Air to Water Technologies
Zero Mass Water – SOURCE Hydro-Panels

Technical Review

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BACKGROUND

Water is one of the most precious natural resources that is vital to life. However, dwindling fresh water supplies have and will continue to have grave impacts worldwide. In the United States (U.S.), socially disadvantaged and historically underserved communities are among the most affected by limited water supplies.

Of the 547 Federally Recognized Tribes in the U.S., 22 are located within the State of Arizona (**Figure 1**). These are predominantly rural communities which consistently suffer from limited access to clean and safe drinking water. In Navajo Nation (NN), 30-50% of residents are estimated to not have access to running water within their homes. Amidst the COVID-19 pandemic, this situation has become more staggering. In April 2020, Arizona State Senator Jamescita Peshlakai stated that limited access to running water within Navajo homes could be as high as 40-50% (Krol, 2020). This is a challenge for the residents as hand washing is vital in deterring the spread of COVID-19. Navajo Nation has been a region with the highest per capita rate of COVID-19, surpassing New Jersey and New York in mid-2020 (Kim, 2020). Limited access to running water has undoubtedly contributed to the fast spread of COVID-19 across Navajo Nation.

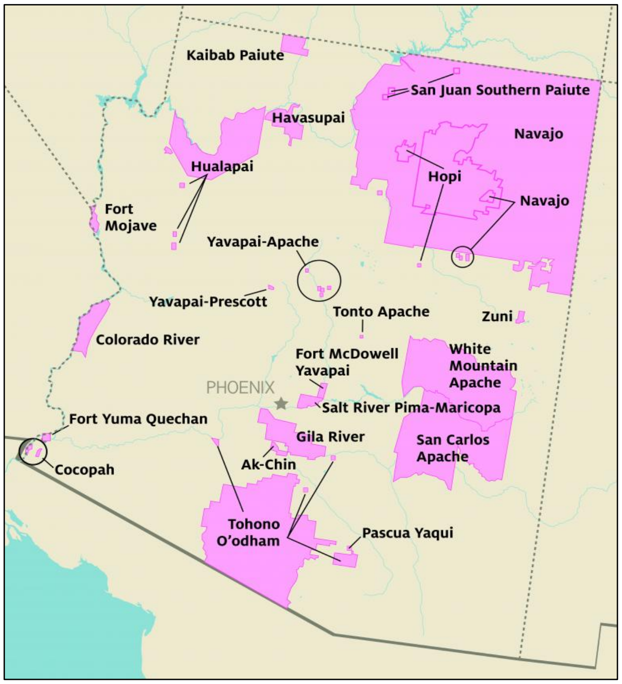

Figure 1: Federally Recognized Tribes in Arizona
(Source: https://statemuseum.arizona.edu/programs/american-indian-relations/tribes-arizona)

Residents living in dwellings without access to running water haul water over long distances, a common practice in remote communities. The residents heavily rely on individual and/or community owned groundwater wells for their respective water supplies. This can be worrisome in some regions as groundwater can be contaminated by natural and anthropogenic activities. In Arizona, common groundwater contaminants include arsenic, fluoride, radioactive elements (i.e. uranium, etc.), and nitrate (Uhlman, Rock, & Artiola, 2009). The World Health Organization (WHO) estimates that nearly 2 billion people do not have access to safe drinking water sources. Globally, it is estimated that contaminated water sources are responsible for 485,000 deaths caused by diseases like diarrhea, cholera, dysentery, typhoid, and polio, annually (WHO, 2019).

From 1944 to 1986, nearly four million tons of uranium ore were extracted from Navajo Nation under a lease agreement. Those activities left behind over 500 abandoned uranium mines, four inactive uranium milling sites, and one former dump site (**Figure 2**) (US EPA, 2008). Many groundwater sources have been contaminated by elevated levels of radiation, which is directly associated to serious environmental and public health concerns.

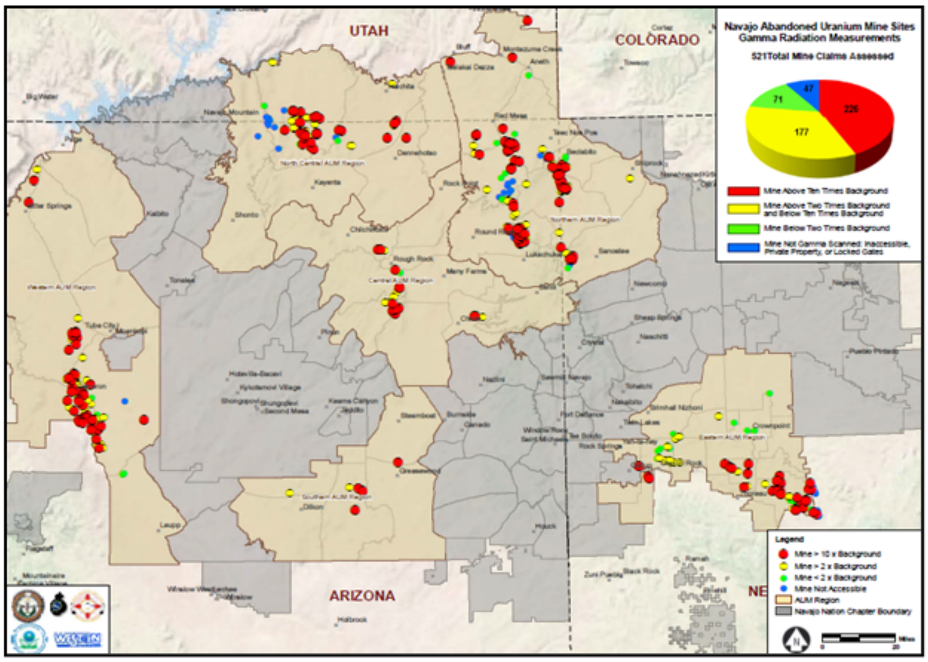

Figure 2: Abandoned Uranium Mine Sites and Summary of Gamma Radiation Measurements in Navajo Nation

(Source: U.S. EPA: https://archive.epa.gov/region9/superfund/web/html/index-14.html)

Groundwater samples taken from a community well in the Shungopovi Village of Hopi Tribe were tested in October of 2019 by the project team. Results showed arsenic concentrations exceeding the Maximum Contaminant Level (MCL) of 0.01 mg/L[2] set by U.S. EPA. This is a reality facing various rural Native American communities in Arizona. Continued exposures to harmful contaminants in drinking water sources are of significant concern, as many contaminants can have synergistic health effects in animals and humans alike (Melkonian *et al.*, 2011).

Although the need for safe and clean drinking water in Native American communities is paramount, conventional ways of providing water access are not ideal as they can be costly, prohibited, and generally, not feasible in many cases. Centralized water treatment and delivery are the most common ways to provide drinking water to homes and commercial/industrial buildings. Development of centralized water delivery systems in remote areas, such as Navajo Nation would be extremely costly, due to low population density (average at 5.7 household/ square mile). Several pipeline projects have been considered in NN; for example, a pipeline between the communities of Leupp and Dilkon alone was estimated to cost over $110 million across a 40-mile stretch. Leupp and Dilkon have populations of 951 and 1,184, respectively. Centralized water treatment and delivery also present challenges in the terms of land requirements and environmental disturbances. Due to the economic and bureaucratic challenges, centralized water treatment and delivery is likely not a viable solution in remote communities. Thus, alternative methods of providing clean and safe drinking water in remote communities must be considered.

Painted Desert Development Projects, Inc. (PDDP)/The STAR School

Founded in 1992, Painted Desert Development Projects, Inc. (PDDP), also known as the STAR School, a non-profit organization under Internal Revenue Code 501(c)(3), is located at 145 Leupp Rd, Flagstaff, in Coconino County, next to the southwestern boarder of the NN. The STAR School currently has over 130 Native American students enrolled for class. In addition to providing educational opportunities for Native American students and their families, PDDP/the STAR School also works on many other community-building programs.

Apex Applied Technologies, Inc. (AATech)

AATech is an Arizona based engineering consulting firm with extensive experience in water/wastewater planning, engineering, and treatment, program development and management, technical grant writing, and construction management. AATech specializes in providing direct technical assistance and training to socially disadvantaged and historically underserved and underrepresented communities in Arizona. Predominantly, AATech works with Native American farmers, ranchers, and non-profit organizations. AATech has initiated and managed well over 50 federally funded programs, some examples include USDA's Technical Assistance and Training Grant, Rural Business Development Grant, Value-Added Producer Grant, and many others. Since 2010, AATech has continued to provide direct technical assistance in low-income rural communities while managing to increase the participation of historically underserved populations in USDA grant/loan programs in Arizona.

Water Technical Assistance and Training Program (Water TAT Program)

PDDP/STAR School has partnered with Apex Applied Technologies, Inc. (AATech) for the Water TAT Program, working to identify and provide viable solutions to solve water and wastewater challenges in Navajo and Hopi tribes. The Water TAT Program is sponsored by USDA Rural Development (RD). In 2019, the program also received a small grant from Agnes Nelms Haury Foundation to evaluate existing "Air to Water" Technologies.

“AIR TO WATER” TECHNOLOGY OVERVIEW

An atmospheric water generator (AWG) (so called “air to water” generator), is a device that extracts water from humid ambient air. It is estimated that the Earth’s atmosphere contains 37.5 million billion gallons of water in its vapor form (*How Much Water in the Atmosphere*, 2018). An AWG is designed to produce potable water from condensation - cooling the air below its dew point, exposing the air to desiccants, or pressurizing the air (*Atmospheric Water Generation Research*, 2019). AWGs are especially useful where pure drinking water is difficult or impossible to obtain, because there is almost always a small amount of water in the air that can be extracted. Cooling condensation is one of the most common techniques in use for AWGs.

In a cooling condensation type AWG (**Figure 3**), a compressor circulates refrigerant through a condenser and then an evaporator coil which cools the air surrounding it. This lowers the air temperature to its dew point, causing water to condense. A controlled-speed fan pushes filtered air over the coil. The condensed water is then passed into a holding tank with purification and filtration system to help keep the water pure and reduce the risk posed by viruses and bacteria which may be collected from the ambient air on the evaporator coil (Latest Willie Nelson venture: Water from Air. Atlanta Journal Constitution).

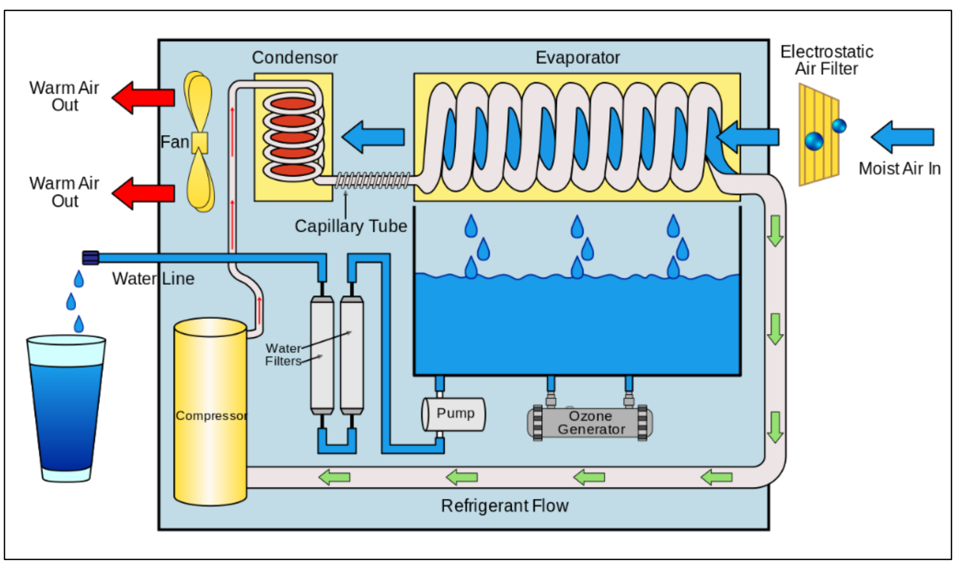

Figure 3: Schematic Diagram of a Cooling Condensation AWG
(Source:https://en.wikipedia.org/wiki/Atmospheric_water_generator#/media/File:Atmospheric_Water_Generator_diagram.svg)

AWGs become more effective as relative humidity and air temperature increase. As a rule of thumb, cooling condensation AWGs do not work efficiently when the temperature falls below

18.3°C (65°F) or the relative humidity drops below 30%. This means they are relatively inefficient when located inside air-conditioned offices, for example. The cost-effectiveness of an AWG depends on the capacity of the machine, local humidity and temperature conditions and the cost to power the unit.

Recent efforts have been made to utilize the Peltier effect of semi-conducting materials in which one side of the semi-conducting material heats while the other side cools (*Peltier Effect*, 2020). **Figure 4** is a diagram showing how this thermoelectric effect works. As electricity passes though the thermocouple, heat is transferred from one side of the system to the other, allowing cooling at one side. In this application, air is forced over the cooling fans on the side that cools which lowers the temperature of the air to its dew point, causing water to condense, the resulting water is then collected.

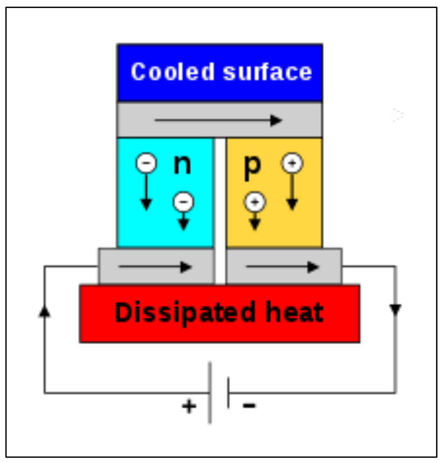

Figure 4: Peltier Effect Cooling

(Source: https://en.wikipedia.org/wiki/Thermoelectric_effect#Peltier_effect)

There are creative ways to enhance the drinking water productivity. For example, the drinking water generation rate can be enhanced in low humidity ambient air conditions by using the evaporative cooler with a brackish water supply to increase the air humidity near to dew point condition.

COMMERCIALLY AVAILABLE AWG SYSTEMS

A few AWG systems have been developed and made commercially available for use in areas where clean and safe drinking water is not accessible. To our knowledge, Akvo®, Zero Mass Water, and Rainmaker Worldwide, are three of the main manufacturers for AWGs. Each company and their respective AWG systems are described below.

1. Akvo®

Based overseas, Akvo® is a clean tech company and a leader in the design and manufacture of a large range of AWGs to provide a solution to global water needs. Akvo® AWGs were developed using optimized dehumidification techniques to extract and condense moisture in air to produce pure water. Water production in a Akvo® AWG system is made possible by simulating the dew point and replicating condensation processes.

An ideal operating environment for Akvo® AWGs is anywhere with temperatures ranging between 25°C to 32°C (77°F – 90°F) with a relative humidity of 70% to 75%. Akvo® AWGs can also operate between 18°C to 45°C (64°F – 113°F) with a relative humidity of 35% to 40%. When the humidity is low, air to water systems face challenges. Akvo machines are not designed for dry or cold climates.

Figure 5 shows the steps of water production in Akvo® AWGs while **Table 1** shows total volume of water produced using various Akvo® AWGs models at both low and high ends of idealized environmental conditions.

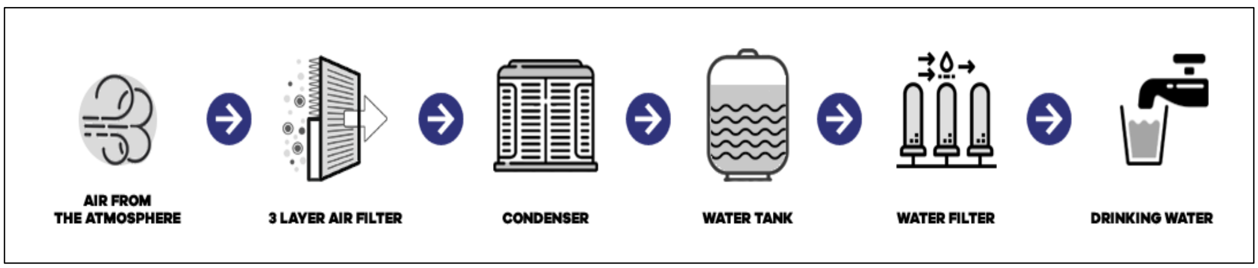

Figure 5: Steps of Water Production in Akvo® AWGs

(Source: https://akvosphere.com/air-to-water-technology/)

Figure 6: Various Models of Akvo AWGs

(Source: https://akvosphere.com/akvo-atmospheric-water-generators/)

Figure 6 shows various models of the Akvo® AWGs. With proper maintenance Akvo® AWGs should last 10 – 15 years since there are few moving parts. The lifespan of the machines will depend primarily on the maintenance of the compressor. Akvo® AWGs have a 1-year limited manufacturer warranty.

Table 1: Akvo® AWGs Models Water Production at Low/High Ends of Favorable Operating Conditions

(Source: https://akvosphere.com/water-calculator/)

Models	**Water Production**		**Production (Liters/Year)**
	Temperature (°C)	Relative Humidity (%)	
Akvo 36K	25	70	24,324
	32	75	38,226
Akvo 55K	25	70	36,486
	32	75	57,338
Akvo 110K	25	70	60,810
	32	75	95,564
Akvo 180K	25	70	121,620
	32	75	191,128
Akvo 365K	25	70	243,240
	32	75	382,256

The Akvo® 365K Machine (producing approx. 1000 LPD) runs on approximately 7 - 10 kilowatts per hour. Systems operate on 50hz or 60hz at either 208 – 240V (single phase) or

380 – 440V (3-phase). This power can be supplied directly or from a generator for portability.

2. Zero Mass Water

Zero Mass Water is an Arizona-based company focuses on providing communities across the world with access to clean and safe drinking water. Zero Mass Water has developed the SOURCE Hydro-Panel system, an independent and waste free air to water system. SOURCE is powered by an integral combination of solar photovoltaics and high-efficiency solar thermal energy. The electrical and thermal power are used to efficiently produce high-purity water in a modified psychrometric cycle, resulting in the formation of liquid water. Collected water is mineralized using a polishing cartridge for optimal taste and health. **Figure 7** shows the SOURCE Hydro-Panel system and the steps to produce clean drinking water. The steps are:

1. Ambient air is drawn into the SOURCE system where water vapor adsorbs onto advanced hygroscopic materials
2. Solar thermal power desorbs water from the hygroscopic materials into amplified water vapor cycling within the Hydro-Panel resulting in liquid water formation, flowing into the reservoir
3. The collected pure water is mineralized for optimal health and taste, and the reservoir is actively managed for cleanliness
4. Water pumps from the onboard reservoir through a polishing cartridge and to a dispenser
5. Each Hydro-Panel connects to a cloud-based network and is monitored for performance and quality

Relative humidity levels optimal for the SOURCE Hydro-Panels span a wide range. In **Figure 8**, a comparison between relative humidity and solar energy show estimated water production rates which can be expected from this system.

Higher humidity and solar radiation will result in more water production. Lastly, **Table 2** shows the effectiveness of the SOURCE system at producing clean and safe drinking water.

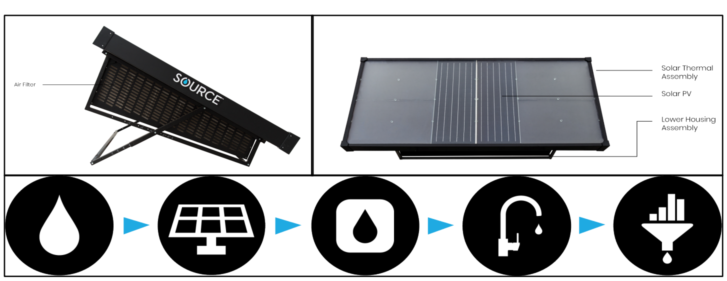

Figure 7: Zero Mass Water SOURCE Hydro-Panel and the Steps to Produce Clean Drinking Water

(Source: https://www.source.co/wp-content/uploads/2020/07/Technical_1-Pager_2018.pdf)

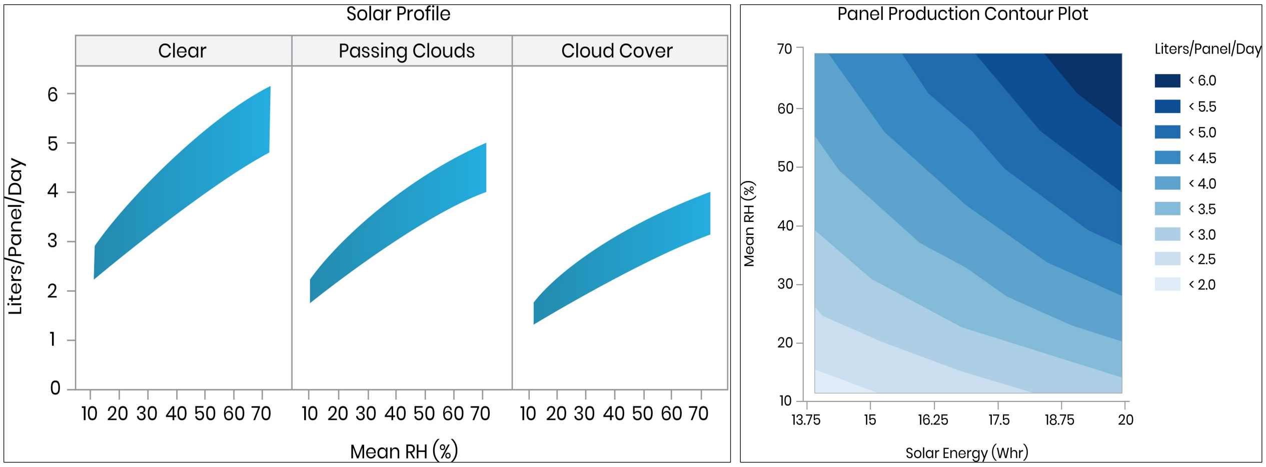

Figure 8: SOUCE Hydro-Panel Production Rates

(Source: https://www.source.co/wp-content/uploads/2020/07/Technical_1-Pager_2018.pdf)

Table 2: Water Quality Parameters Achievable by SOURCE Hydro-Panel System

(Source: https://www.source.co/wp-content/uploads/2020/07/Technical_1-Pager_2018.pdf)

	Parameter	US EPA Limit	SOURCE Standard of Excellence	SOURCE Test Result
Microbial Parameters	Escherichia coli - MPN/100mL	0	0	Not Detected
	Coliform, Total - MPN/100mL	0	0	Not Detected
	2 Others	-	-	Not Detected
Inorganic/Chemical Parameters	Alkalinity	Not Established	10-250	10-94
	Bicarbonate Alkalinity	Not Established	10-250	10-94
	Calcium	Not Established	0-30	2.4-23
	Total Dissolved Solids	500**	20-250	20-240
	Hardness as Calcium carbonate	Not Established	< 200	6.0-100
	Magnesium	Not Established	0-30	Not Detected-11*
	Silica	Not Established	Not Established	Not Detected-2.0*
	Turbidity - NTU	1.0**	0-2.5	0.29-1.7
	Nitrate as N	10	10 (Nitrate-N)	0.16-7.2
	Silver	0.1**	0.01	Not Detected-0.086*
	Barium	2	0.7	0.0027 - 0.017
	Nickel	Not Established	0.02	Not Detected-0.0060*
	pH - SU	6.5-8.5	6.5-9.0	>7
	Sodium	None	150	Not Detected-5.2*
	Copper	1.0**	1.0	Not Detected-0.0027*
	Uranium	0.03	0.017	Not Detected-0.0016*
	Aluminum	0.05-0.2**	0.2	Not Detected-0.11*
	Zinc	5.0**	3	Not Detected-0.017*
	Nitrite as N	1	1 (Nitrite-N)	Not Detected-0.63*
	31 Others	-	-	Not Detected
Volatile/Semi-Volatile Parameters	Benzene	0.005	0.001	Not Detected
	Toluene	1	0.7	Not Detected
	138 Others	-	-	Not Detected
Radiochemical Parameters	Gross Alpha	15	13.5	Not Detected
	Radium 226 - pCi/L	5	5	Not Detected
	Radium 228 - pCi/L	5	2.7	Not Detected
	Gross Beta	4	4	Not Detected
Miscellaneous Parameters	Asbestos - MFL	7	7	Not Detected
	1613B - Dioxin	3x10-8	3x10-8	Not Detected
	8 Others	-	-	Not Detected

* Range represents min and max test result of ZMW's routine water monitoring and testing
** Secondary standard - non-mandatory water quality standards set by the US EPA

Zero Mass Water offers three levels of warranty:

- Standard Warranty – 1 year
- Extended Warranty – 5 years
- Hydro-Panel Lifetime – 15 years

3. Rainmaker Worldwide

Rainmaker Worldwide is a Canadian based company that offers air-to-water, as well as water-to-water (contaminant removal), technologies for underserved communities worldwide. Rainmaker's technologies can be powered by wind, solar, or a combination of the two. This air-to-water technology forces air through a heat exchanger where it is cooled by introducing ammonia, delivered by a compressor, into the system. Through condensation, liquid water is produced and stored in a water storage compartment. Within the system, a fan optimizes air flow in areas where humidity is low. For optimal production rates, Rainmaker advises a minimum temperature of 52°F (15°C). In areas where wind-power is optimal, a wind speed of 6.7-40 miles per hour is recommended. Rainmaker air-to-water technology is available in three sizes, producing 5,000, 10,000, and 20,000 liters of drinking water per day.

Figure 9 shows Rainmaker's recommended technology for water production based on geographic region.

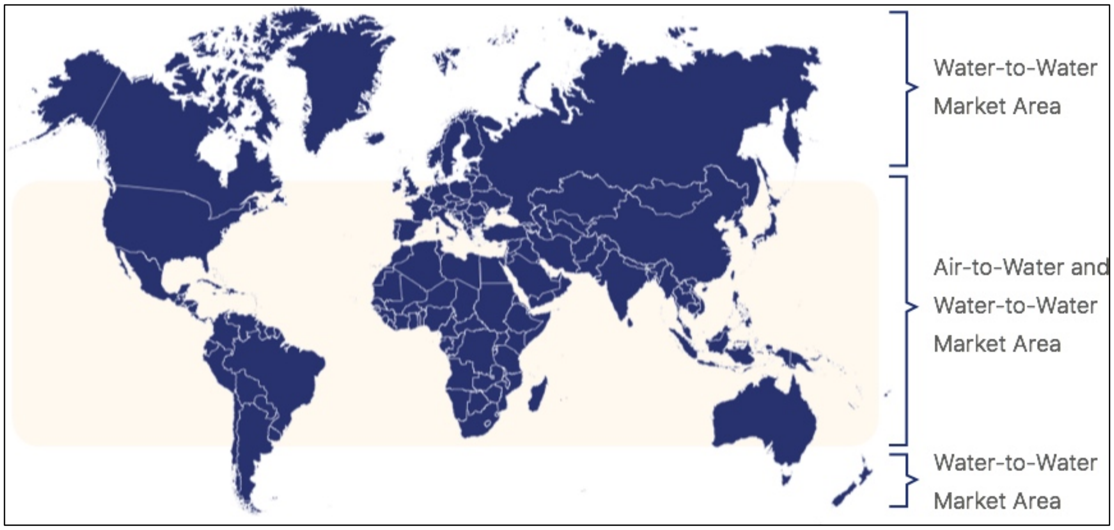

Figure 8: Rainmaker Worldwide Preferred Technology Per Regions

(Source: https://rainmakerww.com/technology-air-to-water/)

FIELD TESTING OF SOURCE HYDRO-PANELS

1. Pilot Study Site

In an effort to find alternative methods of providing rural Tribal communities with clean and safe drinking water, STAR School and Apex Applied Technology, Inc. (AATech), have undertaken a pilot test study to determine the efficiency of the air-to-water technology in Norther Arizona, near the Navajo Nation Reservation.

Based on our initial evaluation, Zero Mass Water's SOURCE Hydro-Panel system is the only small-scale air-to-water technology with the potential to work in Arizona's dry climate conditions. Zero Mass Water is based in Scottsdale, Arizona, so the technology developers are familiar with the climate conditions. This also means the technology is readily accessible. SOURCE Hydro-Panel system runs as a stand-alone two-panel system, relatively small and easy to handle. Because Zero Mass Water is located near the study site, geographically, operation and maintenance services are readily available.

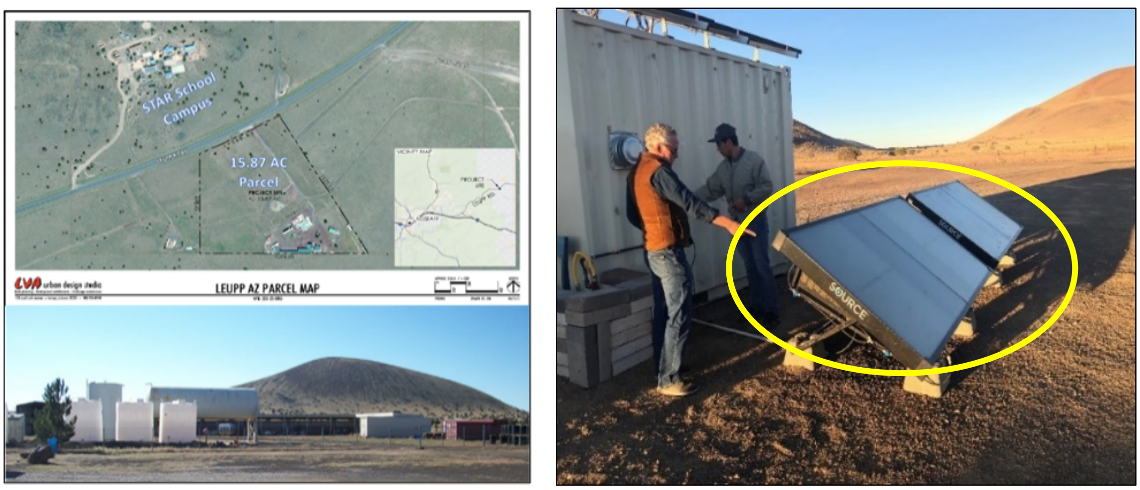

Figure 10: Pilot Testing Site of SOURCE Hydro-Panels at the STAR School

In September 2019, a SOURCE Hydro-Panel system from Zero Mass Water was purchased and installed at the STAR School campus (**Figure 10**).

The primary goal of the pilot study is to test the effectiveness of SOURCE Hydro-Panel system in water production as well as the overall performance under the climate conditions like those present in Navajo Nation and Hopi Tribe communities.

2. Materials and Methods

As mentioned earlier, in September of 2019, the SOURCE system was installed at a technology demonstration site, across Leupp Rd. from the STAR School campus (**Figure 10**). In early Winter of 2019, the SOURCE Hydro-Panel system was damaged due to below freezing temperatures at the demonstration site. Thus, the system was shut off until the early Spring 2020. In Spring, the project team planned to begin data collection via the Zero Mass Water's 'SOURCE' mobile application, which allows user to remotely monitor water production, water consumption, environmental offset, economic offset, and carbon offset of an individual Hydro-Panel or Hydro-Panel array system. **Figure 11** shows the SOURCE mobile application interface. The mobile application tracks accumulated water production by year, month, and week.

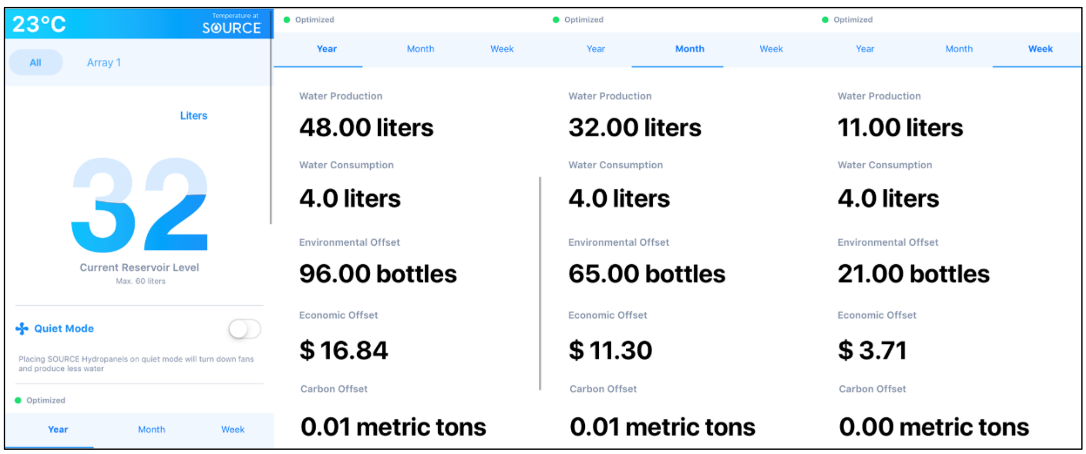

Figure 11: Zero Mass Water - SOURCE Mobile Application

After repairs were made to the Hydro-panels system in the Spring of 2020, the project team experienced another setback due to a typical network connectivity issue in the rural area where PDDP/STAR School site is located. The SOURCE Hydro-Panels were not in the range of a cellular network onto which the Hydro-Panels system needs be connected for SOURCE mobile application updates. Later, a telephone service was established, and the connectivity issue was resolved. Actual data collection started in Mid-July 2020.

Figure 12 shows water production data collected between July 18, 2020 and August 18, 2020 provided to the project team by a Zero Mass Water representative. In addition to water production, a SOURCE Hydro-Panel system also tracks Relative Humidity (RH) and Solar Flux. **Figure 12** shows there were multiple days on which water production was reported to be zero. According to Zero Mass Water representative, these zero readings are a result of network connectivity issues. The project team will continue to work with Zero Mass Water to ensure seamless and accurate tracking.

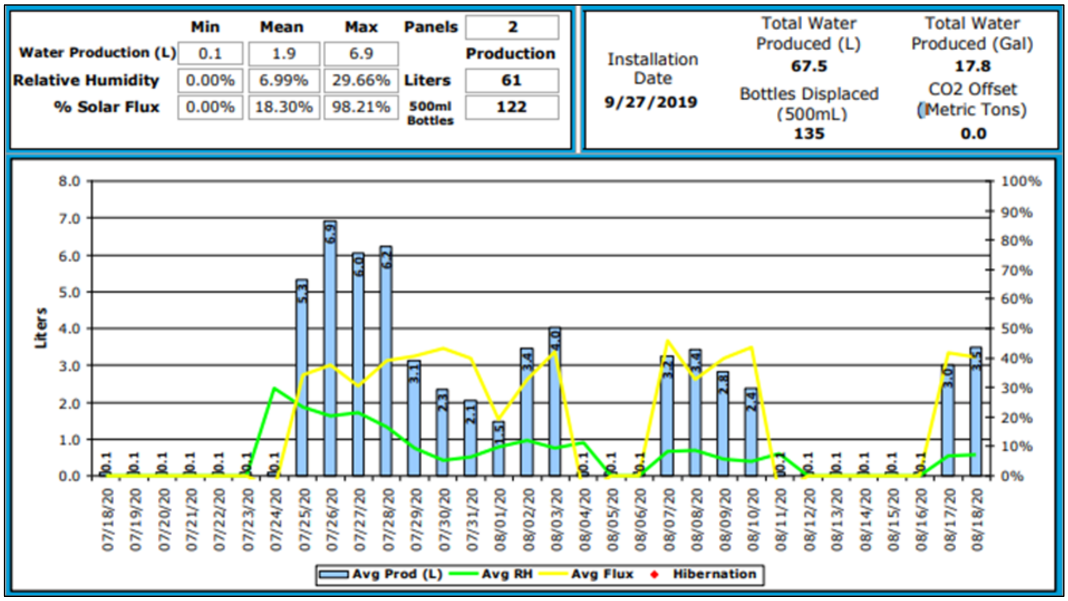

Figure 12: SOURCE Hydro-Panels Water Production at PDDP Site

In addition to the data provided by Zero Mass Water, project team have also collected water production data through September 21, 2020 using the SOURCE Mobile Application.

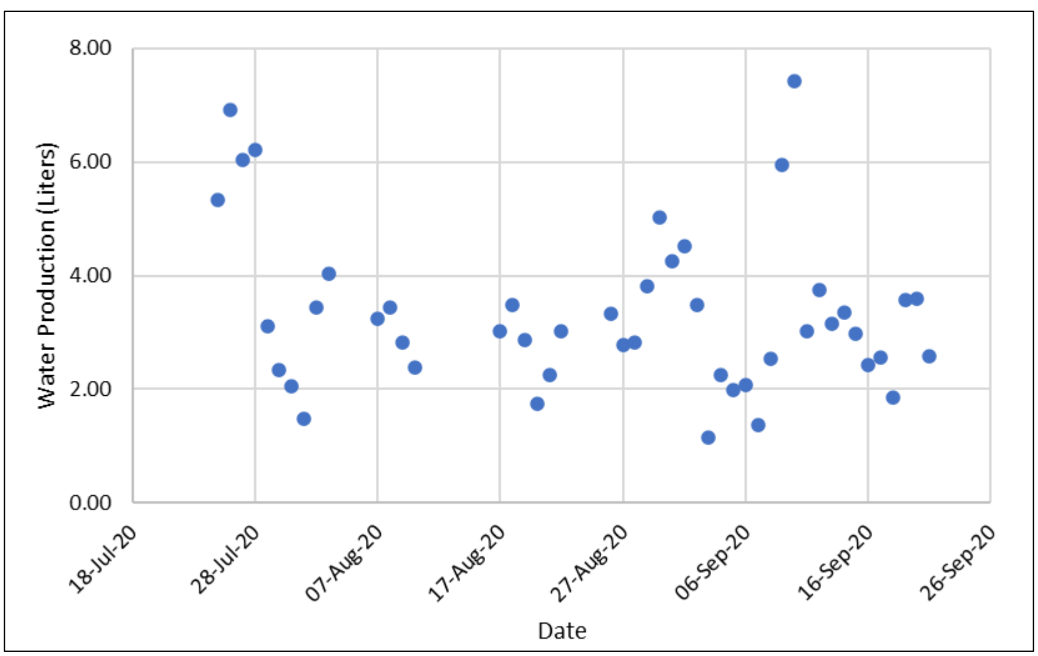

Figure 13: SOURCE Hydro-Panels Water Production at PDDP Site

Data collected by the project team was combined with the data provided by Zero Mass Water to evaluate the performance of the system (**Figure 13**). Over the 66 days within this data collection period, reliable data was generated 71% of the time (47 days). Data was not generated for the remaining 19 days because of the internet connectivity issue. Therefore, to better evaluate the performance of the Hydro-panel system, the zero readings must be removed from the dataset. It is worth noting that on days where production was reported at zero liters, the SOURCE system still likely produced water; quantities are simply unknown.

In addition to the PDDP site, the project team has also assessed the water production for a Hydro-panels system located in New River, Arizona, just North of the Phoenix Metropolitan Area. Results are discussed below.

3. Results

Anticipated average daily production in Flagstaff, Arizona is predicted in the model shown in **Figure 14** (Zero Mass Water). This is based on a SOURCE Hydro-Panel F Prime model under idealized conditions. According to the model, average daily production of a standard two panel system throughout a year is estimated at 5.75 liters (1.52 gallons). Lower and upper deviations for July, August, and September are estimated at 3.00, 2.50, 5.50 and 7.00, 5.00, 10.00 liters of water production, respectively, based on this idealized model.

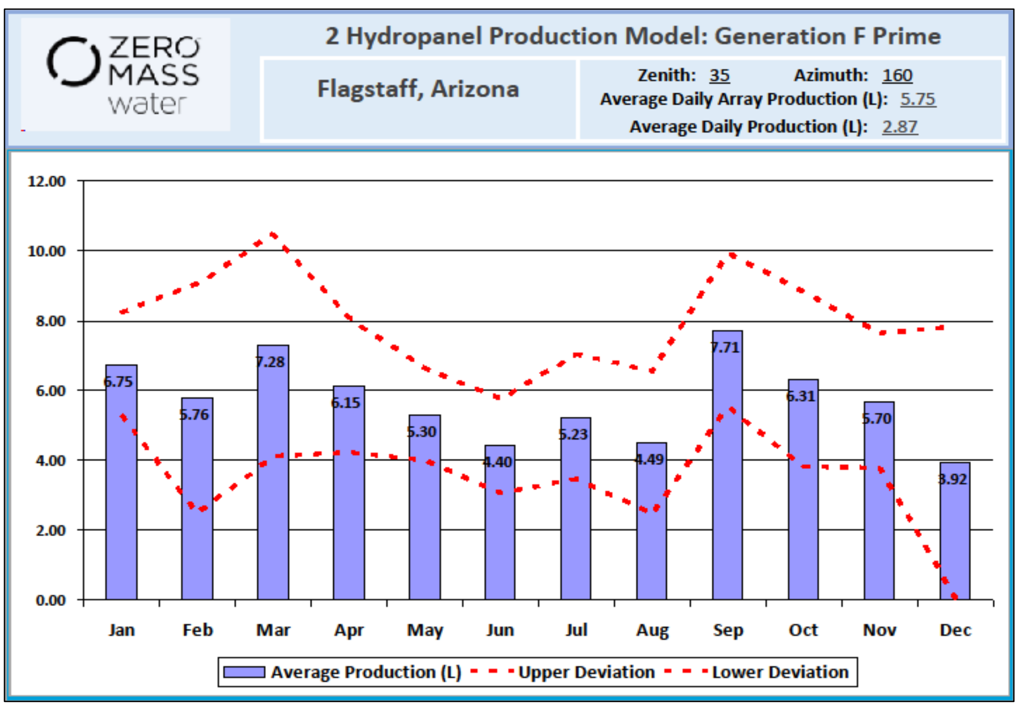

Figure 14: SOURCE Hydro-Panel F Prime Model Water Production – Flagstaff, AZ

Based on the data collected by both Zero Mass Water and the project team, **Figure 15** was prepared to show the comparison of average daily water production in July, August, and September at the study site with the modeling results. From July 18th to September 21, 2020, the SOURCE Hydro-Panels system produced a total of 157 liters of water (41.5 gallons), which is equivalent to nearly 314 bottles of 16.9oz-bottle water. Average daily water production for July, August, and September being 4.57, 3.12, and 3.12 liters, respectively (1.21, 0.82, 0.82 gallons). Average weekly production is estimated at 20.0 liters (5.28 gallons).

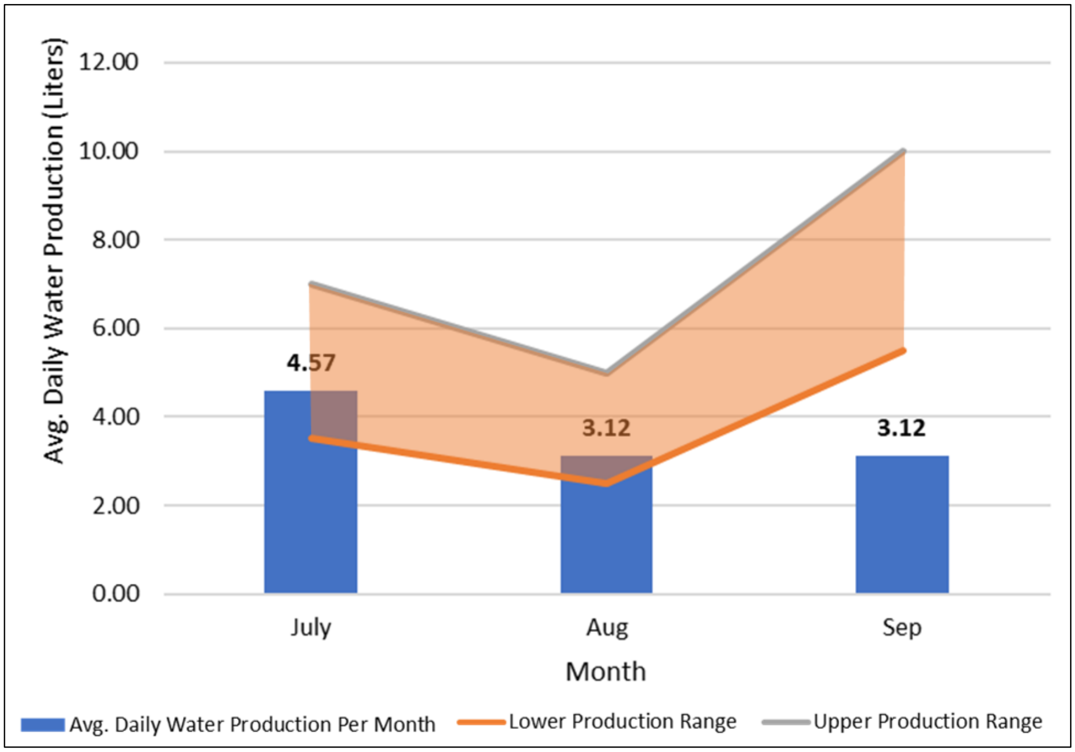

Figure 15: SOURCE Hydro-Panel Average Daily Water Production

Data collected by the project team for July and August, generally falls within the range of average daily water production predicted by Zero Mass Water's model. Daily production rates observed for September, however, fall short. The differences between idealized model predictions and observed rates at the PDDP site are likely a result of a limited data set for this monitoring period alongside environmental conditions which were not anticipated by the project team upon initial installation.

The project team also investigated the impact of environmental conditions on the performance of the SOURCE Hydro-panels system. First, it is expected that water production is directly affected by ambient humidity. In **Figure 16**, water production rates are shown alongside relative humidity for the data collection period. The average relative humidity for the months of July, August, and September measured at the PDDP site were 15%, 17%, and 19%, respectively. As anticipated, the water production rate seems to generally follow the trend set by Relative Humidity.

Because the SOURCE Hydro-panels system is driven by solar power, the performance of the SOURCE Hydro-panels system is also affected by sun hours. **Table 3** shows historic weather data including humidity and sun hours for Flagstaff, Arizona over the last ten years. Using Zero Mess Water model and the weather data, F**igure 17** and **Figure 18** demonstrate the relationships of water production rates with local humidity and sun hours. In summer months, when the sun hours are long and with higher solar radiation, the ambient humidity is a dominating factor on water production. So, the water production rate follows a similar trend as humidity. On the contrary, during winter months, local humidity is high. Water production rates are determined by total solar hours the system is exposed to. Therefore, the water production rate follows the trend set by monthly sun hours.

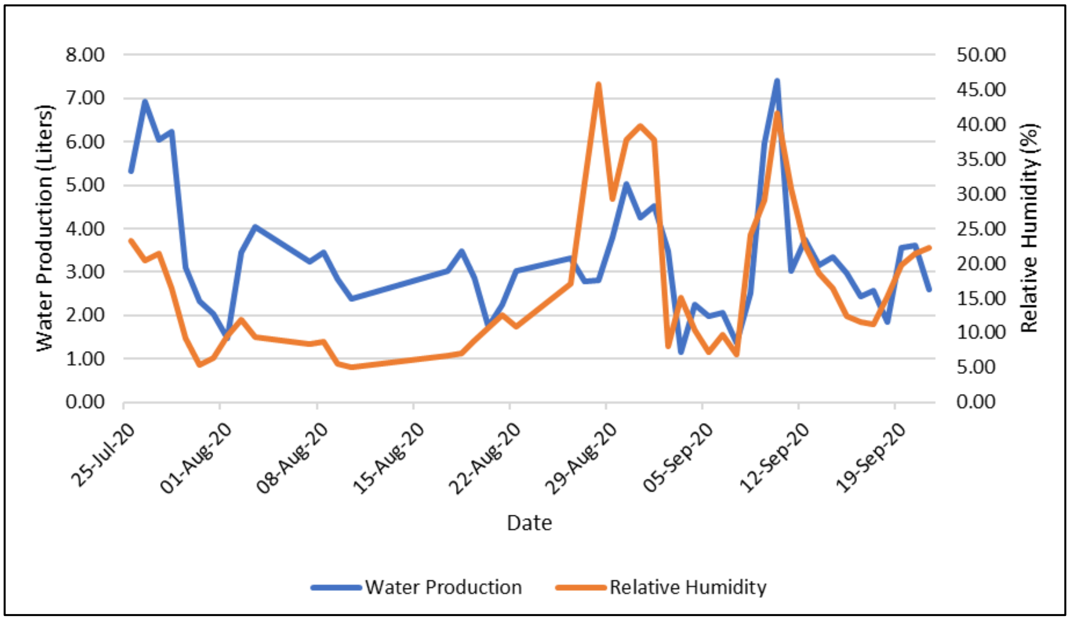

Figure 16: Hydro-panels Water Production vs Relative Humidity at the PDDP Site

Table 3: Monthly Historic Weather Data for Flagstaff, Arizona (10 years)
(Source: https://www.weatherwx.com/hazardoutlook/az/flagstaff.html)

Month	**Avg. Humidity (%)**	**Avg. Precipitation (inches)**	**Avg. Temperatures (°C)**		**Avg. Hours of Sun**	**Avg. Cloud Cover (%)**
			High	**Low**		
January	67%	0.8	6	-4	213	23%
February	60%	1.1	8	-3	243	21%
March	47%	0.9	12	0	283	19%
April	36%	0.6	16	3	322	16%
May	33%	0.7	20	7	362	12%
June	24%	0.2	27	12	364	7%
July	43%	2.6	28	16	368	18%
August	46%	2.0	27	15	379	13%
September	44%	1.0	24	12	292	11%
October	45%	0.7	18	5	246	11%
November	51%	1.0	12	0	219	14%
December	64%	1.1	6	-4	210	24%

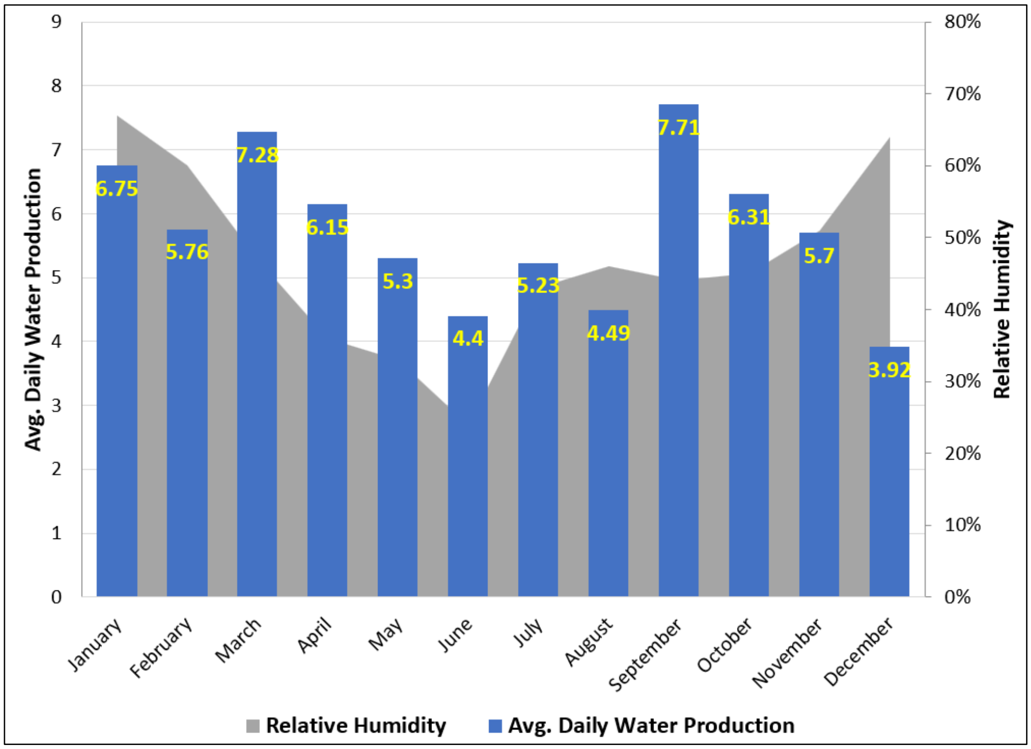

Figure 17: Projected Water Production vs. Avg. Humidity in Flagstaff

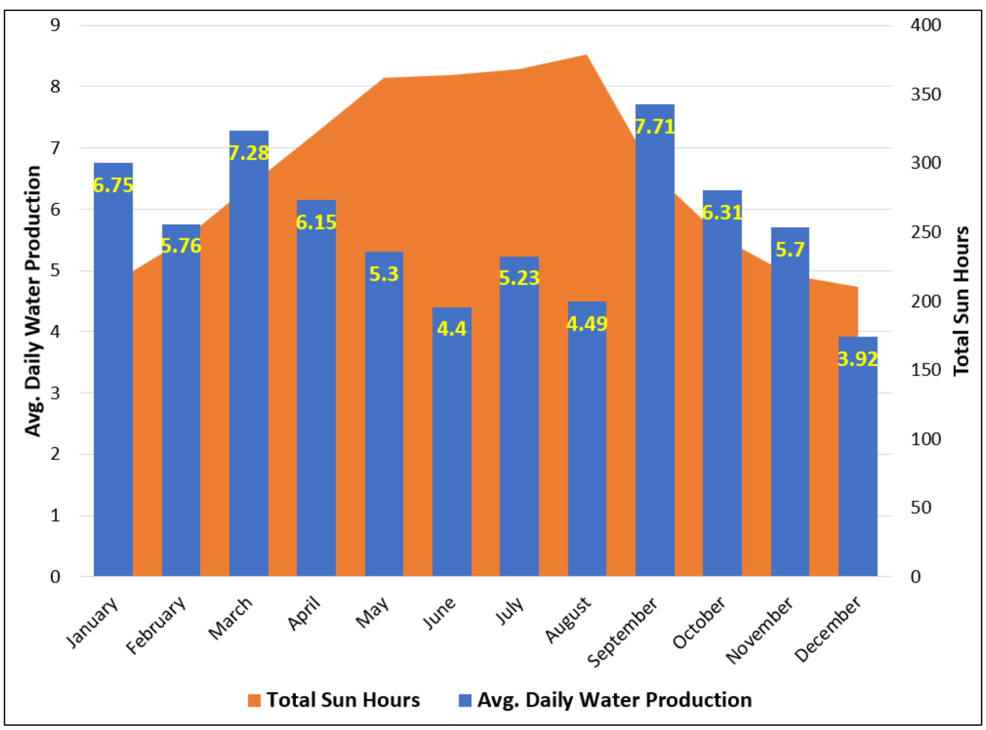

Figure 18: Projected Water Production vs. Monthly Sun Hours in Flagstaff

In **Figure 19**, the graph shows average daily water production of the SOURCE Hydro-Panel system at New River site, from March 21, 2019 through September 10, 2020. Overall production from the New River Hydro-Panel system is estimated at 400 liters of water for the 18-month period. This is equivalent to approximately 800 16-.9oz-water bottles. The monthly production average at this site is estimated at 22.2 liters (5.86 gallons). This breaks down to 5.55 liters (1.47 gallons) weekly.

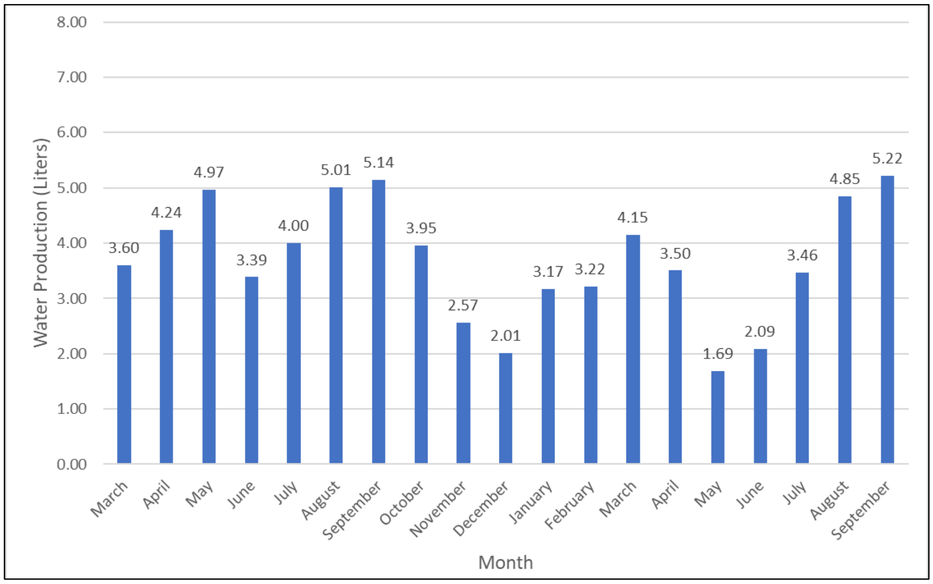

Figure 19: Avg. Daily Water Production at New River Site (2019-2020)

Table 4 shows historic weather data for New River, Arizona, over the last ten years. The same analysis was done using the real data collected at the New River site (**Figure 20** and **Figure 21**).

Table 4: Monthly Historic Weather Data for New River, Arizona (10 years)
(Source: https://www.weatherwx.com/hazardoutlook/az/new+river.html**)**

Month	Avg. Humidity (%)	Avg. Precipitation (inches)	Avg. Temperatures (°C)		Avg. Hours of Sun	Avg. Cloud Cover
			High	Low		
January	44%	0.7	16	7	217	19%
February	41%	1.1	18	8	253	18%
March	32%	0.9	22	11	280	17%
April	23%	0.2	26	14	324	12%
May	21%	0.7	30	17	369	8%
June	17%	0.1	36	27	365	6%
July	31%	1.7	37	27	370	15%
August	32%	1.4	37	27	373	12%
September	32%	1.1	34	24	288	11%
October	32%	0.9	27	11	251	9%

November	35%	0.8	21	11	217	13%
December	45%	1.0	16	7	210	22%

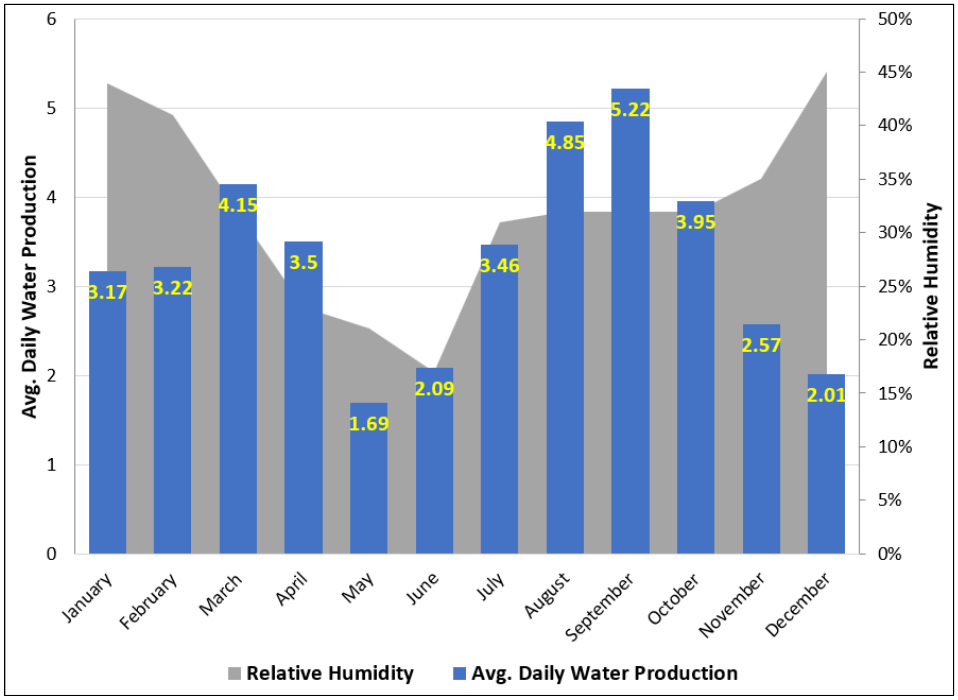

Figure 20: Water Production at New River Site vs. Avg. Humidity in Phoenix

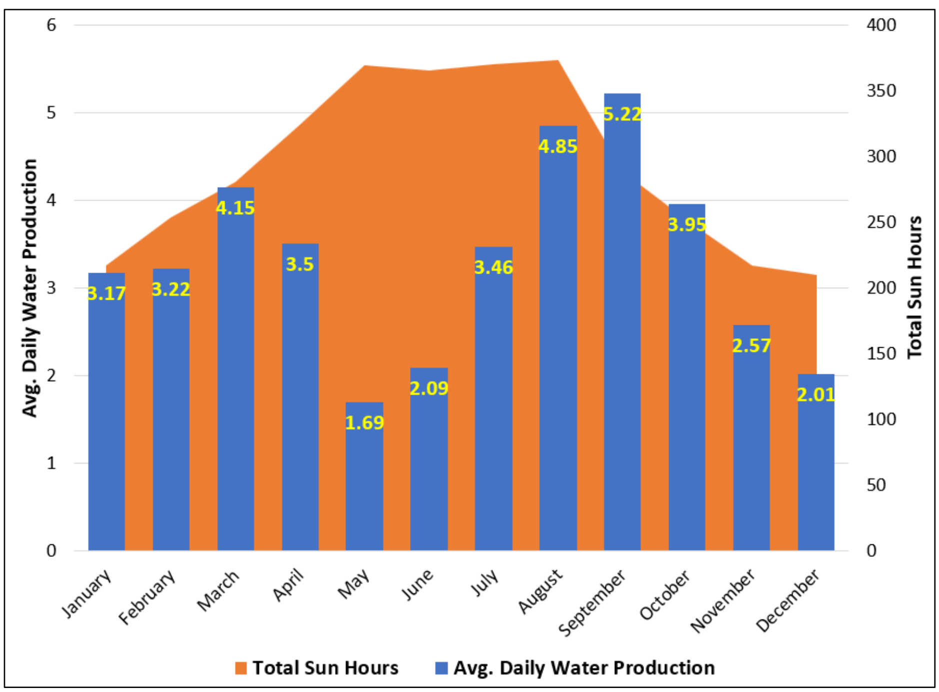

Figure 21: Water Production at New River Site vs. Monthly Sun Hours in Phoenix

4. Conclusion

Based on the data presented, the SOURCE Hydro-Panel system seems to be a promising technology with the potential to provide safe and clean drinking water to rural Native American communities in Arizona. The idealized model (**Figure 14**) predicted water production rates which were noted by the project team. Overall production rates of this system will be determined by array size and environmental factors present at selected installation sites. In order to maximize water production rates, considerations regarding environmental conditions should be made prior to installation of the system. In areas where winters can reach below freezing temperatures regularly, placement of the water storage compartment may be optimal indoors. Other potential conditions may also present, though this was the main challenge faced by the project team at the PDDP site.

Over the estimated 15-year lifespan of the system, cost per liters of water, based on initial cost of the SOURCE system and idealized water production at the PDDP site, is estimated at $0.19 per liter ($0.72/gallon) or $0.10 per 16.9-oz water bottle), which is lower than market price for bottled water. Accounting for challenges relating to development of a centralized water delivery system, time and resources spent on hauling water, and other miscellaneous costs associated with current water procurement tactics, the SOURCE system may be beneficial for Native American families. Being highly scalable, the SOURCE Hydro-Panels system can also be implemented on a larger scale.

REFERENCES

"Atmospheric Water Generation Research." EPA, Environmental Protection Agency, 13 Nov. 2019, www.epa.gov/water-research/atmospheric-water-generation-research.

"Drinking-Water." World Health Organization, World Health Organization, 14 June 2019, www.who.int/news-room/fact-sheets/detail/drinking-water.

"How Much Water Is in the Atmosphere?" The Weather Guys, 5 Feb. 2018, wxguys.ssec.wisc.edu/2018/02/05/water-in-atmosphere/.

Krol, Debra Utacia. "Navajo Nation's Water Shortage May Be Supporting COVID-19 Spread." The Arizona Republic, Arizona Republic, 28 Apr. 2020, www.azcentral.com/story/news/local/arizona-health/2020/04/18/navajo-nation-water-shortage-contributing-covid-19-spread/2992288001/.

Kim, Soo. "Navajo Nation, Which Had Highest Coronavirus Infection Rate in U.S., Reports Zero New Cases." Newsweek, Newsweek, 9 Sept. 2020, www.newsweek.com/coronavirus-zero-new-cases-navajo-nation-had-highest-infection-rate-us-1530656.

Melkonian, Stephanie, et al. "A prospective study of the synergistic effects of arsenic exposure and smoking, sun exposure, fertilizer use, and pesticide use on risk of premalignant skin lesions in Bangladeshi men." American journal of epidemiology 173.2 (2011): 183-191.

"Peltier Effect." Encyclopædia Britannica, Encyclopædia Britannica, Inc., 2020, www.britannica.com/science/Peltier-effect.

Uhlman, Kristine, Channah Rock, and Janick Artiola. "Arizona drinking water well contaminants." (2009).

US Environmental Protection Agency. "Health and environmental impacts of uranium contamination in the Navajo Nation: five-year plan." (2008): 1-46.

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