EA Engineering, Science, and Technology, Inc., PBC

THE CIRCULAR ECONOMY – PERSPECTIVES FOR EA AND OUR CLIENTS

Perspectives for EA and Our Clients

INNOVATION PAPER OVERVIEW

What the Circular Economy is, how we support it, and how we are applying to solve our own internal and client challenges.

Introduction

Synonymous with sustainability, waste management, economics, and corporate social responsibility (CSR) topics, the Circular Economy concept continues to build visibility and momentum as organizations seek transformative approaches to reduce footprint and increase value retention of material cycles. While the Circular Economy concept has deep-rooted origins, it cannot be traced back to any one date or author; however, its practical applications to modern economic systems and industrial processes have gained momentum since the late 1970s, led by academics, thought-leaders, and businesses. More recently and based on growing Environmental, Social, and Governance (ESG) considerations, this Innovation Paper helps frame the concept of "circularity," and how it applies to EA and our clients. Specifically, this paper explains some of the basics about the Circular Economy, namely:

- Where does it come from?
- What principles is it based on?
- What implications does the Circular Economy have for EA and its clients?

Additionally, the paper highlights various EA projects exhibiting circularity principles that are provided for perspective and context.

Origins of the Circular Economy

Swiss architect Walter Stahel came to the realization in the late 1970s that the current linear economic theory was not sustainable due to the fact that if consumption of resources continued to grow over time, it would lead to major problems in the future. He concluded that the current economic production model was not sustainable due to increasing demand for raw materials and worldwide accumulation of waste. Stahel introduced the "circularity" concept of closing material cycles, thus reforming the economy. The concept of closing these cycles has been explored and further developed in business case studies ultimately resulting in the concept of the Circular Economy. For the purposes of this paper, the Circular Economy is defined by the Ellen MacArthur Foundation (EMF) as:

> *An industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts toward the use of renewable energy, eliminates the use of toxic chemicals that impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems, and business models.*[1]

The Circular Economy quandary noted by Stahel and others focuses on the fact that the majority of our current in-place infrastructure was planned, engineered, and constructed using linear economic principles. A linear economy traditionally follows the "take-make-dispose" step-by-step plan, meaning that raw materials are collected, then transformed into products, generating by-product waste, with the end products used until they too are finally discarded as waste. Value is created in this economic system by producing and selling as many products as possible. As such, today we are confronted with products that were not designed and/or produced with reuse in mind. The "leakage" from these linear pathways results in waste, energy loss, and depletion of other resources, which only increases the footprint of these activities, products, and services life cycles. Adopting a circular approach focuses on raw materials that were previously used before recycling the products or components as a raw material again. Circularity focuses on realizing the highest possible value of these materials, as this requires the least effort and/or energy. Recycling/reuse or up-cycling is often more energy efficient than extracting new raw materials through mining or agriculture. Recent global recognition of the shortages of rare earth and precious metals, and opportunities in the recycling of mobile phones are examples of this paradigm shift in thinking[2].

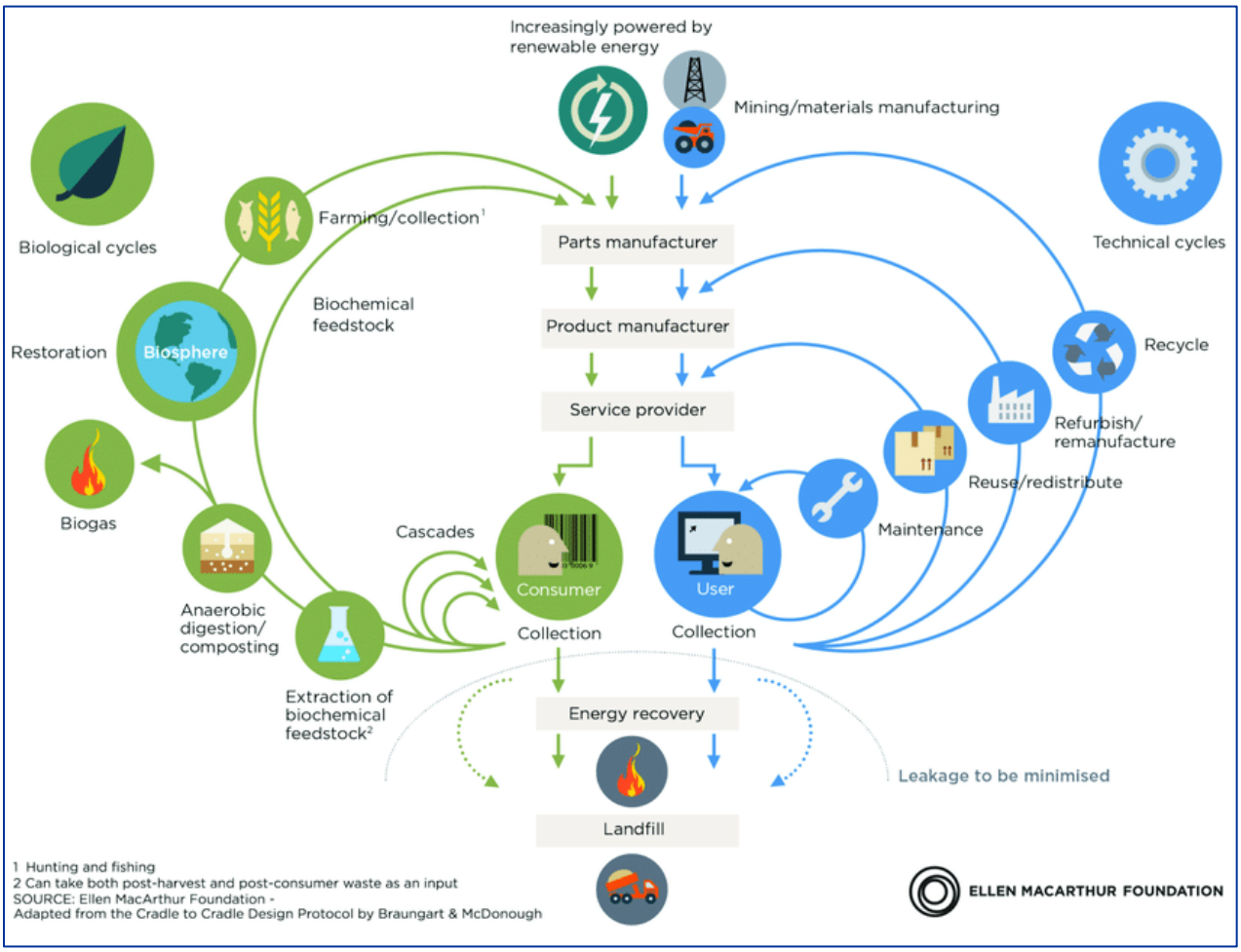
Since Stahel's foundational work, the Circular Economy concept has been further developed by German chemist Michael Braungart and U.S. architect William McDonough as detailed in the 2002 non-fiction book, *Cradle to Cradle: Remaking the Way We Make Things*. This book is a manifesto detailing how to achieve their Cradle to Cradle Design model. More recent evolution on the concept has been developed by EMF in numerous reports including: *The Circular Economy* (2012)[3], *Towards the Circular Economy* (2013a)[4], and *Completing the Picture: How the Circular Economy Tackles Climate Change* (2019a)[5].

Circular Economy Framework

EMF illustrates the Circular Economy in Figure 1[6]. The model distinguishes between two main cycles: technical and biological. Consumption happens only in biological cycles, where food and biologic-based materials (e.g., cotton, wood, etc.) are designed to feed back into the system through processes like composting and anaerobic digestion. These cycles regenerate living systems, such as soils, which provide renewable resources for the economy.

Technical cycles recover and restore products, components, and materials through strategies like reuse, repair, remanufacture, or (in the last resort) recycling or upcycling.

Figure 1: Circular Economy Framework (EMF 2013b)



CLOSING LOOPS

In a Circular Economy, material cycles are closed by following the example of natural ecosystems; therefore, toxic substances are mitigated resulting in no waste because all residual streams are valuable as resources. Moreover, products are taken back after use for repair and remanufacturing in order to reuse the products a second, third, or fourth time, and residual streams are separated in a biological and technical cycle.

SYSTEM THINKING

The Circular Economy provokes systems thinking. Stakeholders (businesses, people, and organisms) are part of a network in which the actions of one impacts other actors[7]. In a Circular Economy, this is taken into account in the decision-making processes through a life-cycle approach where both short- and long-term consequences of each decision are evaluated considering the impact of the complete value chain and aiming for the creation of a more resilient system more effective at every scale. Business models such as the International Organization for Standardization [ISO] 14001 Environmental Management System specification are used by organizations aiming to continually improve the environmental performance of their activities, products, and services. Tools and frameworks such the Institute for Sustainable Infrastructure (ISI) Envision provide a consistent, consensus-based rating system for assessing sustainability and resilience for infrastructure, which considers both short- and long-term consequences.

VALUE RETENTION

A goal of the Circular Economy is to decouple economic growth from resource consumption by focusing on value retention. In order to sustain the ecosystems and natural capital on which we rely, more than financial capital needs to be viewed as valuable natural capital consists of all renewable and non-renewable resources, as well as processes from the environment that provide products or services. Natural capital is also an economic metaphor for the limited stocks of natural materials, land, and ecosystems; in other words…natural assets. The definition of natural capital consists of all renewable and non-renewable resources and processes […]. Social capital and natural capital play a role in the stability of our systems as well. In a Circular Economy, these values are reflected in the costs of products and services; therefore, the energy required to fuel this cycle should be renewable by nature as well[7].

Taking Action: The ReSOLVE Framework

In the 2015 report by EMF[7], McKinsey Center for Business and Environment, and Stiftungsfonds für Umweltökonomie und Nachhaltigkeit entitled *Growth Within: A Circular Economy Vision for a Competitive Europe*, the authors point out that the European economy is surprisingly wasteful in its model of value creation and continues to operate a take-make-dispose system. The report notes that a transition to a Circular Economy would involve considerable transition costs but, if well managed, could create an opportunity for economic and industrial renewal.

The report introduces the ReSOLVE framework (Figure 2), which identifies six actions that organizations can pursue for circularity: regenerate, share, optimize, loop, virtualize, and exchange (ReSOLVE), each presenting an opportunity for Circular Economy implementation. Each action is compliant with three underlying principles that define the Circular Economy: (1) preserving and enhancing natural capital; (2) optimizing resource yields by circulating products, components, and materials at the highest utility and value at all times within technical and biological cycles; and (3) fostering system effectiveness by revealing and designing out negative externalities[7]. ReSOLVE can be used as a guideline for Circular Economy innovations by both helping to define what the Circular Economy is and by providing examples of Circular Economy solutions in given case settings that inspire innovations.

Figure 2: ReSOLVE Framework (EMF 2015)

ReSOLVE promotes Circular Economy thinking, but is not a to-do list. Rather, "each action represents a major circular business opportunity"[7]. In different ways, these actions all increase the utilization of physical assets, prolong their life, and shift resource use from finite to renewable sources. Each action reinforces and accelerates the performance of the other actions, creating a compounding effect. The principles of ReSOLVE individually or aggregated are not necessarily new thinking and, in many ways, build on and reflect proven principles based on pollution prevention (P2) promoting recycling, etc. The COVID-19 pandemic of 2020 has indirectly created a shift toward Optimize and Virtualize actions associated with leveraging big data, material response, and the use of virtual means of communication/collaboration.

When applying the ReSOLVE framework, the Circular Economy becomes an implementable *business strategy* to sustain natural resources for long-term prosperity.

Building Blocks of the Circular Economy

EMF notes that while the steps in the technical cycle in Figure 1 are arranged by products in the circular order, the Circular Economy goes further than just products. As noted earlier, it is really a business strategy. This strategy consists of four building blocks that organizations must apply to implement a Circular Economy: (1) Activity, Product, or Service Design; (2) New Business Models; (3) Reverse Networks; and (4) Enabling Conditions[8]. Each of the four building blocks is described below.

1. Activity, Product, or Service Design

This building block involves improvements in choice of materials and activity and/or service design. For service providers like EA, this requires design in multiple processes associated with sourcing, project execution, etc. Potential ways to realize such changes include standardization of purchases of

environmentally preferred products, zero waste commitments, etc. For product-oriented clients, this building block can involve process design or re-engineering, P2, product end-of-life, and supply chain considerations. The implementation of this building block focuses on behavioral choices and commitments and asks questions such as:

- What is the true cost of the activity, product, or service?
- How can the residual materials (e.g., wastes and/or by-products) be recycled/upcycled?
- How should the product be packaged, marketed, and transported/distributed?
- How can the process or service be designed to reduce or eliminate wastes altogether?
- What is the life cycle of a purchased product and how can this cycle be extended?
- What is the disposition of the products' end-of-life?

EA's consulting services are often sought in the application of this building block. Examples of EA's application are provided in the **EA Integration of Circular Economy Principles** below.

2. New Business Models

The transition from linear to circular process requires change in the use of materials and also a change in structures of ownership, business models, and responsibilities. Ideally, these are "designed into" new processes; however, process redesign, re-engineering, or improvement is required for existing processes. This entrepreneurialism will either replace existing models or lead to new opportunities. This building block focuses on innovative business models, more specifically by changing to performance-driven models. This offers instruments for translating products designed for reuse into attractive value propositions. This perspective requires manufacturers to think differently about products and to take responsibility for products during the life cycle. For EA, it requires us to apply new thought to processes or programs associated with service delivery. The consideration is always how the used products can be made valuable again or the process can be improved. Questions to be asked include:

- Which business models are suitable for this product?
- Can the product be offered as a service rather than be sold as a product (e.g., software as a service)?
- Which optimization/collaboration options are available across sectors or production chains (procurement, transport, or exchanging utilities such as residual energy, heat, materials, water, and space)?
- Can reverse logistics be organized or guaranteed?
- How can value flows (social, natural, and/or economic) be translated to allow for better exchange of circularity benefits?

Integrated Environmental, Quality, and Health and Safety Management System approaches are examples of these new business models that promote continual improvement. The recent emphasis on ESG further promotes and supports the development and implementation of these leading approaches.

3. Reverse Networks

The focus of this building block is the cycle from the user back to the manufacturer resulting in the final return of materials to the soil or back to the industrial production system. Among others, it carries out the manufacturer responsibility methods discussed under building block "Enabling Conditions." This includes, for example, product take-back obligations, reverse logistics, and other systems. This reversal can be expanded on an international scale, allowing for returning materials in exported goods to the manufacturer as waste for reuse. The purpose of reverse networks is to have manufacturers or third-parties, such as shared services, collect materials efficiently. Questions to be asked associated with this building block include:

- Which networks can be deployed?
- How can the product flows be returned?
- What handling, distribution, or transportation networks are available?

Reverse networks require partnerships. Schneider Electric, the global leader in digital transformation of energy management and automation, deploys a growing range of services to help customers extend the life of aging electrical equipment as well as to upgrade their products to the latest technology[9]. This is done, for example, through its ECOFIT™ program, through a global network of refurbishment centers for low and medium-voltage equipment circuit-breakers and uninterruptable power supplies. Additional services exist to take-back and treat batteries and medium-voltage equipment at the end-of-life. In 2018, Schneider Electric's circularity initiatives helped avoid the consumption of 40,000 tons of primary resources and reduced customers' carbon dioxide emissions by 30 million tons, primarily through the renovation of existing equipment (buildings, industry, and infrastructure).

An internal example of circularity is noted in EA's 2019 Public Benefit Corporation (PBC)/CSR Report[10]. EA's Lewisville, Texas office supports Keep Lewisville Beautiful, a non-profit community enhancement organization, to collect plastic waste (bags and overwrap) that will be turned in as part of the "Bags to Benches" program. Bags are collected and turned in to Keep Lewisville Beautiful, who weighs and stores the materials for transport to Trex Company, Inc., a major manufacturer of wood-alternative composite decking, railing, and other outdoor items made from recycled materials. An example of circularity in waste diversion is, for every 500 pounds collected, a TREX® park bench made out of recycled plastic will be donated to a local school or recreational park by the company.

4. Enabling Conditions

This building block focuses on the conditions enabling society to apply circular principles. The application of circular principles requires more transparency in material flows, aligning incentives, and determining industrial standards. Financing, risk management, legislation, infrastructure, and education must facilitate the transition. In addition to industry changes, enhancing consumer awareness is also necessary to enable easier implementation of circular innovations. Finally, companies must buy into cross-sector transparency and be willing to share general and confidential market information to make it effective. The implementation of this building block focuses on organizational choices and commitments and asks questions such as:

- Can legislation be used to encourage reuse of existing materials? Domestically and abroad?
- What incentives are available?
- Which legal and economic aspects have an impact on making the primary process circular?
- Can companies share traditionally business confidential information to promote circularity from a sector perspective?

- Can more extensive manufacturer responsibility be a trigger for more circular use of materials?

Examples of this building block currently exist and can be found in industrial sectors such as the chemical, pharmaceutical, and transportation sectors, where a considerable amount of industry collaboration already exists. Advocacy groups tackle topics such as transparency, legislation, and regulation; confidential business information; and supply chain transformation. The American Chemistry Council is an example organization in the United States driving this building block through the chemical manufacturing supply chain.

EA Integration of Circular Economy Principles

With the theoretical principles of the Circular Economy defined, application through ReSOLVE, and expressed through the building blocks, how is EA responding to the Circular Economy? First, as a PBC, EA is committed to reducing its own footprint through transformative actions, which are described in EA's recently published CSR plans[10, 11]. Specific actions identified in prior CSR reports include:

- Voluntary reporting to Global Reporting Initiative Standard disclosures
- Annual carbon footprint analysis for Scope 1, 2, and 3 emissions
- Footprint reduction through carbon offset programs, renewable energy certificates, and process redesign to incorporate energy efficient electronics, and high performance lease workspaces (e.g., Leadership in Energy and Environmental Design accredited).

More information on EA's corporate sustainability efforts can be found at http://eaest.com/about//#corporate-sustainability.

In our consulting capacity, EA works with organizations in the built and natural environments to address challenges in the environmental space. Often, through our partnership, EA assists clients to apply circularity principles in a practical and informal way, often in support of other defined commitments (e.g., ISO management systems implementation, P2 opportunities to meet Executive Order [EO] or other voluntary commitments, sustainable remediation, etc.).

This section addresses projects where EA, in partnership with our clients, has applied circularity principles to our project delivery. Example projects are further compared to the ReSOLVE framework noted earlier for perspective.

Beyond Pollution Prevention

In the United States, the landmark Pollution Prevention Act of 1990 created a national policy to prevent or reduce pollution at the source wherever possible. The Act focused industry, government, and public attention on reducing pollution through cost-effective changes in production, operation, and raw materials use. P2 is defined by the U.S. Environmental Protection Agency (EPA) as any practice that reduces, eliminates, or prevents pollution at its source (EPA 1992[12]). P2, also known as "source reduction," is the ounce-of-prevention approach to waste management. Reducing the amount of pollution produced means less waste to control, treat, or dispose of. Less pollution means less hazards posed to public health and the environment. Opportunities for source reduction are often not realized because of existing regulations, and the industrial resources required for compliance focus on treatment and disposal. P2 supports the Regenerate, Optimize, and Exchange actions of the ReSOLVE framework.

EA has been a leader in P2 planning and implementation with government and industry since the early 1990s, when the concept was conceived through Federal EO 12856. In fact, EA managed the first P2 program management plan under the Federal EO for Armstrong Labs through the U.S. Air Force, completing hundreds of P2 Opportunity Assessments and action plans focused on process optimization,

material replacement, and recycling at U.S. Air Force bases worldwide. Since then, EA has worked with public and private interests to assess P2 opportunities in a wide range of industries and sectors.

For a global healthcare leader, EA developed a source reduction strategy for trichloroethane (TCA) as an interim step to TCA replacement in pharmaceutical manufacturing operations. At the time, TCA was actively used in four production processes: packaging operations, tablet compressing, bottle plant operations, and graphic services. Circular methods for reducing the amounts of existing TCA were identified through second tier reuse and more extensive actions, such as solvent recovery. Solutions required process redesign and application of new business models. Other opportunities for minimizing TCA use were also explored, including alternative cleaning procedures and alternative bottle de-labeling procedures. Solvent minimization opportunities were ranked, and advantages and disadvantages of each were noted through a cost-benefit analysis. Actions were implemented and resulted in the client avoiding millions in waste disposal, improved management systems, and re-engineered manufacturing projects. Application of P2 projects involves all phases of the ReSOLVE framework including process redesign (regenerate), material substitution (optimize), and recycling (loop).

Green Sustainable Remediation

The application of circularity principles to the investigation and remediation of contaminated sites is an area of rapid development, with new business practices, tools, and performance standards for identifying, evaluating, and managing the residual impacts of cleanup projects to the environment, economy, and society. Guidelines, frameworks, and standards of practice for "green and sustainable remediation" (GSR) have been developed and are dynamically evolving through forums like the Sustainable Remediation Forum (SURF), ASTM International, Interstate Technology & Regulatory Council (ITRC), and other organizations in the United States and internationally. In response to EOs, Federal government agencies have developed policies, procedures, and guidelines for evaluating and reporting the sustainability of their environmental restoration projects.

State government agencies have also taken up the cause, with some states leading the charge and developing comprehensive guidance utilized within and outside of their state. GSR has even infiltrated regulations although, for the most part, these regulations are more of the "endeavor to" than the "shall" variety at this point. Private sector companies in the oil and gas,

energy, manufacturing, defense, and other sectors are developing their own corporate GSR programs to improve day-to-day management of contaminated sites and to support external reporting commitments.

Expressed through its PBC Pillar I, EA actively contributes to industry through application, use, and critical input on various GSR tools to assess life-cycle impacts of remediation of contaminated sites. EA is an active participant in the organizations noted previously, using a wide range of tools and technologies to assess life-cycle GSR impacts. One tool EA uses widely, SiteWise™, was developed by Battelle and the U.S. Army Corps of Engineers and designed to calculate the environmental footprint of remedial alternatives. The Microsoft Excel™ tool provides assessment of quantifiable sustainability metrics including: greenhouse gas (GHG) emissions, energy usage, electricity usage, criteria air pollutants, water usage, and accident risk that can be evaluated. During the feasibility study/design phase, we perform life-cycle analyses and compare remedial technologies based on sustainability metrics to consider short- and long-term energy and water consumption, air emissions, ecosystem impacts, material consumption, and waste minimization or recycling. Wherever feasible, we promote the use of environmentally preferred technologies, products, and clean construction techniques. EA has applied SiteWise™ to over 60 projects using our GSR toolbox approach, which allows for comparison of various alternatives to aid decision makers.

An example project highlight where we used SiteWise™ to assess remedial alternatives for groundwater treatment at Kirtland Air Force Base in New Mexico is provided in the inset box. Remediation projects like this address all of the ReSOLVE action areas. Another example client program that highlights circularity partnership with the federal, state, local, and non-governmental organization community is the Great Lakes Environmental Restoration Initiative (GLRI). The GLRI, founded in 2009, is a federal program that provides funding for the protection and restoration efforts in the Great Lakes region. EA has been awarded successive 5-year contracts by EPA to provide technical and management services to EPA's Great Lakes National Program Office. Work under this contract includes contaminated sediment evaluations, remedial design activities, habitat evaluations and restoration designs, and oversight of contaminated sediment remediation projects. Activities include site characterizations, remedial investigations, risk and impact assessments, feasibility and treatability studies, pilot tests, engineering services, construction support, community outreach, technical support, fieldwork, and remedial action oversight. To date, EA has been awarded over 40 task orders valued in excess of $25 million. The Former Zephyr Refinery Fire Suppression Ditch (see inset box below) project in Michigan, received the Western Dredging Association's 2019 Environmental Excellence Award for Environmental Dredging.

Another area EA is applying circular approaches is in the chemicals and contaminants of emerging concern, notably per- and polyfluoroalkyl substances (PFAS). EA is an active participant in PFAS working groups such as ITRC, and technology development programs such as Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP). EA has also aligned with academic partners and leading research and development programs to advance the understanding of emerging contaminant science and has recently focused on issues related to PFAS. More information on EA's emerging contaminant services and research can be found at https://eaest.com/innovation/emerging-contaminant-services-and-research/.

Emerging contaminant project examples address all of the ReSOLVE action areas and demonstrate knowledge sharing building blocks linking regional/community habitat restoration goals.

Planning for Resilience

Coastal areas are particularly vulnerable to the effects of climate change. Sea level rise and increased storm intensity/frequency can result in erosion and flooding of these sensitive areas as well as loss of natural habitat. EA's Coastal Resilience services focus on applying multi-disciplinary green infrastructure or design with nature approaches. In addition, EA's Coastal Resilience services, combined with traditional remedial evaluation, design, and implementation services, ensure that remedies implemented on contaminated sites are resilient to the impacts from climate change.

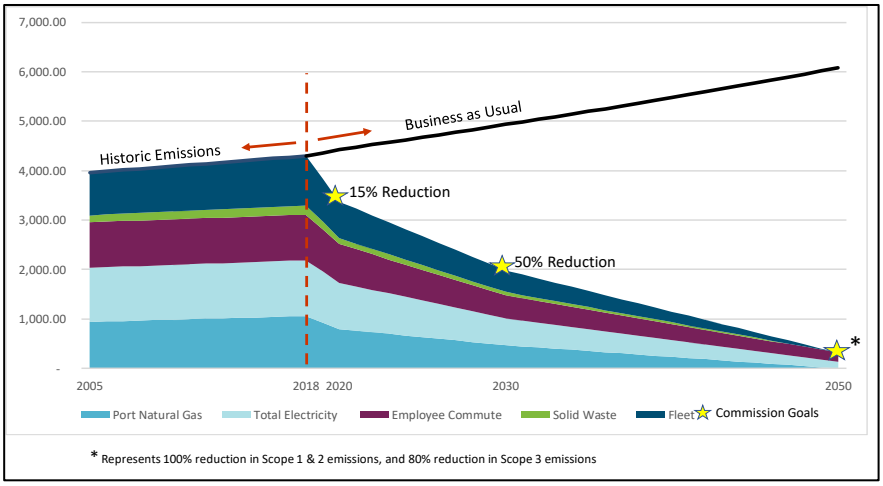
Recent efforts relating to the assessment of sea level rise impacts upon the natural environment include support to various counties situated along Chesapeake Bay in Maryland, which is experiencing some of the most profound impacts to natural systems along the East Coast of the United States. Specific assessment and planning supported the development of a regional strategy needed to address concerns related to sea level rise. A regional adaptation strategy was developed by first evaluating critical coastal vulnerabilities and then developing an adaptation plan focused on nature-based features, which will inform the selection of coastal adaptation strategies. EA used geographic information systems to present sea level rise scenarios, identify vulnerable areas prone to major flooding, prioritize vulnerable natural areas, and recommend opportunities for developing more resilient marsh habitat. This successful assessment and planning project was completed in early 2019, and was recognized by the *Climate Change Business Journal* for advancing best practices. EA is using tools like the ENVISION infrastructure rating system to assess life-cycle aspects and offer sustainable solutions, which align with ReSOLVE Optimize and Regenerate actions.

This project restored a 13.6-acre wetland, removed 48,870 cubic yards (CY) of contaminated sediment, and successfully treated another 1,370 CY of sediment onsite. Efforts began with intensive investigative activities, including spatial modeling, to accurately identify the extent of sediment requiring remediation. Using resulting data and data from a habitat evaluation, EA's design team prepared construction plans and specifications, cost estimates, and secured permits for the project remedy, which included a cofferdam, water treatment system, dewatering pad, haul road, petroleum pipeline protection, and water supply pipelines. Employing innovative methods and technologies, EA developed an adaptive design approach that provided the flexibility necessary to successfully address site challenges, which included limited site access, dewatering, and unforeseen site conditions.

Environmental benefits of the project:

- Treated 91.9 million gallons of contaminated water (process and contact)
- Removed contaminated sediments with concentrations above 2,000 milligrams per kilogram (mg/kg) total petroleum hydrocarbons and 128 mg/kg lead to protect benthic organisms
- Dredged a total of 49,491 CY of contaminated sediment including: 38,272 CY from wetland areas and 11,219 CY from the approximately 1,350-linear-foot ditch portion of the site. Dredging required a phased approach for sheet-pile installation to stabilize the ditch banks, support dredging, and provide stabilization for haul roads to allow access
- Treated 1,370 CY of characteristically hazardous sediment (lead) *in situ*, rendering it non-hazardous via mixing (Lang Tool) prior to removal
- Restored a 13.6-acre monotypic submergent wetland dominated by invasive species with 3 acres of emergent marsh, 5.1 acres of submergent marsh, 1.2 acres of deep marsh, and mitigation of 4.3 acres of temporarily impacted wetland
- Restored 1.6 acres of open water habitat (ditch)
- Planted 223 trees and shrubs and 13,620 live herbaceous plugs/bare-root native plants
- Seeded over 1.5 acres of wetlands with native seed mix
- Installed 6 habitat structures (root wads, brush piles, etc.) per acre of restored wetland.

Climate Action Planning



The Port of Seattle (PoS) aims to be the greenest, most energy efficient port in North America. In support of the Port's Maritime Division (PoS Maritime), a team led by EA, has been working with the PoS decision-makers to develop a GHG Reduction Strategy defining strategies to meet 2020, 2030, and 2050 goals. The PoS Commission adopted Port-wide GHG emission reduction targets in 2017 that align with the Paris Climate Agreement. The Port's targets include a long-range commitment to deeply "decarbonize" maritime activity and make Port operations carbon neutral or carbon negative by 2050 (see inset box). The PoS has adopted strategic objectives and has committed to meet the science-based GHG reduction goals of the Paris Agreement to mitigate climate change. The EA Team engaged a number of leading experts to address all aspects of the ReSOLVE framework to develop a strategic plan for future operations, which is being implemented. A 2019 study by EMF noted that applying circular economy strategies in just five key areas (cement, aluminum, steel, plastics, and food) can eliminate almost half of the remaining emissions from the production of goods—9.3 billion tonnes of carbon dioxide equivalent in 2050—equivalent to cutting current emissions from all transport to zero[13].

Promoting Development of New Business Models

Circularity principles promote the development and sustainment of transformative business models to eliminate residual wastes (e.g., energy, physical waste, etc.). This is done in both new settings and in the redesign/re-engineering of existing processes. EA works with clients to assess, design, implement, and sustain management systems that are tailored to their business objectives, operating contexts, and the unique environmental, health, and safety (EHS) challenges that their organizations need to manage to deliver ongoing success. Our experience with various ISO standards (i.e., 9001; 14001; 45001, other voluntary schemes [e.g., *Responsible Care®,* TRUE Zero Waste, etc.]) provide a unique perspective. Efforts typically start with a gap assessment to document the "as is" condition of the program or process. We then apply standard techniques and tools to assess conformance to standards (e.g., ISO or other), recommending effective ReSOLVE actions. We employ tools, such as "visioning" and scenario planning, to identify a "to be" condition, which emphasizes a system's approach that is often solved with information technology solutions. ReSOLVE actions including Optimization, Loop, and Virtualize are employed. Outcome actions from Environmental, Health, Safety, and Sustainability (EHSS) management systems redesign include all ReSOLVE actions. The use of these tools is also utilized in strategic planning efforts like the PoS Climate Action Plan process described above.

Circularity requires rethinking of existing business models with vastly differing value propositions—shifting from linear "take-make-dispose," uniqueness, and competitive to open, transparent, and life-cycle approaches. When one of the largest global pharmaceutical research and development companies was struggling with integration of ISO standards across global operations, EA staff were retained to facilitate, assess, design, and implement support for an integrated EHS management system at 19 global facilities. The approach defined integration points, and documented conformance with corporate guidelines, ISO 14001, and Occupational Health and Safety Assessment Series 18001 (ISO 45001 predecessor). EA's gap assessment included a "visioning" session with global EHS managers to document "as is" and "to be"

conditions for an integrated EHS future state. EA led internal assessment teams assessing EHS management systems and guidelines at pilot sites in the United States and United Kingdom. EA benchmarked best in class attributes in similar organizations to help frame the business case to leadership. Unique aspects of the project included global integration across multiple business units and geographic boundaries, roles and responsibilities, and leveraging of technology as a force multiplier to gain efficiencies across sites and common EHS processes. Using the playbook developed by EA, the client achieved ISO registration at all global sites within a 3-year period.

Knowledge Sharing and Partnership

Two of the ReSOLVE actions focus on Optimization and Engagement, both focused on information exchange. EA invests in partnerships within our industry; notable examples include SERDP and ESTCP, the Department of Defense (DoD)'s environmental research programs, harnessing the latest science and technology to improve DoD's environmental performance, reduce long-term liabilities and costs, and enhance and sustain mission capabilities. These programs focus on government-wide issues and pursue solutions to the DoD's biggest environmental challenges, complementing other federally funded research programs. SERDP and ESTCP promote partnerships and collaboration among academia, industry, DoD, and other Federal agencies.

Under SERDP, EA has been collaborating with academia, federal agencies, and other industry partners on environmental-related research projects since 2017. EA successfully completed a pilot-scale/proof of concept demonstration test using indirect thermal desorption coupled with thermal oxidation to destroy PFAS and treat PFAS-contaminated soil to concentrations low enough for beneficial reuse. EA developed a probabilistic risk framework for assessing threatened and endangered species exposure to PFAS on DoD sites using the overlay of spatial data coupled with known PFAS concentrations. EA is supporting Towson University in evaluating toxicological effects of PFAS to fathead minnows and assessing physiological, ecological, and environmental determinants of PFAS uptake in freshwater fish. EA is conducting research on candidate fluorine free firefighting foams in consideration to replace current PFAS-containing firefighting foams to fill ecotoxicology data gaps for several ecological receptors (algae, aquatic invertebrates, fish, reptiles, and birds) and to provide an assessment of the biodegradation potential of fluorine-free replacement foams.

Other examples from private industry are noted. For over 10 years, EA has partnered with the American Chemistry Council assessing trends and associated metrics for the *Responsible Care*®, the voluntary EHSS management system for the North American chemical industry. EA provides benchmarking; supports metrics data collection and trending; and provides a technical support in the development of new guidance, metrics, and programs aimed at chemical sector EHSS program improvement. Successful partnerships like these noted above ensure EA is staying abreast of emerging issues and contributing to challenge resolution.

EA's Approach

EA has been working with organizations to implement circular approaches throughout our 45+-year existence directly and indirectly. There is no doubt that the economic and societal rationale for moving toward circular approaches has significantly increased, and appears to be increasing more rapidly in the pandemic-impacted world. In a dynamically changing world with geopolitical, climate, and global health challenges, there is a growing awareness that we are at the limits of the current linear economy and should promote principles of the Circular Economy.

Recognizing this, EA stays abreast of leading tools and approaches, implements delivery in our service line execution, and tracks emerging opportunities through formal working groups and dedicated strategies—each of these dedicated practice areas promotes emerging business lines such as GSR, resilience, technology, etc. These groups serve as incubators for multidisciplinary teams addressing emerging tools and processes, which support circular principles. Currently, EA has numerous groups

focused on tools such as SiteWise™, EPA's Spreadsheet for Environmental Footprint Analysis (SEFA), ENVISION, and Zero Waste; each of these involves technical staff from across EA disciplines and operations.

What's Next?

The common theme of this paper is that the concept of circularity is not necessarily new—its principles have been embedded in other tools and approaches. Another theme is that now is the time for organizations to be forward thinking, dynamic, and agile in response to new perspectives on activities, products, service, and business models embracing circular principles. As noted earlier, the Circular Economy is really a *business strategy* that transforms organizations from a linear economic model to a newer circular model.

Wholesale adoption is not required to move forward; rather, incremental thinking can serve as the basis for integration. The way EA approaches the Circular Economy is by not making the Circular Economy concept the goal, but rather a means to strengthen the systems/processes currently in-place. We, therefore, advise our clients to develop a strategy that explores how circularity can firstly strengthen its core processes and provide a transformation to new opportunities. Once this is accomplished, it is easier for circular principles to be advanced in new start initiatives. As we note herein, elements of circularity are all around us and have been used in various approaches since the 1990s.

So, the future does indeed look bright. A 2018 survey by ING encouragingly noted that interest in circularity is growing[14]. ING's research shows that while only 16 percent of United States businesses have adopted the circular economic framework, 62 percent say moving toward this is part of their business strategy. Challenges like resource availability, volatile commodity prices, and changing consumer preferences are forcing organizations to rethink wasteful and inefficient models of production and consumption.

Here is what we also know from ING's survey:

- Nearly twice as many U.S. companies say that they are embedding sustainability in strategic decision-making in 2019 compared to 2018.
- More companies are now designing products or services from the start for longer-term use, reuse, and recycling.
- Markets are increasingly disrupted as leasing and sharing business models challenge traditional "linear" models of product manufacture, ownership, and disposal.
- What's more, governments are recognizing the potential of the Circular Economy to drive business competitiveness, sustainable economic growth, and job creation. China, Japan, and the European Union are among those with circular policy strategies and programs.

Given the learnings from the COVID-19 pandemic, the circular economy may emerge as a preferred business and economic model to protect the economy and environment based on the exposed weaknesses/failures of the linear economy experienced through supply chain shortages, etc. GreenBiz Group, a leading media and events company that advances the opportunities at the intersection of business, technology, and sustainability noted the rising trajectory of circular economy trends that dominated 2020—namely reuse, new metrics to evaluate ESG claims, and plastic source reduction[15].

For businesses adopting circular models, benefits include greater efficiency and profitability, less waste and cost, better innovation, and stronger relationships with customers. Research suggests the economic opportunity for business is huge; therefore, a transition to a Circular Economy for any organization starts with a focus on the horizon, and the organization's business goals.

We will be monitoring the topic as it develops and look forward to sharing more feedback in the future. If you are interested in learning more about the Circular Economy and how it can impact your organization, please contact one of our experts below:

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