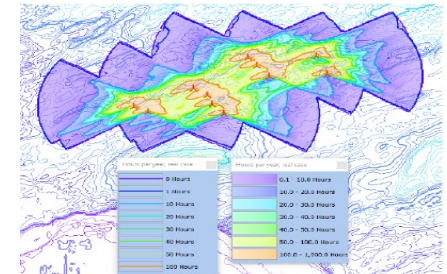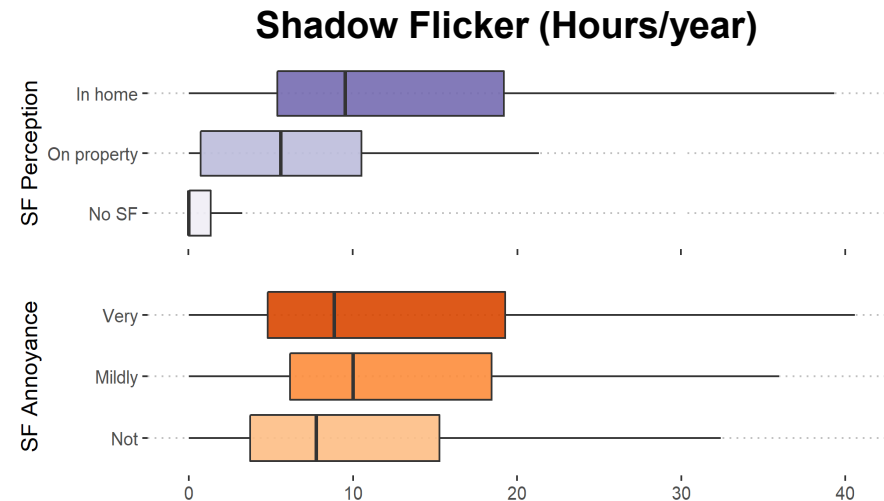
Project Performance: Accomplishments, Progress, Impact
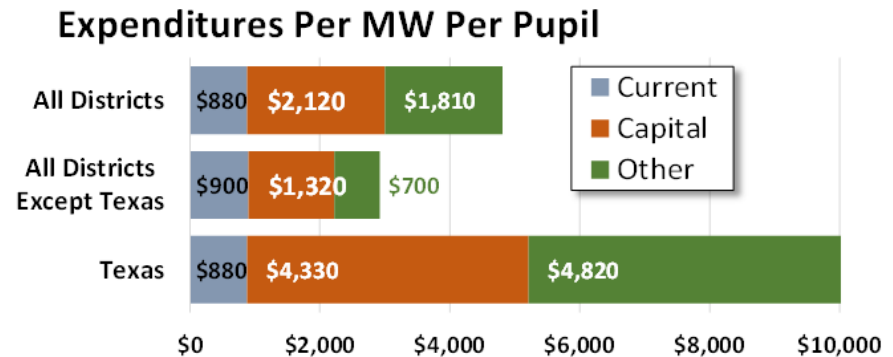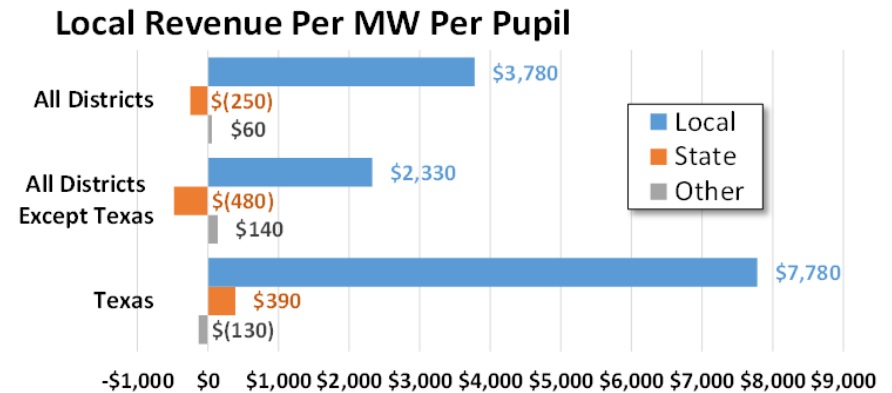## *School Revenue and Student Outcomes in High Wind Energy Districts*

- **Goal:** For the first time, examine the degree to which higher levels of wind deployment impacts school finances and students' outcomes nationally

- **Process:** Combine USWTDB data with time-series school district-level data on revenue and expenditures and students' outcomes, such as teacher-student ratios, test scores and graduation rates.

- **FY19 & 20 Results:**
  - **A clear link was found:** capacity increases correlated with higher revenues and expenditures (see figures)
  - **Wind money went mostly to buildings not teachers, though:** bottom figure
  - Although, class size was improved...
  - Test scores and graduation rates were not

- **FY21 Plans:**
  - A journal paper draft completed in FY20 will be finalized and submitted in FY21
  - LBNL will host a webinar of results and distribute fact sheet, paper and powerpoint,

Local Revenue Per MW Per Pupil

All Districts	Local $3,780 / State $(250) / Other $60
All Districts Except Texas	Local $2,330 / State $(480) / Other $140
Texas	Local $7,780 / State $390 / Other $(130)

Legend: ■ Local ■ State ■ Other

-$1,000 $0 $1,000 $2,000 $3,000 $4,000 $5,000 $6,000 $7,000 $8,000 $9,000

Expenditures Per MW Per Pupil

	Current	Capital	Other
All Districts	$880	$2,120	$1,810
All Districts Except Texas	$900	$1,320	$700
Texas	$880	$4,330	$4,820

Legend: ■ Current ■ Capital ■ Other

$0 $2,000 $4,000 $6,000 $8,000 $10,000

Note: "Other" expenditures are predominantly debt service and payments to state

Accomplishments and Progress:
Other Activities and Accomplishments

Wind Turbine Radar Interference Mitigation (WTRIM) Working Group

- **Provide High-Resolution data: 1)** Provided WTRIM members (and other federal agencies) a dataset of to-be-built turbines to provide info on where turbines will be in the future; **2)** continued to serve on steering committee to provide turbine location and characteristic data guidance

International Energy Agency (IEA) Task 28 – Public Acceptance of Wind Energy

- **Extend DOE Research Reach Internationally: 1)** Continued to collaborate with IEA member countries on pushing state-of-art research on wind energy and public acceptance; **2)** Co-led the development of the successfully adopted plan for a new 4-year term for Task 28

European Union Funded Renewable Energy and Social Acceptance Projects

- **Provide Technical Assistance and Advice Internationally:** Served as chair of external experts for an EU funded project to train the next generation of thought leaders in social acceptance called MISTRAL: <u>M</u>ulti-sectoral approaches to <u>I</u>nnovative <u>S</u>kills <u>Tr</u>aining for Renewable Energy & Soci<u>al</u> Acceptance.

National Wind Neighbor Survey

- **Conduct Outreach and Dissemination of Past Wind Neighbor Survey Work: 1)** Completed the publishing of six papers on national survey of 1,705 wind project neighbors; **2)** The papers have already been cited >300 times by other published papers

Technical Assistance

- **Provide technical assistance to numerous parties: 1)** including the DOE, academic researchers, state and federal decision-makers, and a variety of wind and community stakeholders on USWTDB, social acceptance and other work as requested; **2)** Assisted WETO in developing a long-term Community Impacts Research and Outreach (CIRO) strategy

Project Performance - Upcoming Activities

Goal: Research and disseminate information on current <u>and</u> future community impacts, both positive (benefits) and negative (costs), to help mitigate market barriers and encourage more community-centric wind development

FY21 Current and Ongoing Work

- **Expand USWTDB:** add a retrofit flag and year to the database to indicate turbine characteristics have changed and when, and continue to update and refine dataset
- **Update Property Value Analysis:** Update research on impacts to home values near wind projects clarifying recent trends with this common and influential impact
- **Disseminate Shadow Flicker Results:** Submit journal paper and disseminate results on this first-of-its kind analysis.
- **Estimate Future Turbine Impacts:** Add new site and "Future" turbines to examine community impact changes well into the future of turbine models
- **Assess Cumulative Impacts:** Scope possible FY22 project to develop national sound, shadow flicker and viewshed models to accurately assess cumulative impacts.
- **Estimate High-Resolution Wind Income and Employment Impacts:** Support Colorado School of Mines' work on census-based local economic and jobs impacts analyses

FY21 Milestones and budget are all on track

Stakeholder Engagement & Information Sharing

Clear evidence that our work is being used by industry, other researchers, federal agencies and the public:

- **Needed by others to do their job:** The USWTDB has been accessed over 5 million times, providing data that are mission-critical to DOD and of unique value to industry, researchers, and the general public.
- **Highly cited:** The location impacts research is not only highly cited by other academics, but is also commonly referenced by developers and community-based organizations.
- **Regular media contact:** We are regularly approached by the media to provide comments on community acceptance topics, extending our impact to wider audiences.
- **Lots of Technical Assistance (TA) provided**: We regularly provide TA and presentations related to the USWTDB, the US Wind Neighbor Survey, and sound and shadow flicker research.
- **International TA provided too:** We provide value and benefit from international collaboration via IEA Wind Task 28 and MISTRAL.
- **Strong connection to industry:** We engage with and solicit feedback from industry stakeholders (via ACP and industry participants directly) in order to make the work more relevant, impactful, and timely.
- **Maximize academic rigor:** by publishing in peer-reviewed journals, while maximizing impact and uptake by making the reports and data publicly available and offering targeted outreach and presentations.