Ash Recycling: Partnering for Progress

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ABSTRACT

For several US communities municipal waste combustor (MWC) ash recycling has been a commercial reality for almost a decade with over 1 million tons processed and beneficially used to date. Yet, despite the successes to date a recent report by the Integrated Waste Services Association shows less than 5% of the 7.5 million tons of ash generated in the US is recycled and beneficially used [1]. The technological, scientific and myriad of commercial successes categorically demonstrate the feasibility of ash recycling. The next step is for communities, regulatory agencies, transportation departments, and customers to partner with businesses to recycle their ash stream in an economically and environmentally sound manner. An example of this “partnering for progress” is the focus of this paper. The ash recycling partnership described in this paper was presented the Pennsylvania Governor’s Award for Environmental Excellence in 1999. Proving that Partnering is a win-win situation for businesses, communities and the environment.

HISTORY

Ash recycling was first investigated in Europe and then in the US more than 25 years ago, with the initial investigations focusing on the physical characteristics of the ash. Universities and departments of transportation performed most of the initial studies with mixed results. The ash itself had great stability and compressive strength and looked promising for construction applications but without removing the metals and other unwanted debris the ash was considered unusable as a “product”. For a material to be sold as a construction product it must have uniform characteristics that meet required specifications otherwise it cannot be competitive in the market. As a result, real progress did not occur until a commercial process was developed that removed both the ferrous and non-ferrous metals and the unburned materials from the ash.

During the 25 years of investigation, environmental concerns were raised as to the potential for the ash to leach detrimental constituents into the environment. Thus started a serious evaluation of the chemical characteristics of MWC ash. A plethora of investigations have been conducted by world renowned experts in this particular field of study resulting in eleven international ash conferences and a multitude of other meetings and conferences that focused on ash generation and its proper handling. Studies were conducted by agencies ranging from the US Environmental Protection Agency, (USEPA), Department of Defense (DOD), Department of Energy, NYSERDA, Corp of Engineers, and a multitude of state agencies and universities. The University of New Hampshire and the State University of New York at Stony Brook have contributed greatly to the knowledge base collected to date. The findings of several of these studies are discussed in later sections.

Over the course of the 25 years of investigation commercial ash recycling became a reality with initial operations occurring in Europe, Asia and Bermuda. The Netherlands recycles and beneficially uses more than a million tons per year of the ash it generates. Sweden and Germany beneficially use a major portion if their ash and Bermuda recycles 100% of its MWC ash into monolithic blocks for shore abatement. The National Renewable Energy Laboratory has recently published two papers on ash recycling which can provide additional information on the present and historical perspective on ash recycling in Europe and the United States [2,3].

In 1990, Duos Engineering brought the European technology to the United States where it was enhanced to meet US requirements and initially used in Sumner County, Tennessee as a pilot project. Its success led American Ash Recycling Corp. (AAR) to utilize the Duos technology to develop the first commercial ash recycling facility in the United States. Since 1993 the AAR facility located in Nashville, Tennessee has continually operated processing more than 80,000 tons per year of ash that otherwise would have been placed in the local landfill.

A much larger facility was built in 1998 in York, Pennsylvania using AAR’s advanced design, enabling AAR of Pennsylvania (AARPA) to process up to 240,000 tons of ash per year. The enhancements to the AAR facilities over the years have shown that ash recycling is environmentally and economically viable. The Pennsylvania facility’s success was due in large part to the partnership developed between AAR and its community. The partnership was built on the sound foundation of AAR’s experience in commercial operations at the Nashville ash recycling facility, and was
on the sound foundation of AAR's experience in commercial operations at the Nashville ash recycling facility, and was enhanced with the commitment to innovative solutions to solid waste management championed by the York County Solid Waste Authority (YCSWA). The Commonwealth of Pennsylvania recognized the success of the partnership by awarding both AARP and YCSWA the 1999 Governor's Award for Environmental Excellence.

A brief overview of AAR's ash recycling process and operational history is presented below, followed by a discussion of the various components of the partnership that lay the foundation for others interested in innovative environmental action.

COMMERCIAL PROCESS

The process AAR utilizes to produce its uniform product is a continuous loop system that segregates the ash into its component parts, consisting of ferrous and non-ferrous metals, unburned combustibles and the final aggregate product, which is sold under the trademark name of AggRite.

Incoming MWC ash is staged in a designated area within the receiving building for drying. Once fed into the system the ferrous metals are removed by magnetic separation and an eddy-current separator is used to remove the non-ferrous metals which are further segregated into their individual components of aluminum, brass, copper, and coins.

Once the metals are removed, they are cleaned to remove any ash that may adhere to the pieces. The removed ash is returned for processing and the metals are placed in designated storage areas. The unburned combustibles such as paper, plastic, and wood are removed by a Windzifter® unit, which uses proprietary air separation technology. The unburned stream is then returned to the MWC for recombustion. Once all the metals and unburned materials are removed and the ash is properly sized and graded, it is then treated with the chemical immobilization system called WES-PHix®, as the final step in the production of AggRite.

Virtually 100% of the material currently diverted from landfills to AAR's facilities is being recycled making this process unique in the recycling industry by not generating any new waste. AAR's ability to recycle virtually 100% of the incoming MWC ash helps to meet the nation's goals of reduction and recycling.

Figure 1. Closing the Loop

The benefit of recycling 100% of the ash was experienced by the Metropolitan Government of Nashville and Davidson County when they were able to extend the life of the monofill into perpetuity as a result of AAR's MWC ash recycling activity instead of closing it in April of 1994 as originally planned. In addition, the City's cost of MWC ash management over the past 8 years that AAR's facility has operated was less than half of the expense that it would have incurred had the ash been disposed of in an off site location.

It should be noted that the Metropolitan Government of Nashville and Davidson County was the first administration in the United States that achieved virtually 100% of recycling through their municipal solid waste management program. York County is the second to achieve the status of 100% recycling. YCSWA realizes that by recycling their ash into a marketable aggregate product effectively closes the loop on recycling and saves approximately 13 acres of valuable land space 35 feet deep annually.
AAR’s Nashville facility is located on Metro’s (Metropolitan Government of Nashville) monofill. A fully enclosed 15,400 square foot building houses the process and ferrous and non-ferrous metal storage. An additional paved and covered area of approximately 4,050 square foot is used for material storage. The MWC ash is mined from the adjacent monofill cells and stored daily under cover for processing during the following day. Once produced, AggRite is staged adjacent to the processing building until it is sold for approved end uses. The MWC ash recycling process has been demonstrated by AAR to produce a high quality homogeneous aggregate product with physical properties suitable for a variety of construction applications.

AARPA’s York facility is AAR’s second full-scale MWC ash recycling facility and the largest in the United States. The facility cost $6.8 million to construct and is designed to process up to 1,000 tons per day, or more than 240,000 tons per year. The York facility is located on a quarry owned by York Building Products Inc. (YBP). Through an agreement with YBP, the AggRite is temporarily stored at the YBP’s quarry, or mixed with natural aggregate material and temporarily stored at the quarry until it is transported off-site for permitted reuse.

Since start-up in May of 1998, the AARPA facility has processed more than 431,000 tons of ash and produced over 356,000 tons of AggRite. In addition, the process has recovered more than 47,000 tons of ferrous and non-ferrous metals and more than $246,000 in coins have been returned to the U.S. Mint in Philadelphia.

Combined the AAR facilities have processed well over one million tons of ash that otherwise would have been disposed of in a landfill. In addition, the production of AggRite prevented the mining of a million tons of natural aggregate, a non-renewable natural resource, for construction applications.

**PRODUCT**

The aggregate is marketed under the trade name AggRite and is approved as structural fill material; base and subbase under roads and other paved surfaces; aggregate for asphalt manufacturing; substitute aggregate in concrete; pipe bedding and embankment. The statistics for ash recycling in Nashville and York combined are quite impressive. The MWC ash recycling process has been demonstrated by AAR to produce a high quality homogeneous aggregate product with physical properties suitable for the following uses:
Table 1. Combined AART & AARPA Processing Totals

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Ash Recycled</th>
<th>AggRite Produced</th>
<th>Ferrous Recovered</th>
<th>Non-Fe Recovered</th>
<th>Unburned</th>
<th>Moisture</th>
</tr>
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<tbody>
<tr>
<td>1993</td>
<td>18,446</td>
<td>15,410</td>
<td>1,943</td>
<td>130</td>
<td>833</td>
<td>130</td>
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<tr>
<td>1994</td>
<td>107,392</td>
<td>91,997</td>
<td>9,598</td>
<td>730</td>
<td>4,383</td>
<td>684</td>
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<tr>
<td>1995</td>
<td>87,720</td>
<td>74,830</td>
<td>6,034</td>
<td>458</td>
<td>5,534</td>
<td>864</td>
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<tr>
<td>1996</td>
<td>81,077</td>
<td>67,000</td>
<td>5,935</td>
<td>557</td>
<td>6,561</td>
<td>1,024</td>
</tr>
<tr>
<td>1997</td>
<td>79,888</td>
<td>68,201</td>
<td>5,527</td>
<td>488</td>
<td>4,907</td>
<td>765</td>
</tr>
<tr>
<td>1998*</td>
<td>106,691</td>
<td>91,138</td>
<td>7,874</td>
<td>433</td>
<td>5,460</td>
<td>4,548</td>
</tr>
<tr>
<td>1999</td>
<td>262,112</td>
<td>215,886</td>
<td>22,195</td>
<td>1,015</td>
<td>18,073</td>
<td>9,879</td>
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<td>2000</td>
<td>244,300</td>
<td>202,015</td>
<td>21,314</td>
<td>1,085</td>
<td>12,608</td>
<td>10,502</td>
</tr>
<tr>
<td>2001 YTD**</td>
<td>35,469</td>
<td>29,585</td>
<td>2,823</td>
<td>125</td>
<td>2,137</td>
<td>1,549</td>
</tr>
<tr>
<td>Total</td>
<td>1,023,095</td>
<td>856,062</td>
<td>83,243</td>
<td>5,021</td>
<td>60,495</td>
<td>29,945</td>
</tr>
</tbody>
</table>

* AARPA facility startup  
** January 2001

Figure 4. AggRite as Base Material

The high internal shear strength, free draining characteristics, exceptionally favorable compaction density, uniform and consistent gradation of AAR's processed ash aggregate make it an excellent structural fill material and as a subbase under roads and other paved surfaces.

Figure 5. AggRite in Road Construction Applications
ENVIRONMENTAL ISSUES

Since the beginning of operations AggRite samples have been taken every 200 tons. Over 6,150 single samples and more than 2,166 composite samples have been analyzed for a diverse array of chemical constituents.

AAR has developed an extensive database on the chemical and physical characteristics of its AggRite product. The data collected is over and beyond the analysis required by the permit and has been used to prepare a comprehensive human health and environmental risk assessment in accordance with USEPA guidelines. The risk assessment shows that both potential non-carcinogenic and carcinogenic risks are well within USEPA goals for all exposure situations evaluated in the assessment.

AAR performs daily, weekly and quarterly analyses to ensure environmental compliance with TNDEC’s and PADEP’s permit limits for the beneficial use of AggRite. AggRite test results have been well below permit limits 100% of the time with most of the analyses being several orders of magnitude lower than the established limits.

A comprehensive QA/QC program has been established and vigorously enforced since start up of both facilities. The QA/QC program is multi-dimensional and includes daily, weekly, quarterly and annual testing of AggRite both for physical and environmental characteristics. To ensure accuracy of the analysis data, AAR has split samples with other laboratories to determine reproducibility of the data. The results of this evaluation showed the accuracy and precision of the data.

To evaluate the safety of AggRite, the company enlisted prominent independent scientists such as Dr. Haia Roffman and Dr. Frank Roethel to perform several life cycle human health risk assessments (HRA). The HRA’s evaluated 47 different potential exposure scenarios. All studies conclude that the potential carcinogenic and non-carcinogenic risks in connection with the use and the application of AggRite are well below EPA and TNDEC regulatory limits. Multiple state regulatory agencies have independently reviewed the HRA’s and have concurred with the findings of AAR’s own team of experts and have concluded that AggRite does not pose a risk to human health and the environment.

In addition to the scientific research and data collected by AAR since the startup of operations in 1993, several large studies have been completed that support the beneficial use of recycled MWC ash. One such evaluation was a 1990 study, co-sponsored by EPA and CORRE, on combined fly and bottom ash streams and the leachates from companion monofills, show ranges of heavy metals in actual field leachate samples. The report shows that, although the leachates are not used for drinking purposes, the majority of the metals analyzed achieve the USEPA Primary and Secondary Drinking Water Standards [4]. Another study published in May 1994 by the Long Island Regional Planning Board for the New York State Energy Research and Development Authority (NYSERDA) focused on the potential for use of MWC ash [5]. The exhaustive studies of both the chemical and physical properties of ash collected from five waste-to-energy facilities included a diverse array of leaching tests, some of which simulated actual field leachate behavior of ash. In addition, in an attempt to identify potential environmental and health risks associated with ash recycling activities, a comprehensive environmental assessment was prepared. The 7-volume NYSEDA report concluded in summary that:

- There is no rational scientific basis for the widespread rejection of ash use as a viable ash management strategy.
- The physical and chemical characteristics of ash suggest that reuse would be an attractive alternative to disposal.
- Properly processed MWC ash is suitable for use in numerous construction-related activities.
- The beneficial use of ash provides the most cost-effective long-term solution for the management of MWC ash.

Many more studies have evaluated the beneficial use of recycled MWC ash for construction applications with the findings that MWC ash is safe to use in the environment and does not pose a risk to human and health and the environment.
PARTNERSHIP

Overview

The success of the AARPA ash recycling facility is an example of how well constructed partnerships between the public and private sectors can work together to benefit the community. Beyond the YCSWA and AARP partnership is a multi-level group of participants that includes York Building Products, Inc. (as the marketer of the AggRite), PADEP as the regulator, West Manchester and Manchester Townships as the host municipalities, PennDOT as a potential major end-user, MYRES as the RRC operator, and many other private industries such as construction entities and secondary metals markets.

The AARPA ash recycling facility began as a collaborative effort between YCSWA and American Ash Recycling Corp. (AAR). AAR's success in Tennessee with its wealth of positive research data on ash recycling when combined with YCSWA's innovative approach to solid waste management forged an alliance that brought this project from the conceptual stage to becoming the award winning solid waste management success story that it is today.

Both YCSWA and AARP played lead roles in communicating the benefits of ash recycling to others and identifying participating entities. YCSWA implemented an ash management study to determine the best method for managing the RRC's ash. After exhaustive research, YCSWA selected AAR's technology and communicated those benefits to the 72 municipalities it serves as well as to its facility operator, vendors and customers. AAR's response to YCSWA's RFP demonstrated that ash recycling could compete economically with traditional ash management methods showing that recycling is not only environmentally the right thing to do, but also the most cost effective method of ash management.

Part of AAR's contribution to the partnership was its belief in its technology and product as shown by AAR funding the entire project. The York facility was designed, built and is operated by AARP. YCSWA demonstrated their support by making a capacity reservation payment of $6.8 million dollars to AARPA for ten years of ash recycling capacity after the facility passed its acceptance test.

The decision to shift from a primary reliance on landfilling ash in York County has resulted in preservation of York County land; the utilization of state-of-the-art technology to provide environmentally safe and responsible management of ash; and reduced liability for their citizens, businesses and local governmental entities. In addition, the ability to recycle ash has ensured long-term stable disposal costs that support an overall integrated system. York County is committed to environmental stewardship, which includes conserving traditional energy resources by replacing them with the highly renewable fuel known as municipal solid waste and the resulting ash. Additionally, energy savings are realized by AARPA in reducing quarrying activity and in savings associated with recycling of ferrous and non-ferrous metals when compared to production of virgin metal.

York County Solid Waste Authority

Established in 1971 by the York County Board of Commissioners, YCSWA coordinates the environmentally responsible, efficient and economic management of all municipal solid waste generated in York County. YCSWA also manages residual wastes that are compatible with the AAR technology. YCSWA utilizes an integrated approach to the management of waste that emphasizes waste reduction, reuse, recycling and resource recovery. YCSWA is the owner of the York County Resource Recovery Center (RRC) in Manchester Township, Pennsylvania; and owns and operates the Yard Waste Compost Site, Recyclable Materials Drop-off Center, and the Education Center.

YCSWA's Municipal Waste Management Plan provides a 25-year blueprint for managing the County's municipal solid waste using an integrated system. This Plan includes the utilization of the RRC; emphasizes recycling, reuse, and waste reduction, and incorporates major participation from the private sector. YCSWA conducts countywide programs such as household hazardous waste collection, household battery collection, leaf composting, telephone book recycling, and Christmas tree recycling/mulching. YCSWA uses a waste-to-energy facility that produces and sells electrical power generated from the processing of municipal solid waste.

YCSWA's comprehensive approach can be attributed to the contributions of many starting with its nine-member volunteer board. This board is appointed by the Board of York County Commissioners and sets the organization's policies and goals. Members are appointed to five-year terms and serve on at least one committee. YCSWA committees include the Operating Committee, the Recycling and Planning Committee, the Administrative Committee, and the Community Services Committee. YCSWA also has a Licensing Committee that meets as needed to address
licensing compliance issues. YCSWA is comprised of four divisions: Administrative, Engineering and Operations, Recycling and Planning, and Community Services. YCSWA staff consists of 20 full time and 2 part-time positions.

**American Ash Recycling Corp. of PA (AARPA)**

AARPA is a wholly owned subsidiary of the privately held American Ash Recycling Corporation (AAR), which is headquartered in Jacksonville, Florida. AARPA provides ash recycling services to York County and other municipal entities utilizing AAR's patented process developed by Duos Engineering (USA). AARPA sought and received a statewide Beneficial Use Determination permit, which will allow for additional AAR recycling facilities to be constructed in other Pennsylvania communities.

As highlighted earlier, the York facility has the capacity to process up to 240,000 tons of ash per year and thus far has processed, and thereby diverted, a total of 431,000 tons of ash from disposal in a local landfill. Production-wise, the plant has generated more than 356,000 tons of AggRite for use in roadway and construction applications. The process has recovered greater than 47,000 tons of ferrous and non-ferrous metals (a 1,516 ton per month average), or an 86 percent increase over metals recovered with resource recovery alone. Finally, more than $246,000 in coins have been recovered and returned to the U.S. Mint.

AARPA created approximately 35 new jobs in York County with a total annual AARPA payroll and benefits in excess of $1 million. In addition, over $1 million is spent locally for other services, supplies and parts annually; more than $1.3 million worth of ferrous and non-ferrous metals are recycled per year; more than 150,000 cubic yards of land space with an approximate market value of $6 million per year are saved by recycling ash versus disposing it in a landfill; approximately $100,000 of local and state taxes are generated annually; and approximately $6.3 million in total gross revenues are generated annually.

**Community Benefits**

The AAR process preserves valuable land space by using MWC ash as a beneficial aggregate and alleviates the need for future construction of an ash monofil. The process also preserves the life of existing quarries by providing a uniform material that complements the use of natural aggregate. Over 140,000 tons of natural lime rock is preserved annually in the York Building Products’ quarry. Over 20 years (potential long-term option of existing agreement between AARPA and YCSWA) the life of the quarry will be extended by two additional years. The process enables 100 percent recycling of MWC ash and recovers all ferrous and non-ferrous metals from the ash.

The high quality AggRite is less costly than natural aggregate thereby providing significant cost savings to the community when used for local construction projects.

Community, employee and environmental health and safety are a top priority of the partnership. The WTE facility, already a leader in industry safety, began in 1998 to lay the groundwork for initiating a Voluntary Protection Program (VPP). This program institutes safety standards that exceed stringent OSHA requirements and will position the RRC to attain “STAR” recognition within the WTE industry distinguishing it as a workplace with exceptionally high safety standards. This high quality standard was matched by AAR’s commitment to employee health and safety. AARPA’s plant design meets or exceeds all OSHA requirements and stringent Health and Safety Work Rules are implemented and strictly enforced. AAR has an elaborate health and safety program in place, which includes personal air monitoring to ensure exposure to particulates or other contaminants, are well below OSHA requirements; hearing tests are conducted annually to ensure personal protection equipment is performing as required; and weekly safety meetings are held and safety audits are conducted.

Other benefits of the collaboration of YCSWA, AAR, WTE facility, employees and community include economic as well as environmental enhancements. YCSWA was able to take a complete municipal solid waste system to the rating agencies and potential bondholders when it completed its most recent financing in November 1997. The system assures long-term disposal capacity with stable cost. Communities with landfill disposal systems rarely see capacity commitments for 25 years with fixed cost. Due to the long-term contracts of the system YCSWA was afforded the opportunity to enter the financing market at a very favorable time resulting in an interest rate on bonds at 5.0%. The system and the proactive management approach was looked upon favorably by the rating agencies resulting in an A2 rating from Standard & Poor's and an AA-rating from Moody's Investor Service.

Another economic benefit is these two entities combined employ 73 people with total payroll and benefits in excess of $4 million. YCSWA benefits from long term fixed ash management costs as opposed to risk of market fluctuation for disposal. The partnership agreement also entitles YCSWA to a host fee for ash processed at the York
with the same cooperative spirit as demonstrated by the AARPA and YCSWA partnership. This partnership offers a framework for others to follow that are mutually beneficial to the community, business and most importantly, the environment.

YCSWA, York Building Products and AARPA have combined efforts to further promote the use of AggRite in the community by establishing the YCSWA AggRite Program. The Program makes available 50,000 tons of AggRite to any local municipal entity for their reuse projects. Examples include usage by a Township for its road building projects, use as backfill for pipe bedding, a school district is utilizing the AggRite in the construction of a Middle and High School (mainly as parking lot subbase) and for use as the base in the parking lot of a new Township building. This program has saved the communities over $200,000 in construction costs by replacing the need to purchase the higher priced natural aggregate. The communities can then fund other much-needed projects with the savings.

Both YCSWA and AARPA practice what they preach by participating in their own programs. For example, YCSWA used the AggRite as an aggregate replacement to pave their own facility roadways and AARPA used 100 percent AggRite as structural fill for the footers and slab foundation when building an addition to its facility.

Education

Combined YCSWA and AARPA have made extensive efforts to promote the project within the business arena. For example, representatives from AARPA, YCSWA and York Building Products gave a presentation to the Public Works Directors Association to describe how municipalities could use the AggRite in municipal construction projects. Outreach efforts and tours have been provided to members of the state chapter of the Solid Waste Association of North America; public agencies representing regional facilities involved in waste-to-energy; and private ash users and metals recyclers. Representatives from the SWANA National Waste-to-Energy Committee and the Waste-to-Energy Committee of the U.S. Conference of Mayors’ Municipal Waste Management Association have also been included in outreach efforts.

YCSWA describes ash recycling in numerous community and municipal newsletters and has added ash recycling to programming at its Education Center. The project has been showcased via exhibit displays at YCSWA’s community Open House event and at the York Fair. In addition, the waste-to-energy/ash recycling story is told at YCSWA’s Education Center via an overhead projector presentation provided to all visitors upon arrival. More than 5,000 people visit the Education Center annually.

YCSWA’s outreach efforts and public education programs focus on teaching residents that environmentally responsible management of garbage is everyone’s responsibility because “we all make waste”. The ash-recycling project enables York County to improve on an already outstanding recycling and waste reduction track record.

AARPA developed an interactive learning station featuring the ash-recycling project that was installed at the Education Center in the fall of 1999. In addition, the waste-to-energy/ash recycling story is also provided to schools and civic groups through YCSWA’s outreach speaker program. Both YCSWA and AARPA support local community environmental education programs such as the York County Science Fair and the York County Envirothon Competition.

CONCLUSION

The AARPA recycling project puts York County in the forefront of environmentally responsible management of municipal solid waste by enabling it to recycle 100 percent of the waste stream processed at the York County Resource Recovery Center. The American Ash Recycling facility in York is the largest and most technologically advanced commercial ash recycling facility in the United States and the first in the Commonwealth of Pennsylvania.

The merits of this joint partnership project benefit the citizens of York County by closing the loop on recycling and taking the logical next step to improve upon an already strong commitment to providing environmentally safe, efficient and economic management of municipal solid waste.

In order for recycling to become a viable alternative to disposal, businesses and communities must band together with the same cooperative spirit as demonstrated by the AARPA and YCSWA partnership. This partnership offers a framework for others to follow that are mutually beneficial to the community, business and most importantly, the environment.
REFERENCES


