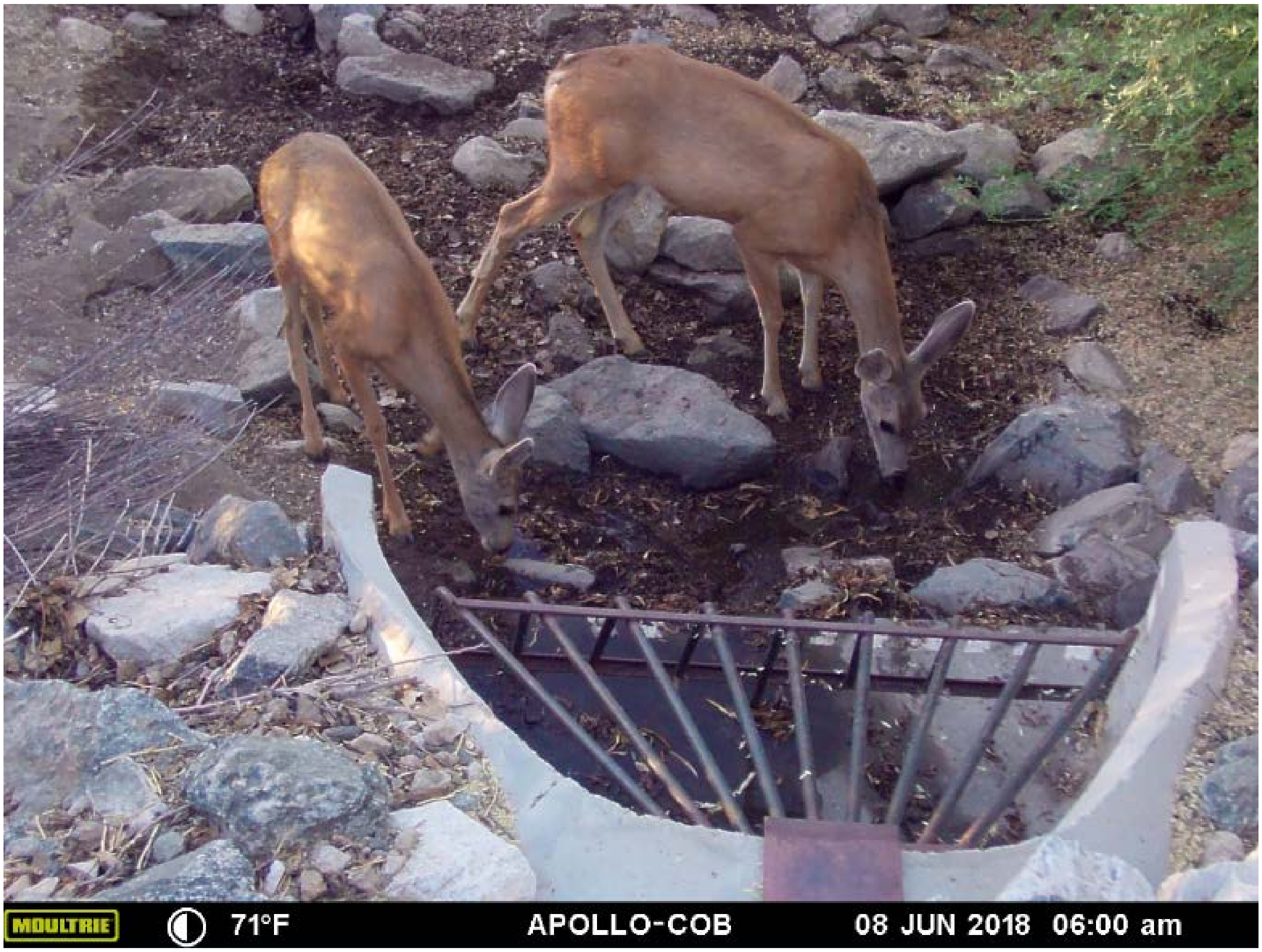

APOLLO

Auto Visual Monitoring – a pilot program with collaboration between the City of Buckeye Public Works and the Arizona Department of Environmental Quality

FY18 Permit Cycle – July 1, 2017 through June 30, 2018

By: Amy Murray and Robert van den Akker

Contents

Project Management Team

Amy Murray – City of Buckeye
Meghan Smart – ADEQ (pictured Figure 1)
Robert van den Akker – City of Buckeye (pictured Figure 1)

Figure 1

Introduction

A collaboration between the State of Arizona Department of Environmental Quality (ADEQ) and the City of Buckeye Public Works Department was created and designed to help develop and enhance the outfall monitoring requirement of the municipal stormwater permit to capture the "first flush" of an outfall. This auto visual outfall monitoring pilot program, along with the camera named "Apollo" on loan from ADEQ, has collectively been referred to as "Apollo-COB Project" or simply "Apollo".

The State of Arizona Small Municipal Separate Stormwater Sewer "MS4" Permit #AZG2016-002, section 6.4.3.8(b) *Visual Monitoring,* allows for an alternative practice to visual discharge monitoring of outfalls. The Apollo project was proposed by ADEQ to test an alternative method that allows frequent, repetitive, and automated documentation of the outfall via programmed photography. The City of Buckeye volunteered to test this monitoring method.

With the addition of programmed photography, it was proposed the municipality would be able to monitor the area for up to half-hour intervals in an attempt to observe the "first flush" outfall discharge. Staff visited the monitoring location on a routine basis to check the status of the outfall and camera in place of the permit requirement of running to the outfall during potential rain events for wet weather monitoring.

Stormwater Quality Program

The City was charged with implementation of a stormwater quality program on September 29, 2016. This monitoring program is in direct response to the City's Arizona Pollution Discharge Elimination System (AZPDES) Permit #2016-002 (the general permit issued by the State of Arizona in place of the federal National Pollution Discharge Elimination System (NPDES) Small MS4 permit).

In addition to, and separate from the auto visual monitoring during wet weather, the City used this opportunity to capture visual assessments of the variety of wildlife, (including varmints) living in the area, the potential effects of neighborhood irrigation runoff on outfalls, and detection of illegal dumping. Visual monitoring began on August 23, 2017, and continued daily through June 30, 2018, (FY18, Permit Year 2 – the first full year of the City of Buckeye's AZPDES permit).

Project Area Description

This study focused on an outfall located in the Verrado subdivision. Verrado is located within the east-central portion of Buckeye, Arizona, a city the Phoenix Metropolitan area of Maricopa County, an area of the Sonoran Desert of the Southwestern United States.

As detailed in the City of Buckeye General Plan (Imagine Buckeye 2040), the planning area of the city includes 642 square miles, making it the largest planned land area in the state of Arizona. According to the 2010 decennial census, the City had a population just over 50,000, with more than 18,000 homes, and based on current estimates, the population is over 70,000 with more than 23,000 homes with the majority of homes having been built after the year 2000. According to the 2010 Decennial Census, the Buckeye population has a significant mix of demographic types; however, the majority of the Buckeye population has an average of a high school education, identify themselves as 80% White by race, and 40% Hispanic by ethnicity. The population consists of 20% school age children, 25% young adults, 25% adults, and 20% elderly (the remaining 10% are younger than school age). The average household income is less than $100,000, with 70% home ownership by first-time home buyers. Living condition consists of a 70/30 split between owners and renters.

Verrado is a high-profile area with small-town charm boasting over 70 parks nestled in the southeast foothills of the White Tank Mountains and features a Main Street with shops servicing many of the community's needs.

Tree-lined streets, access to trails, swimming, golf, activities, celebrations and more makes this community one of the most desired in Arizona and very unique in the Phoenix Metropolitan area. An overhead photo of a sample of the community may be seen in Figure 2.

This subdivision consists of approximately 3,200 residential homes and more than 60 non-residential properties encompassing 3.5 square miles (2,247 acres).

The development of this community began in 2002. It is unique in that it's Community Master Plan, approved November 17, 1999, designates the stormwater drainage structures to be owned and maintained by the City of Buckeye. No other newly developed (post- 2000) subdivision in the City has this designation.

Figure 2

Outfall Location

The City of Buckeye and the State of Arizona chose the Tuthill/Acacia/Osborn Road Wash (the wash) within the Verrado neighborhood as its monitoring location (see Figure 3).

Figure 3

The watershed, outfall (see red dot on Figure 3), and the wash (see blue line on Figure 3) are a general representation of 10 similar features within this large subdivision along the two mile stretch of Acacia Road located adjacent to the wash. All ten outfalls were scrutinized for this project and all had negative constraints ranging from being too close to homes and pedestrian walkways, to over-vegetated areas, or vegetation that was too large, or difficulty in access to the outfall. This location (see Figure 4) was decided due to its ease of access, direct discharge to a wash[1], low profile area, significant low brush vegetation masking visibility from neighboring properties, and distance from pedestrian walkways. Additionally, this location had safe street parking, as frequent site visits were important to retrieve data and monitor equipment status.

The monitoring area is located at the central portion of the Verrado community near the intersection of N. Acacia Way and W. Springfield Street, just south of Indian School Road. The outfall empties approximately 25' above the high water mark of the wash. The watershed seen in Figure 3 spans approximately 15 residential acres containing nearly three miles of curb and gutter.

Figure 4

During FY18, confirmation of the wash, regional drainage flows, and collaboration with the Flood Control District of Maricopa County, proved that this area was not, by definition, an outfall as it did not discharge to a Water of the United States (WOTUS) directly, nor was it a tributary to a WOTUS. From this point forward this discharge point will be referred to an as outlet, not an outfall[2].

[1] This connection to a Water of the United States has been disproven.

[2] A point source that discharges to Waters of the United States as defined in 40CFR122.26(b)(9)

Outlet Drainage Area and Rainfall Totals

According to data collected by the Flood Control District of Maricopa County, The Phoenix Valley averages 24 rain events per year measuring ½" or less, and experiences an average annual rainfall of 8 inches. During 2017 and 2018, the region was continuing to experience a multi-decade time of drought. The total number of rain events with a threshold of .01" of measurable rainfall or greater during the monitoring period of July 1, 2017, through June 30, 2018, was 16. The City experienced a drought year with 4.5" of measurable rainfall during FY18. Precipitation records from Maricopa County Flood Control District's historical data period July 1, 2017-June 30, 2018, for White Tanks Flood Relief Structure (FRS) #4 (ID# 87800), Buckeye, Arizona, shown graphically in Figure 5 below.

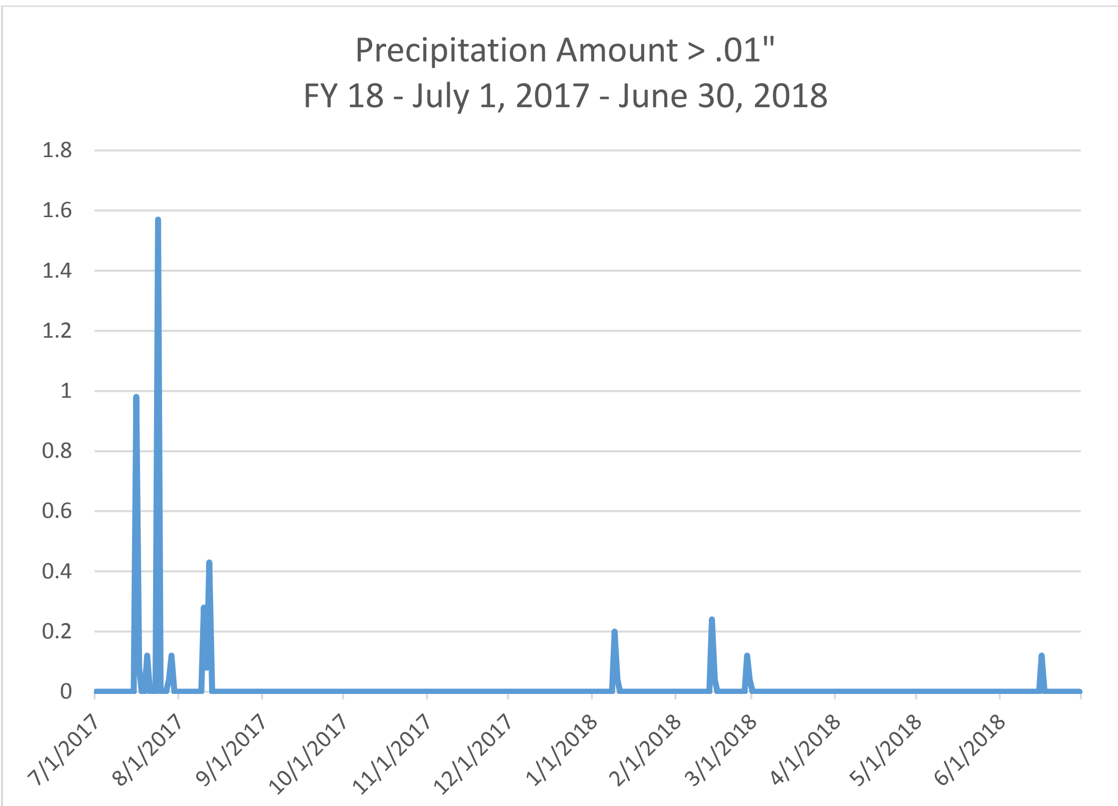

Figure 5

Stormwater Flow Design

Stormwater runoff drains from residential homes to the curb and gutter system of Shadow Drive, Springfield Street, and N. Acacia Way. Rainfall entering the wash flows approximately 1¾ miles south to a retention basin designed to hold a 100 year flow, located at the southeasternmost corner of the development.

Should rainfall exceed the drainage basin storage volume, overflow would continue south to a Flood Control District of Maricopa County (FCD) earthen flow way, and continue underneath Interstate 10. The FCD's channels empty to a 500-year design basin named "White Tanks Flood Relief Structure #4 Dam" (FRS #4). Should rainfall exceed the FCD's White Tanks FRS #4 design, flow would then discharge to the Blue Horizons subdivision retention basins. The FCD is currently redesigning FRS #4 to redirect flow to larger channels that will flow to the Southeast.

Note: As discussed earlier, but significantly noted again, because there is no discharge to a WOTUS, the discharge point from the subdivision to the wash is noted by City as an outlet or discharge point, not an outfall which by definition may only drain to a WOTUS.

Weather Sources

The City utilized various weather sources (Flood Control District of Maricopa County, National Weather Service, Weather Underground, local meteorologists, etc.) to forecast precipitation opportunities.

When days of dry weather (no rainfall forecasted) were present, the photo controls were set at various options to gauge the effectiveness of the data capture including motion detection, hourly, and half-hour settings. When rain was forecast, photo capture camera setting options were set to increased frequency.

Figure 6

Camera Details, Settings, Data Storage

The State of Arizona loaned the City of Buckeye a Moultrie M-550 (Gen2) Digital Game Camera (Moultriecam) with metal encasing (Figure 6). The City mounted the equipment onto a metal pole and posted signage. The camera was equipped with a metal covering which the City was able to lock in place to help deter tampering and theft. Additionally, ADEQ recommended use of a non-threatening sign to deter tampering with the camera, which the city installed shortly after camera placement (Figure 7 and Figure 8). During this program the City did not experience vandalism.

Figure 7

The camera was supplied with various setting capabilities to capture photos, which the City tested and changed based on weather conditions. Staff placed makeshift markers (utilizing rocks from the area) to indicate 5', 10', and 15' distances from the discharge point of the outlet to assist with determining the approximate volume of flow.

The date/time stamp, photo quality (high 7MP), fast flash, temperature, motion detection and time lapse features were each tested to determine efficiency of capturing a "first flush" scenario.

Settings included various capture modes:

- Continuous motion detection with a 5-second delay
- 30-minute intervals between specified times during one or two periods of the day (morning and afternoon)
- 1 photo between specified intervals during morning and afternoon hours
- Hourly photos between specified intervals during forecasted times

Figure 8

The City used a 16 MP SD card to store images. Images were downloaded onto a permanent server which allowed for adequate review and documentation. The camera photo capture settings were increased prior to rain events down to 30-minute intervals. Photos were captured more frequently during forecasted rain event periods in order to attempt to capture the first flush and subsequent visual flow activities.

The Multriecam was user friendly, and easy to set-up and operate. This collaboration allowed the City to capture much more data than a staff member could have the possibility of collecting from frequent visits to the site. The photos were of good quality and were able to assist the City in showing the flow patterns of discharge through this outlet. Interval and motion detection photos were both tested. The motion detection proved insensitive to small flows and the desired first flush was not able to be captured. Thirty- and 60-minute intervals were attempted without first flush rain flows being captured.

The flare at the end of the outlet pipe did not allow for a method to determine low flow volume. In an attempt to add a gauge of flow volume, 2" marks were painted onto the flared edge of the outlet at 2" intervals.

Findings

This outlet receives irrigation flow frequently each week, with flows reaching the 5' to 15' distance mark beyond the end of the outlet, but flows rarely discharged into the wash. During measurable rainfall events where runoff was able to enter the wash from the outlet, the flow patterns did indicate two instances of significant foaming. Very little trash was observed and turbidity was not able to be detected. Volume of flow was very difficult to measure. Photo documentation as seen in the photos series in Figure 9 included rain events, irrigation flow, dry weather events, and wildlife.

Wildlife:

- Coyote
- Dog
- Rabbit
- Ground Squirrel
- Squirrel
- Quail
- Dove
- Owl
- Bobcat
- Javelina
- Rats-(Sonoran & other)
- Mule Deer
- Chipmunk
- Roadrunner
- Rattlesnake

Figure 9

The wash - unable to see outfall and wash at the same time

Outfall with 2” markings added

Camera angle adjusted to see discharge point. No outfall markings observed

First light rain capture - January 9, 2018

First full rain event capture – January 9, 2018

Normal irrigation flow observed – volume too low to measure

Foam observed during rainfall - January

Normal irrigation flow to the 10’ mark

Foam observed during rainfall – June

Roadrunner

Coyote entering culvert

Rats

Javelina

Botcat

Quail

Mule Deer

Squirrel

Owl

Lessons Learned

Outfall? Outlet?

As mentioned previously, the outlet point was chosen based on current knowledge of the time. The outlet drains to a named wash (Tuthill/Acacia/Osborn Road Wash) that was thought to be a tributary that discharged directly to the Gila River. However, upon mapping of the City's stormwater infrastructure and review of drainage documentation from Flood Control District of Maricopa County (FCDMC), staff determined this to not be an outfall by definition, but a discharge outlet. This outlet drains to a designed retention basin located 1¾ miles south.

The retention basin has an overflow structure that discharges to a Maricopa County Flood Control District dam known as White Tanks Flood Relief Structure #4 Dam (FRS #4). FRS #4 is designed to hold a 500-year rain event. FRS #4 has a redesign plan to direct flow to another Flood Control District structure on Cotton Lane (adjacent to the Loop 303) in Goodyear.

While performing this visual assessment, the City was also mapping its stormwater infrastructure (curbs, gutters, inlets, outlets, basins, pipes, culverts, etc.) and discovered the City's drainage is typically stored in private retention basins. There are also a few drains that flow to irrigation canals; therefore, this discharge point is representative of all stormwater structures throughout the City in that they do not discharge to a WOTUS.

Development of the city, dramatically increased since 2000, has followed good stormwater quality regulations that meet or exceed current development standards. These standards were established many years prior to the issuance of the stormwater permit.

Getting the Right Angle

The camera was placed landward of the wash. Placement of the camera in the wash, if it were a WOTUS, would have required obtaining a 404[3] permit from the U.S. Army Corps of Engineers

[3] Section 404(a) of the Clean Water Act provides the federal government authority over dredging and filling in Waters of the United States (WOTUS).

and a 401[4] permit from the State of Arizona. The City decided to place the camera in an area where the outlet could be visually monitored, a section of the wash’s southern flow could be seen, and without having to obtain permitting.

The camera set-up was not at the best angle to capture discharges from the outlet and wash. Additionally, the angle of the sunlight negatively affected the outcome of the photos. Heavy shadows falling during late afternoon obscured many photos. Future monitoring events include testing camera angle and direction to find the best picture location.

The camera’s photo resolution was seven (7) mega pixels with a small lens. Moving forward, it is suggested to obtain the highest mega pixel and largest lens trail camera possible to capture higher-quality photos.

While our method of camera use and placement did not achieve the desired result of obtaining “first flush”; other placement areas of the carema, and possibly a more senstaive camera might meet the permit required method of data collection.

What’s the Volume?

Staff were unable to determine the volume of discharge. Most flows were slow, low volume, taking up small portions of the discharge area outlet apron with unknown duration of flow and unknown percolation rates of the soil.

Missing information included:

- Soil percolation rates
- Flow rate over time
- Beginning and end time of flows

Two inch marks were added to the outlet structure to gauge width of discharge at the exit point of the structure, and non-intrusive markers (larger rocks standing on end) were added to gauge distance of flow at 5’, 10’, and 15’ points. Although these markings did help in qualitative analysis, quantitative analysis was not possible.

Summary

In summary, the daily water discharge to this outlet during non-rain events was found to be from the neighborhood irrigation system of individual homes and common areas of the development, as well as occasional washing of personal vehicles. This type of runoff rarely exceeded 15’ past at the end of the outlet and did not contribute flow into the wash.

Foam of unknown origin and content (seen in Figure 9) was observed during several rain events, and would not have been observed without this camera capturing live flow. It is common knowledge that possible sources of foam could include organic detritus from heavily watered and maintained lawns and flower beds.

[4] Section 401(a)(1) of the Clean Water Act requires a permit from the State for activities that discharge to WOTUS.

The City does not recommend our camera placement method for use to capture visual assessments of "first flush." The rainfall events that caused flow captured by motion detection occurred during the late night and early morning when natural light was not present (also, typically on weekends). Due to lack of natural light, the photos lacked density and perception, so turbidity and color were not observable. That being said, this visual monitoring enabled staff to capture routine irrigation runoff, loose trash, qualitative discharge volumes, and wildlife populations. This information has assisted City staff to identify possible waste problems, erosion and sedimentation control issues, and added knowledge on necessary efforts to stop or identify sources of pollution being discharged from this residential community (Figure 10).

Analysis: Camera vs. Self-Monitoring

	Camera Set-Up	Manual Inspections
AZPDES Permit Compliance	Yes. Need to tweak location.	Yes
Identify Need of Infrastructure Maintenance Activities	No	Yes
Other Information	Yes • Irrigation flow rates • Varmints • Wildlife	No

Figure 10

Capturing data through photographs saved City staff from having to physically monitor 16 rainfall events equating to a labor and equipment expense savings of approximately 64 hours or between $2,000 – $4,000 in resource costs*.

**Resource costs calculation includes a summation of staff and equipment usage for the 16 forecasted rain events, the mid-range average Environmental Compliance officer salary, $2 per hour on-call costs during non-operating hours per City policy, and a 4-hour minimum work time per event to obtain necessary equipment and wait for potential rain events to occur.*

Positive Outcomes

- Qualitative analysis of flows (light or heavy flow)
- Observable flows
- Bulk material/trash deposits
- Irrigation flow documentation
- Identify areas of erosion
- Wildlife sightings
- Varmint identification (Figures 9 and 12)
- Monitoring areas difficult or costly to access
- Wonderful collaboration project opportunity with ADEQ and a municipality
- Development of an auto monitoring process for outfalls (Figure 11)

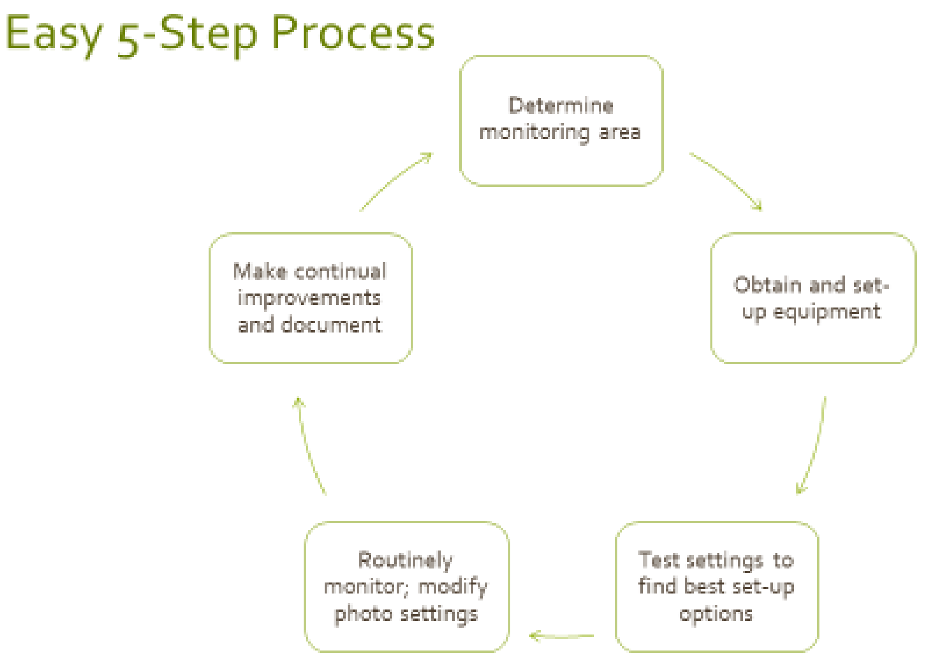

Figure 11

Figure 12