Making Visible Alternative Futures on Mine-Scarred Lands in Appalachia

Peter Butler, Angela Campbell, Jing Chu, Ayaka Hosogaki, Adam Riley

West Virginia University, Morgantown, West Virginia

ABSTRACT: The Southern Coalfields of West Virginia is a region undergoing extraordinary levels of change through the practice of mountaintop removal mining (Todd 2008). At the core of the disturbance is northern McDowell County in deep southern West Virginia, an economically and ecologically compromised area long dependent on extractive industries, and a venue of ongoing degradation. Mountaintop removal involves the excavation of a coal seam from the top down, rather than traditional tunnel mining. As 'developable' flat land, the remnant landscape is perceived to provide economic development opportunities for local communities. The 'site' (6000 acres) of this project is a reclaimed surface mine north of the town of Welch WV and on the border between Wyoming and McDowell Counties including the Indian Ridge Industrial Park (600 acres). This project proposes the positive reuse of the landscape through the installation of alternative energy infrastructure: biomass, wind and solar; and a phased plan for integration of mixed-use development.

In visualizing change within the project area researchers created a three-dimensional digital model of the site using ground-based static and aerial LiDAR (Light Detection and Ranging). The model provides a very recent (2012) portrait of the landscape and its components: bare-earth topography; drainage systems installed as a part of the reclamation mitigation; groundcover, shrub layer, sub-canopy and canopy vegetation; infrastructure, roads, and buildings. The lone resident buildings on the site are components of a Federal Correctional Institution (FCI-McDowell). Designing within the model allowed researchers to test a variety of planning scenarios and create visualizations that captured the phasing of the project, and expressed the aspirations of the community. Visualization phases included: 1.Biomass, Solar, Wind and Recreation; 2.Expressway Development and Interchange Zone; 3.Residential; 4.Commercial and Industrial; and 5.Stormwater Infrastructure, Green Infrastructure and Bioremediation. Local participation ensured that the project addressed local needs in becoming a model project for the region promoting sustainable development approaches to heavily impacted landscapes.

KEYWORDS: visualization, participation, LiDAR, renewable energy, mixed-use, mine-scarred lands

INTRODUCTION

SOCIAL/ENVIRONMENTAL/CULTURAL CONTEXT

McDowell County is deep in the steep mountains of southern West Virginia. Once the leading coal producer in the country (Myers 2008), during 'coal boom' times in the 1950s, the population of the county was near 100,000 with burgeoning towns and bustling rails feeding the Norfolk and Western Railroad's Ohio Branch and Norfolk Southern line. Post World War II the companies that were able to mechanize did so, and the others closed shop leaving thousands that had depended on coal without work. Today the population has fallen to below 20,000 and the once brimming towns are emptying. Statistics from the 2010 census are staggering. Only 39.9% of the population graduated from high school or equivalent (US Census 2011). Poverty is rampant with 59.9% of families with children under five living below the poverty line (US Census 2011). The county has the highest rate of child abuse and neglect in West Virginia; and high rates of welfare dollars; drug use; and teen pregnancy (State Journal 2012). The economy that long depended on coal has been 'deindustrialized' through consolidation and disinvestment, drawing jobs away from the area. The disinvestment did not include liquidation of land. Non-resident corporations now own over 80% of McDowell County, holding lands until the timber is ready for another harvest or the costs of extracting more coal balances with the benefits. So the people with an ingrained sense of commitment to corporate coal are left without work and without lands to develop. Residents have been said to suffer from "mountaineers' fatalism" (Myers 2008) or mental and cultural isolation- "mountain isolation" (Myers 2008). The region has been termed an "internal colony" (Myers 2008) which is reflected in a lack of home rule for many unincorporated communities. The wealth has been, and continues to be, extracted from the region with little to no benefit for the local economy.

The coal in McDowell County is some of the most valuable in the world. Under the surface and revealed in deep cut stream valleys, lies the Pocahontas No. 3 seam which covers nearly nine hundred square miles in Mercer, Wyoming, and McDowell counties in West Virginia, and neighboring Tazewell County, Virginia. Extracted first through 'backyard' pick and shovel mining to the now over-scaled machinery the coal is so valuable that removing the mountaintop overburden for a twelve-inch seam is economically viable in some cases. The low-volatile, low-sulfur, ''smokeless'' coal originated during the Lower and Middle Pennsylvanian Period and is older and better than most coal found elsewhere in the world. It was the US Navy's chosen fuel for powering steamboats (McGehee 2012). It is estimated that of the original three billion tons in the field, some 900 million remain. Cities that were created in relation to coal reserves include: Bluefield, Bramwell, Keystone, Northfork, Kimball, Welch, and Gary with many unincorporated coal company towns following river drainages and hollows. These towns attracted settlement from all over the region in the late 19^{th} and early 20^{th} century with 20% immigrants and 33% African American (McGehee 2012).

McDowell County is found within the Central Appalachian Ecoregion, stretching from central Pennsylvania to northern Tennessee. The geology includes a highly dissected landscape of ridges and valleys cut from an ancient seabed plateau. The bedrock is sandstone, shale, conglomerate, and coal. A mixed Mesophytic forest cover dominates with rugged oaks and hardwoods. The soils are thin and poor and limit agricultural development. Coal and timber have been the predominant industries since settlement (Omernik 2007). Straight pipe sewage systems, mining and forestry practices have compromised hundreds of miles of streams in the county with over 90% of the Tug River Watershed, within which this project is found, considered 'impaired' (EPA 1998). Primary pollutants are tied to mining: aluminium, iron, and manganese.

Without a new vision for this region, communities, landscapes, ecologies and economies are destined for further diminution. Imagining alternative futures has been underway since the time that Appalachia was rediscovered and brought to light during the Kennedy administration in the 1960s, creating the Kennedy Task Force. Efforts to integrate the region with the nation included many federal programs (Appalachian Regional Commission, Volunteers in Service to America, the War on Poverty, etc.) and projects that sought to 'fix' the people and the place. Recently, John Todd, in a report to the Lewis Foundation, 'A new shared economy for Appalachia: an economy built upon environmental restoration, carbon sequestration, renewable energy and ecological design' (Todd 2008) presented another strategy towards sustainable development. Todd's vision promotes technologies that "tap into the dynamics of the natural world to self-organize, self-design, self-repair and self-replicate" (Todd 2008, 7). He has proven the effectiveness of passive, nature-based systems approaches with his 'living machine' for sewage treatment at a smaller scale. Though at a larger scale, a landscape scale, the method calls for the ecological design and management of "biomass and forest ecosystems, agro-forests, and farms that integrate traditional and ecological values" (Todd 2008, 9) that is focused on soil building, or rebuilding in the case of the reclaimed surface mine where soil and stone are so compacted that promoting plant growth requires extensive inputs. The goal of carbon sequestration as an economic development strategy seeks to cultivate a sustainable market-based transformation. Encouraging and supporting, almost choreographing, succession is a core premise in Todd's healing process. This is accomplished through the introduction of both mineral and ecological elements towards building a natural resource base including forestry, biomass forestry, agro-forestry, and ecological agriculture (Todd 2008). These new products would thus create new industries and cooperative markets.

Peter Del Tredici, a biologist, asks planners and designers to consider two central models for the approach to reclaiming mined landscapes towards a productive second life. Del Tredici suggests reclamation and restoration. Reclamation allows that there is not a strong potential for returning the landscape to its previous pre-mining state, and that the "ecological clock cannot be turned back to a previous time" (Del Tredici 2008, 13). More realistic goals would be to minimize the negative impacts that the site may have on the surrounding environment and to maximize its aesthetic and ecological functionality. Functionality is the key component of this model and containing the impacts of the mining activity and subsequent redevelopment so as not to negatively impact downstream resources, or adjacent landscapes. Succession, encouraged by intervention, is the main process by which the land revitalization process may occur. Del Tredici proposes four steps to ecologically sound mine reclamation: 1. establish an appropriate substrate and soil that can support the growth of plants. 2. begin a re-vegetation strategy that makes an effort to enrich the degraded land with the organic matter of the local pre-existing plants, so that it jump starts the soil forming process, increases water capacity, and allows for the growth of Mycorrhizal fungi. 3. select plants that are native to the area and thus can best withstand the local climates and microclimates and those that produce shoots from their roots in a short period of time, or branching from the base of their trucks after being traumatized. 4. acknowledge and accept a long-term process of maintenance and care. This means that the design must coincide with local support and monetary constraints.

As the beginning point of this research/design project the various social, cultural and environmental contexts were central to the planning process. An understanding of the complex fragmented local ecology was established. A participatory process was designed to tap into local populations and engage them in visualizing change. The now well-documented (though still elusive in definition) culture of McDowell County played a role in forming the model for change. The driving force behind the research/design project is to provide some relief and generative momentum for the economic conditions at the local level and to provide a new model for reintegrating surface mined landscapes across the region.

1.1. Creating the three-dimensional digital model: Aerial LiDAR

In order to better communicate and perform the inventory/analysis, design, planning, and potential of a Sustainable Energy Park in McDowell County researchers constructed a digital three-dimensional model of the approximately 6000 acre site. LiDAR (Light Detection and Ranging) has become an established method for collecting very dense and accurate elevation values and subsequent modelling of large scale environments. This active remote sensing technique is analogous to RADAR but uses light pulses instead of radio waves to measure travel times. The location and elevation of the reflecting surface are derived from: 1.the time difference between the laser pulse being emitted and returned; 2.the angle that the pulse was 'fired' at; and 3.the location and height of the aircraft (i.e. sensor location). Unlike RADAR, LiDAR cannot penetrate clouds, rain, or dense haze and must be flown during fair weather.

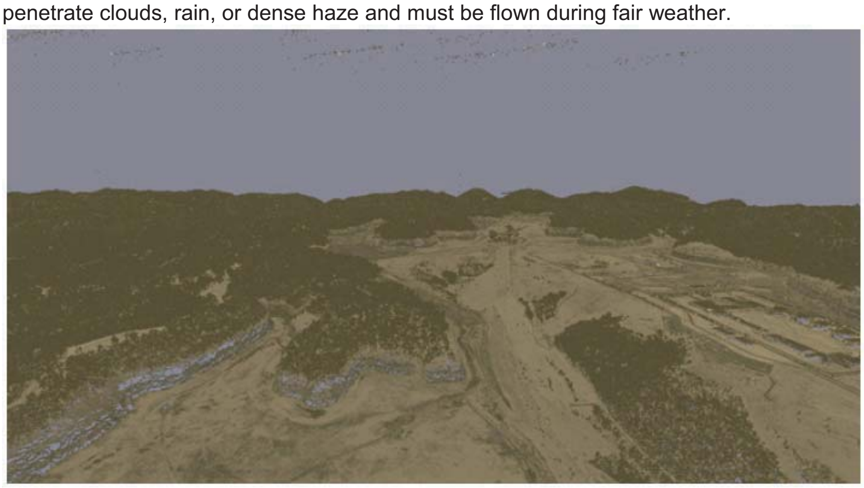

Figure 1: A bird's eye view of the Indian Ridge Industrial Park site in McDowell County, WV. This image was created in Pointools® and shows the raw pointcloud with a sepia tone elevation gradient. Source: (Butler 2012)

Collected pointclouds create an accurate depiction of overall landscape characteristics, topography, elevation, vegetation and site hydrology. The model then serves as a base for the rendering of design alternatives and for tracking change over time, and as an immersive environment for design visualization. The resulting pointcloud model (Figure 1) was exported to Pointools® software that allows planners and designers to work with very large data sets through linkages with design software (Google SketchUp®, AutoCAD®, 3D Studio Max®, Rhinoceros®, etc.).

The research team performed a review of the spatial requirements (physical, structural, infrastructural needs, etc.) in state of the art and practice alternative energy facilities. Investigations included the collection of case studies of completed projects throughout the United States. These projects provided detailed information in the physical needs for site suitability and feasibility of alternative energy facility development. Structural elements included the dimensions of specific facilities and forms. Facilities and structures were modeled three-dimensionally at scale so that they could be placed within the 3D digital model for visualization.

1.2. Pointools®, Rhinoceros®, and ESRI ArcMap®

The primary design software used to create visualizations was Rhinoceros®. Geographic Information Systems (GIS) data provided alignments for the Coalfields Expressway (north/south) and the King Coal Expressway (east/west) which are planned to intersect on the northern border of the project boundary. With the existing pointcloud researchers were able to model the future expressways planned for the area. Researchers also modeled the existing prison, FCI-McDowell, in the three-dimensional digital model.

A detailed inventory and analysis was performed using the LiDAR data. One example of the use of the model in performing site inventory and analysis is the creation of very detailed topographic data allowing researchers to create a map of site hydrology (Figure 2). Site hydrology information was then applied to the development of green infrastructure design focused on stormwater management. Vegetation for the approximately 6000 acres was also modeled showing areas of canopy, sub-canopy, shrub layer, grasses and bare earth. When combined the layers create an accurate depiction of overall landscape characteristics.

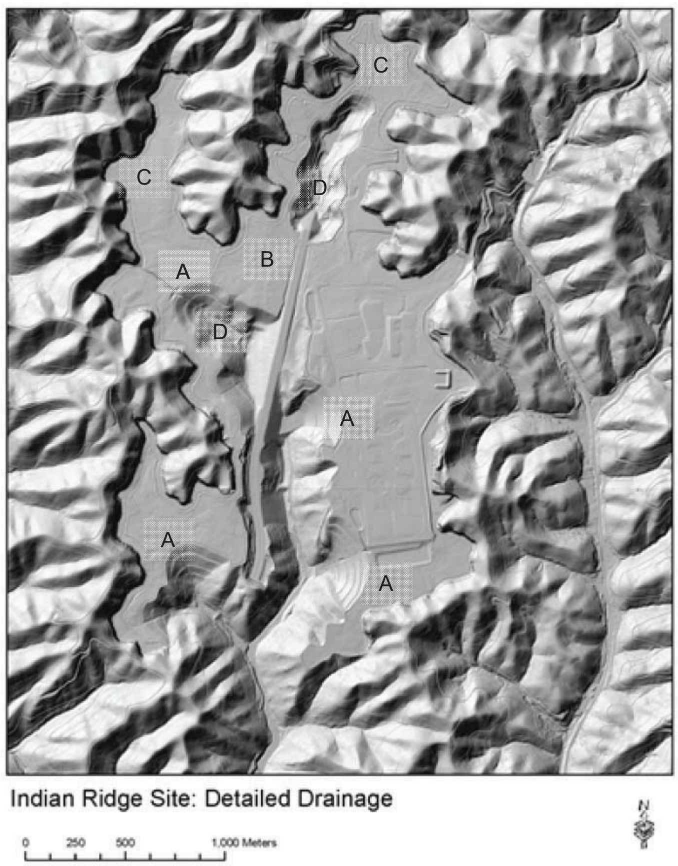

Figure 2: The LiDAR pointcloud was processed in ESRI ArcMap to create a hillshade image of the site revealing A. valley fills; B. new expressway alignments; C. existing post reclamation drainage features; D. large scale water retention areas. With the use of LiDAR and the creation of a hillshade image for site topography, a highly detailed inventory of drainage patterns is possible. The drainage plan post-surface mine reclamation includes swales that follow along the edges of highwalls. The swales bring stormwater runoff to two very large detention ponds. Also visible in the model is the planned and graded alignment for expressway development. Source: (Natural Resource Analysis Center, Jackie Strager & Aaron Maxwell 2012)

1.3. Visualization: Participation and Gaming

The LiDAR model was also used as a mode of communication and interaction in administering participatory design processes. In order to address questions and concerns of local youth an event was scheduled at the McDowell and Wyoming County 4-H camp with a self-selected student group. The digital model, now exported to and enhanced using Rhinoceros® software, became a gaming environment (Mayer 2005) for participation. The model was rendered in a 'cartoonish' style to appeal to the youth, and used to educate participants on the suitable siting of alternative energy infrastructure and as an environment for visualization and planning. Students were provided a 'kit of parts' including a wind turbine, perennial grasses, a solar array, an industrial building, suburban type housing, high density apartment style housing, high income detached housing, and single family detached low density housing. After an introduction to the siting suitability of the three alternative energy elements, the students were able to move elements around, multiply them, and create a vision of the sustainable energy park (Figure 3).

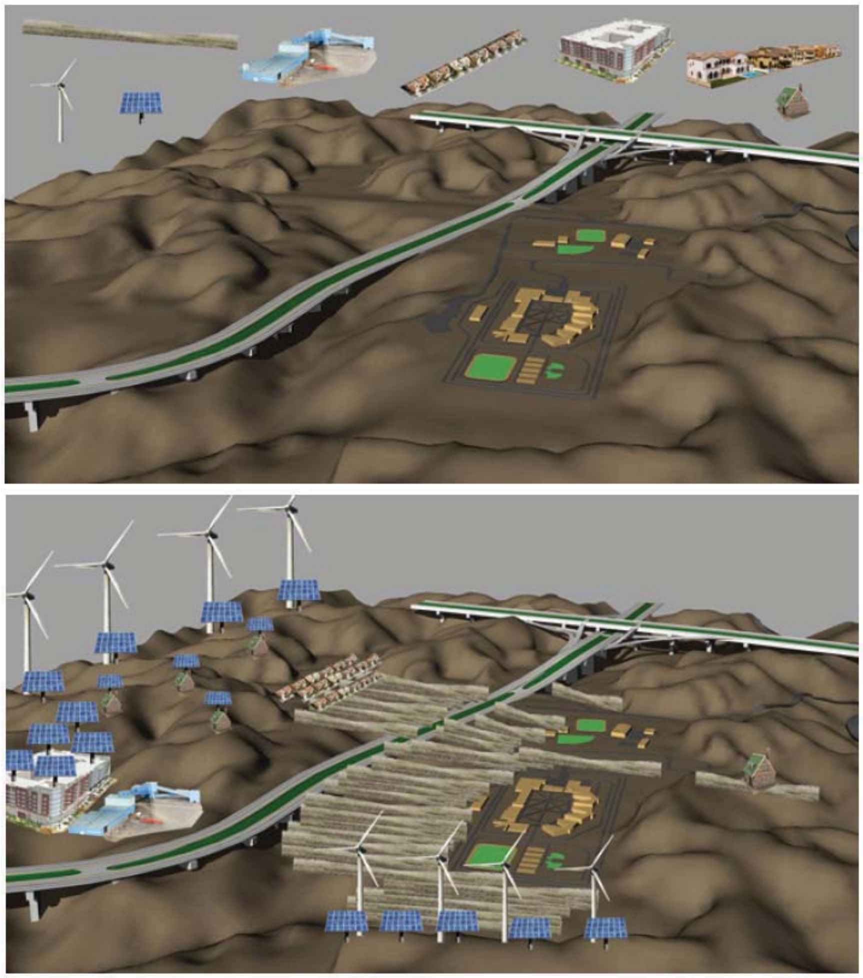

Figure 3: depicts a three-dimensional digital site model and the 'kit of parts' that students were able to use in designing the site. The prison, FCI-McDowell, property is also shown, as are the planned expressways. The second image shows one of the three mixed use and alternative energy development scenarios developed by students. Source: (Chu and Butler 2012)

2.0. SITE SCALE PLANNING

Developing a digital model of the new mixed use and alternative energy facilities was the next step. After integrating all of the previously described information and defining areas for specific land uses within the Indian Ridge Industrial Park through masterplanning a model was created. Guidance in identifying needed land uses was gained through local participation. Identified needs included: industrial, commercial, recreational and residential. Alternative energy suitability modeling allowed researchers to site these facilities in the most appropriate locations. The land use masterplan for the Indian Ridge Industrial Park attempted to satisfy the community needs for developable land and provide for spaces to integrate alternative energy generating facilities. The topography of the existing stormwater infrastructure created limitations in siting facilities. Other primary limiting factors were the planned expressway corridors which require a buffer. Leaving these areas open for future road construction by planting biomass/switchgrass in the corridor allowed for transitioning the area at a later date. Industrial uses were placed adjacent to the main highway interchange, while residential development was proposed in the south and east of the site. Locating residential development here provided for a sense of seclusion from the highway. Solar infrastructure was located close to FCI-McDowell so that the facility could take advantage of nearby energy production. This location, with its full southern exposure was identified as the most efficient in solar collection. Commercial development was included in an ‘Interchange’ zone, providing needed services that were identified as desirable by participants. Areas of biomass were located in marginal settings- areas lacking the spatial requirements of other land uses or in close proximity to areas of sensory disturbance, i.e. highways and industrial development. The integration of alternative energy elements (wind, solar, and biomass), on a smaller scale, was interwoven with necessary infrastructure and building prototype design. Green infrastructure design of stormwater systems was also interwoven within the overall pattern of the masterplan.

2.1. Planning and design visualization: energy systems

Phasing development of the Indian Ridge Industrial Site allowed for a marketing effort with designated areas of future development. The ‘Interchange Zone’ would not be a suitable land use until the expressways are constructed so using the land temporarily in producing biomass through perennial planting and soil building strategies creates a placeholder for change. Additionally, lands designated for residential/commercial development and industrial development can support biomass production through planting or encouraged succession while waiting for investment. Solar infrastructure would necessarily be permanent, however, so designating the area adjacent to FCI-McDowell as a future ‘new energy’ gateway element into the industrial park created a sense of character for the overall site and defined a powerful entry experience. Switchgrass, or other grasses, to be used for biomass production are very rugged species- drought-tolerant and fast growing. The soils on site are currently compacted and require specific additions to be productive. Necessary soil amendments for creating a positive growing medium were calculated for the site. Locations and character of alternative energy installations are seen in Figure 4.

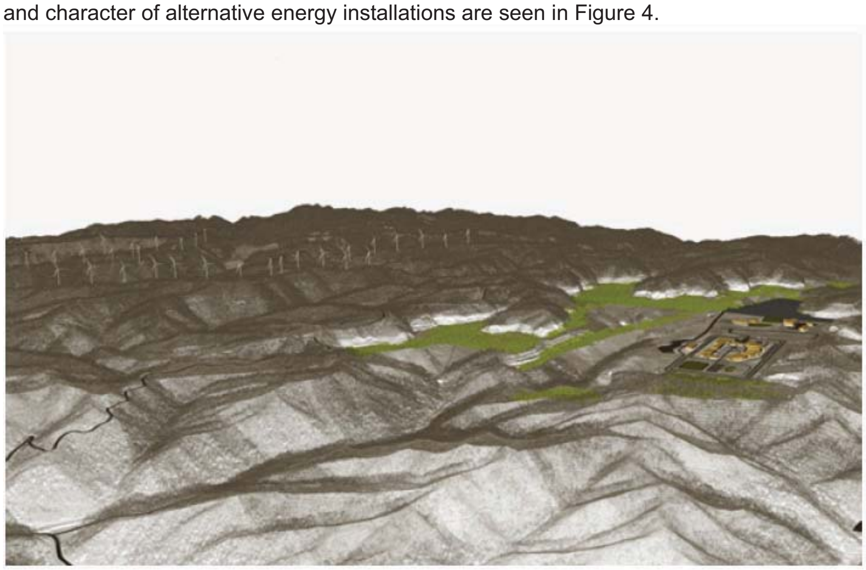

Figure 4: Three-dimensional digital site model with integrated wind, biomass and solar facilities (view from southeast). Source: (Chu and Butler 2012)

2.2. Mixed use development

Focus group participants guided the research team in identifying new land uses for the Indian Ridge Industrial Park site. The participants saw a need for a tourism visitor center on the site as a gateway into the region and the adjacent National Coal Heritage Trail (US 16). They also identified a need for housing. Many local employees commute long distances from other states to workplaces in the county, especially FCI-McDowell and local schools. Focus group participants envisioned different businesses and services that could be a part of the Indian Ridge site development that were lacking in the area. Throughout the visioning process, participants voiced their hope that this development could spur entrepreneurial spirit in the area. New expressway and utility development were seen as necessary elements in the development of the region creating better access into and out of the area. Roads and railroads would help to counter loss of population trends and enhance local school investment and quality, a perceived barrier to in-migration. Fulfilling all of these needs within the scope of this planning project was not possible though the appropriate location for siting of facilities, determining circulation patterns and connections, and integrating alternative energy and green infrastructure that would accommodate new development was completed. The overarching goals of healing the scarred landscape, making it productive and functional, and minimizing new development's impact on adjacent landscapes were central to the visualization of mixed use development.

2.3. Green infrastructure interventions in creating public space and connective tissue

The community's identity as formed during past mining operations, created a need in planning for alternative futures, to reflect on the scars of former surface mining operations; while recognizing the successional landscape within new development. All of the community groups that engaged in the planning process asked that the mining history be acknowledged, celebrated, and interpreted. The form of the design responds to the orderly frames of development, mining and mine land reclamation, interrupted by the chaos of biological patterns. These patterns are recognized through natural processes such as stormwater movement and forest development that organically weave through the site. Green infrastructure (Benedict 2002) and open space areas heal the landscape, filtering water and collecting sediments, and are linked through pedestrian greenways creating connections that seek to reconnect local peoples to the site (Figure 5). Core areas connect varying land uses and serve as spaces for reflection of historical landscape patterns. The valley fill ponds reflect both pre-mining vegetative forest cover and new orderly topographic tiers and linear streams resulting from mining operations. These areas are designed to be experienced from multiple elevations, further referencing succession. The reflective spaces can be intimately experienced at the base valley fill, explored through the valley fill climb, serve as a gateway at the development level or be viewed from the proposed freeway above. The visitor's comprehension of the landscape constraints associated with former landuse is a necessary component towards successional landscape healing. Community and ecology bond to create the energy to drive this process forward.

Figure 5: Illustration of stormwater infrastructure and public space design. Source: (Campbell 2012)

CONCLUSION

The vision of a renewed Appalachia through the creation of new economies related to alternative energy and ecological mine reclamation holds potential. At the Indian Ridge site, the reclamation process strives not to obscure the extractive industry, but rather apply the past setting as precedent for the ecological development of the future (Barnett 2008). Focusing the healing on stormwater management and soil-building adds value by building ecological function (Dickson 2003) into the landscape. The designed spaces provide a mutually supportive habitat; considering people, wildlife and plant communities. This holistic approach to place-making inspires people to experience nature while improving their ecological literacy (Lister 2009). Through the use of three-dimensional digital models and visualization, these values are communicated revealing links between nature, science and art.

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1. Brownfields Redevelopment Program, West Virginia Water Research Institute, National Research Center for Coal and Energy, West Virginia University. 2. Natural Resource Analysis Center, Davis College of Agriculture, Natural Resources and Design, West Virginia University. 3. Landscape Architecture Program, Davis College of Agriculture, Natural Resources and Design, West Virginia University. 4. Center for Business and Economic Research, Marshall University.

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