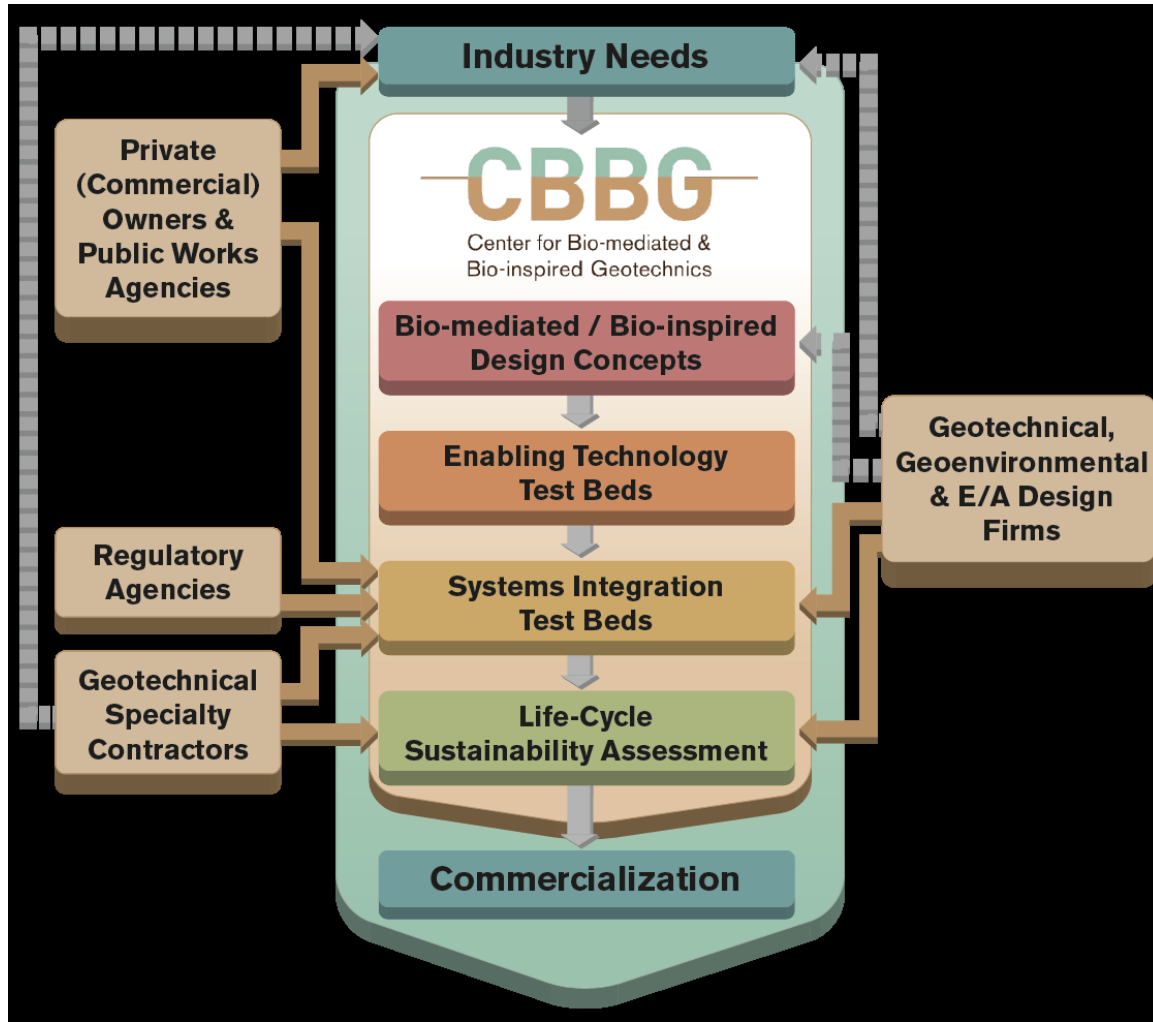


Industrial Collaboration Program and Innovation

Nasser Hamdan
Industrial Collaboration Director
October 19, 2021

Industrial Collaboration Program (I)



Stakeholders span the value chain

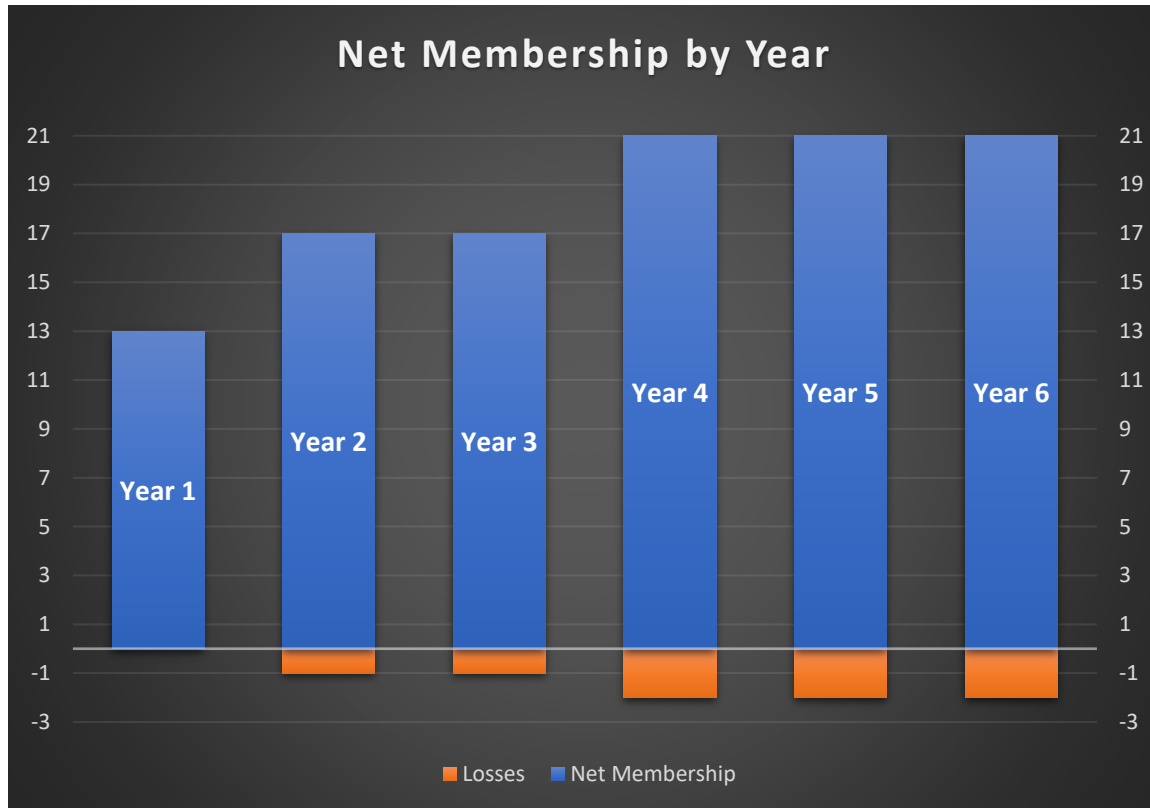
- Geotechnical
- Mining
- Municipal solid waste
- Engineering & architecture
- Construction / Ground improvement specialists
- Environmental
- Federal agencies
- State DOT and DEQ
- NGOs

Industrial Collaboration Program (II) – Covid19

- **RECALL:** Covid-19 impacted budgets, threatened IAB engagement, hampered recruitment efforts, etc.
 - Identified as “Threat” per IAB SWOT, etc.
- One-year member extensions appreciated, preserved IAB engagement
- Business sentiment has greatly improved, recruitment open, projects on the table, “Threat” removed . . . but not out of the woods yet.
- We remain strongly focused on year-over-year retention of existing industry partners (Year-7 target goals)

Industrial Collaboration Program (III)

IAB remained actively engaged throughout year 6



- Net membership in Years 1- 6: 13, 17, 17, 21, 21 and 21
- Losses countered by new members
- **Added 2 new members** in Year 6
 - New Mexico DOT, Menard USA
- **Sustainable growth** requires **retention**

Industrial Collaboration Program (IV)

- Leadership **engagement** and project **collaborations with Industry** are major factors in retention and growth of IAB
- Enhanced engagement of IAB in strategic direction of Center research
 - Stand-alone IAB-Leadership Team meeting e.g.
- Involvement in CBBG projects, various project types and support modes
 - Lab to field scale
 - Technical support
 - Direct financial support (full/partial)
 - In-kind support (materials, services/expertise)
- Stable IAB and we continue to seek new Industry Partners

Industrial Collaboration Program (V)

Maintaining and growing Industry Partners requires engagement and project collaborations leading to systems integration **(field deployment)**

→ **Systems Integration (S.I.) is a powerful outcome.**

Senior Investigators play important role in moving projects towards S.I.

- Revised/expanded project review metrics in Year 6 and beyond

Reduced project portfolio to free-up funding for S.I. projects

- NSF funding ended for 4 projects in Year 6
- Four (4) more projects ending in Year 7
 - Put 4 additional projects on notice
- No new NSF-funded projects for Year 7

Still funding some Fundamental Knowledge, Enabling Technology work

- However, must support project in S.I. **OR** moving towards S.I.

Stakeholder Community (I)

- Diverse project portfolio attracts diverse IAB with broad interests
- Leverage IAB's diverse strengths, interests and foresight to:
 - Address modern engineering challenges
 - Identify emerging opportunities where biogeotechnics can serve a role
- Play different roles in CBBG value chain based on sector, interests, etc.
- Collectively, role is singular and forms the **basis of the stakeholder community**: *shared goal of developing nature-inspired technologies and practices for civil infrastructure systems*

Stakeholder Community (II)

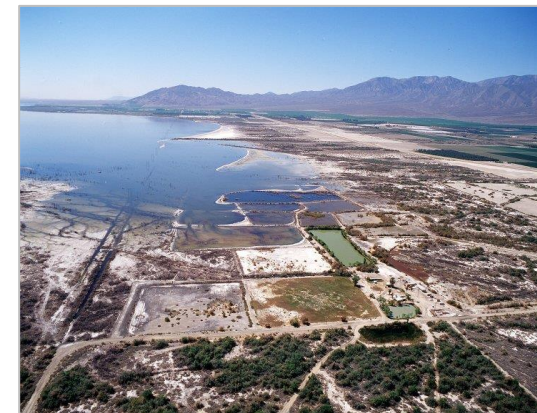
- IAB forms the core of the CBBG stakeholder community
- CBBG's work impacts society, drawing interest and partnerships outside of IAB that expand the **stakeholder community** . . .

“includes all parties who may contribute to the ERC or may be impacted by the ERC”

- Stakeholders and their networks provide opportunities to:
 - Grow our IAB
 - Engage partners in EWD
 - Disseminate CBBG knowledge to the general public
 - Create partnership opportunities w/public agencies and NGOs

Stakeholder Community (III)

- We continue previous year's successful efforts to recruit additional public agency partners to the CBBG stakeholder community
- New Mexico DOT
 - Newest member, joined at ***Fellowship Level***
 - Over \$50K initial commitment
- Bureau of Reclamation
 - Began as sponsored research in Year 4
 - Now, \$200K funding for Salton Sea project
 - “Functioning” as CBBG member



<https://www.usbr.gov/lc/images/gallery/Saltonsea/saltseasaline2.jpg>

Stakeholder Community (IV)

- Cosanti Foundation, CBBG's first NGO, joined as COVID began
- Initiated project discussions during recent site visit to Arcosanti
 - Identified needs and mutual interests
 - Engaged in learning about opportunities w/CBBG

Presentation tomorrow-

- Paolo Soleri's "urban laboratory" begun in 1970 (Arcosanti)
 - Coined "arcology" (architecture + ecology), share common principles w/CBBG
- Site challenges potentially amenable to biogeotechnical solutions

Agencies and NGOs add to synergy w/in stakeholder community and strengthen the value chain, increase appeal for existing members



<https://www.arcosanti.org/history>

Stakeholder Community (V)

Community grows via dissemination of CBBG knowledge

- **Canadian Geotechnical Society webinar: “Emerging Biogeotechnical Methods for Hazard Mitigation, Infrastructure Construction, Remediation, and Site Investigation”**
- Included participants from consulting engineering firms, site owners, and academia
- Lead to follow-up requests for other webinars

Center for Bio-mediated & **CBBG** Bio-Inspired Geotechnics

Emerging Biogeotechnical Methods for Hazard Mitigation, Infrastructure Construction, Remediation, and Site Investigation

Researchers from the Center for Bio-mediated and Bio-inspired Geotechnics (CBBG), a consortium of Arizona State University, the University of California at Davis, Georgia Institute of Technology, and New Mexico State University, will describe ongoing work on a suite of nature-inspired methods for ground improvement, soil and ground water remediation, and subsurface exploration. Methods under development by the CBBG partner universities include liquefaction mitigation via carbonate precipitation and desaturation, mitigation of wind- and water-driven soil erosion, bio-inspired foundation and anchor systems, removal of phosphorus and nitrogen from agricultural waters, and self-burrowing robotic probes for subsurface exploration. Development and commercialization of these methods is being conducted in collaboration with an Industry Partner group that includes owners, contractors, consultants, manufacturers, and regulatory agencies under the US National Science Foundation Engineering Research Center program.



Slag Filter Bed for Phosphorous Removal



Self-propelled Earth Exploration Device

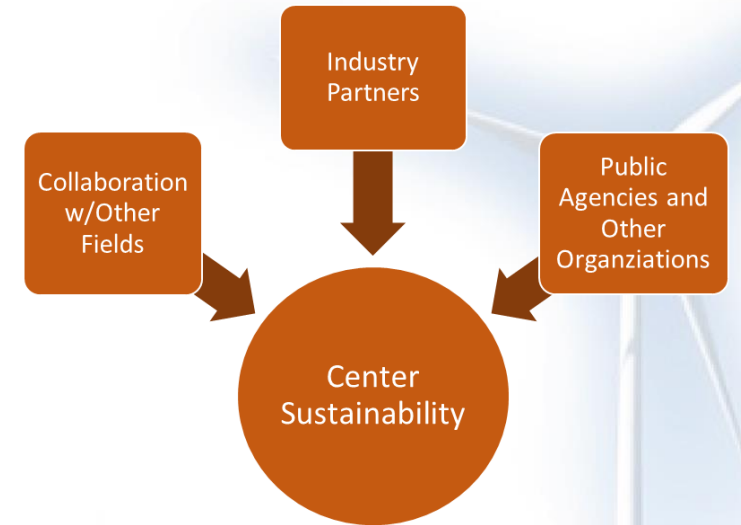


Biocemented Column

Sustainability (I)

The financial approach/contribution

... a look back



Numerous projects w/**Industry Partners** in Yrs 1-6

- Past and current projects demonstrate added value (~17 so far)
- Continue to identify opportunities for existing and new projects

New funded projects w/**Government/Public Agencies**

- Reclamation and NMDOT

Collaboration with **Other Biomimicry Fields**

- Co-funded projects w/ASU Biomimicry Center, opportunities w/NASA for bio-inspired exploration on moon and Mars

We continue our efforts to grow this financial approach

Broader Impacts (I)

Projects/collaborations towards systems integration form core sustainability

What about the broader impacts on the stakeholder community?

“includes all parties who . . . may be impacted by the ERC”

More holistic effort to sustainability: tied to broader impacts

- *How else does CBBG engage stakeholders?*
- *How is the Center perceived, public impacts?*



Broader Impacts (II)

Engage IAB stakeholders- experiences & opportunities

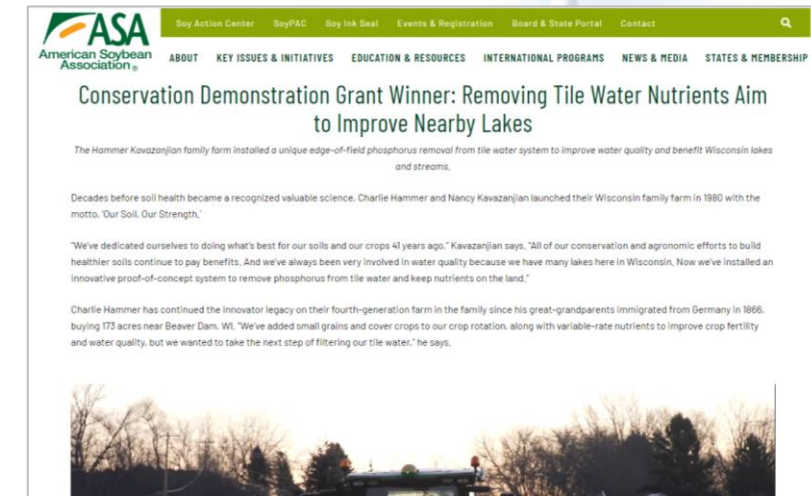
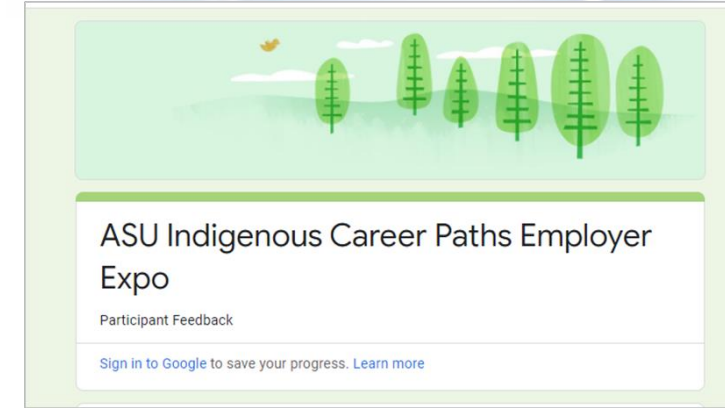
- Serve on graduate committees
- Co-development of IP (\$ not necessarily forefront)
- Native American Career Expo

Enhanced public perception/impacts-

- Featured in *American Soybean Association*, (April 2021)
 - Numerous public and private stakeholders
- Innovative bio-based contaminant cleanup

“Given the widespread groundwater contamination and importance of groundwater as a resource for society, the value of this development cannot be overstated”

[emphasis added]. P. Bennett, principal hydrogeologist for H&A



Bio-based process promises better contaminant cleanup


ASU researchers use mixtures of microorganisms in a new approach to neutralizing toxic solvents in the environment



Innovation (I)

Patents/IP

- One new patent awarded in Year 6
- Five (5) active provisional patents
 - FYI: Another patent recently awarded: “Bio-Inspired Deep Foundation Pile and Anchorage System” U.S. Patent No. 11,142,878
- Six (6) patents to date
- Completed licensing of EICP technology w/Industry Partner
- Seven non-active applications for provisional patents/invention disclosures from previous years

 US010794029B2	
(12) United States Patent He et al.	(10) Patent No.: US 10,794,029 B2 (45) Date of Patent: Oct. 6, 2020
(54) HYDROGEL BIOCEMENT SYSTEMS AND METHODS	(52) U.S. CL. CPC <i>E02D 3/12</i> (2013.01); <i>C09K 17/50</i> (2013.01); <i>C04B 14/285</i> (2013.01); <i>C04B 24/14</i> (2013.01);
(71) Applicant: ARIZONA BOARD OF REGENTS ON BEHALF OF ARIZONA STATE UNIVERSITY , Scottsdale, AZ (US)	(58) Field of Classification Search CPC <i>E02D 3/12</i> See application file for complete search history.
(72) Inventors: Ximin He , Tempe, AZ (US); Edward Kavazanjian , Tempe, AZ (US); Nasser Hamdan , Scottsdale, AZ (US); Zhi Zhao , Mesa, AZ (US)	(56) References Cited U.S. PATENT DOCUMENTS 5,670,567 A 9/1997 Lahalih 5,824,725 A 10/1998 Lahalih
(73) Assignee: Arizona Board of Regents on behalf of Arizona State University , Scottsdale, AZ (US)	

Innovation (II)

Translational Research

Project collaborations provide opportunities to form translational research partnerships . . . developing technology in collaboration w/industry

Six (6) translational researcher partners engaged on four CBBG technologies in Yr. 6

EICP Fugitive Dust Control (*PR13-INF-ASU*)

N and P Removal from Impacted Waters (*PR42-ENV-ASU*)

EICP Biocemented Soil Columns (*PR56-INF-ASU*)

Sustainable Methane Biogas Energy (*PR71-ENV-ASU*)

We continue to advance innovation activities, including translational research partnerships, as we move beyond COVID

Thank You... Questions?

