WEFTA Site Visit to the Urubamba Valley in Peru
March 2013

Introduction

The purpose of this trip was to meet with representatives of the various communities in the Urubamba River Valley in Peru (El Valle Sagrado de Los Incas) to discuss their plans and/or issues that they had encountered in implementing wastewater treatment for their respective communities. The WEFTA attendees at these meetings were Lou Harrington, John Lincoln, and Jennifer McDowell. Linda Ochoa, who lives in Urubamba, served as facilitator and provided introductions to the representatives of the various communities. Linda was also present for many of the meetings. The site visit occurred between March 4 and March 8, 2013.

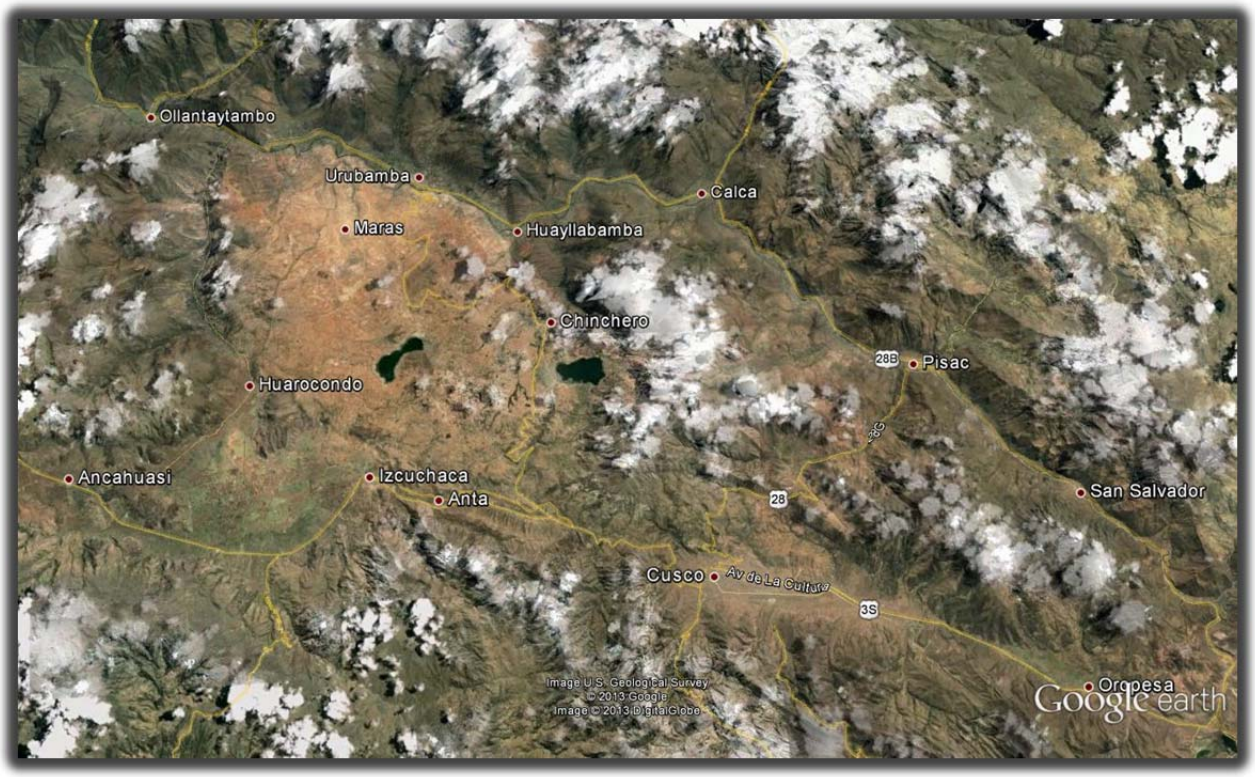
A common theme throughout most of this particular trip was the need for just the type of expertise that our volunteer engineers possess, in this case dealing with wastewater treatment. Each community official that we met with, without exception, was eager to hear what WEFTA had to say about wastewater treatment technologies and processes, and was just as eager to create a strategic alliance with WEFTA in the development of the most viable option for achieving their goals. Perhaps the most surprising was the openness and eagerness on the part of local engineers hired by these municipalities to hear what WEFTA had to say about wastewater treatment alternatives. It was clear very early that this topic is not something that these local engineers are well versed in, to say the least, but their openness to hearing us out was encouraging.

The key challenge for our volunteer engineers is to help the locals develop simple but effective solutions for treating their sewage waste, and not outpace the people we're committed to serve. It'll be important to ensure that the long term operation and maintenance of the suggested solutions are feasible and cost-effective, and that the capacity exists locally to assure proper O&M.

The WEFTA team stayed at accommodations that are somewhat atypical for a WEFTA trip. Linda Ochoa's son has recently opened a resort hotel (Sacred Dreams Hotel) overlooking the Urubamba valley, and Linda's son was kind enough to offer the WEFTA team rooms at the hotel at one-half the normal prices for the hotel. A view of these "Spartan" accommodations is shown below.

Sacred Dreams Hotel, Urubamba, Peru

The Urubamba River originates in the highlands southeast of Cusco, and is a major drainage in central Peru. The upper portion of the valley includes extensive irrigated agricultural land and extends from the town of Pisac at the upstream end to Ollantaytambo at the downstream end (see map below). Downstream from Ollantaytambo, the gradient of the river increases and it flows through a whitewater canyon to the town of Aguas Calientes at the base of Machu Picchu mountain. The Urubamba River ultimately drains to the Amazon River.



Urubamba River Valley

There are a number of communities along the Urubamba River, with the main communities being Pisac, Calca, Urubamba, and Ollantaytambo. The town of Yanahuara and small community of Pumahuanca are located just downstream of Urubamba, and village of Yucay just upstream; all of which were also included in the site visit, as was the Habitat for Humanity community near Pumahuanca (which has its own community septic tank system). All of these communities have wastewater transport systems (sanitary sewers), except Yanahuara, and all of these systems discharge to the Urubamba River without treatment (with the exception of the Habitat system, which includes primary treatment). Most of the communities have multiple discharge points to the river. The sanitary sewer systems are generally constructed with PVC pipe, with 8-inch pipe being the normal minimum pipe size in the collection systems. The design of the sanitary sewers appears to be in accordance with normally accepted practices in the US.

There is considerable political pressure from the regional and federal governments in Peru to clean up the Urubamba River because the Urubamba valley is a major tourist destination with Machu Picchu being the main attraction. However, there are also many Incan ruins in other places in the valley and the river itself has become a major attraction for whitewater enthusiasts.

March 5, 2013

In the morning, Lou, Jennifer and Linda met with Eriberto Acurio, the mayor of **Yanahuara**, a small town about 8 kilometers downstream from Urubamba. Eriberto explained that the village currently has no community wastewater collection system and obviously no treatment facilities, however they have every intention of constructing such infrastructure to serve an existing population of approximately 4,200, with a total of 1,050 connections (1,000 residential and 50 commercial). They do have a communitywide potable water system. Eriberto explained that he felt the topography would necessitate two treatment sites, however such final determination will have to occur during the final design process where the incorporation of a lift station, or multiple lift stations could be evaluated. Our WEFTA volunteers could play an important role in the final determination of which treatment technology is most appropriate for the community. We expressed to Eriberto our desire to help him throughout the final design process while evaluating alternatives with whomever he ultimately works with locally in the preparation of final design drawings. We need to keep this communication channel open during all subsequent visits to the valley, and build on experiences gained while assisting with the implementation of wastewater treatment systems at communities further along in the process.

Linda, Jennifer and Eriberto at the proposed site of the WWTP for Yanahuara

Upon leaving Yanahuara, we travelled to **Yucay** where we met with Norman Ochoa of the municipality. Norman shared with us the plans prepared for the proposed treatment plant, evidently consisting of basic primary treatment (Imhoff Tank) and from there discharging directly to the river. The community is one of the smaller urban centers in the valley. Norman explained that the town consists of about 100 families, and 20 businesses (restaurants and hotels). The mayor of Yucay, Leoncio Espinoza, who Lou had met with last year, was unfortunately away on travel during the time of our visit. A follow up visit with Leoncio will be required the next time WEFTA representatives are in the valley to look more closely at the proposed WWTP and discuss other options that may provide additional treatment.

John arrived about midday and we all met with Oscar Olazabel/Pumahuanca and Raul Otazu/Urubamba Assistant Public Works Director, and members of their staffs in the afternoon, at the public works offices of Urubamba. In the evening, we also met with Lucho Acuña, who is a consulting civil engineer from Cusco. His firm has been hired to provide wastewater system design services for Urubamba. These meetings included the following discussions:

The town of **Urubamba** has a population of about 11,000, with about 2,500 sewer connections. The current sewer system has four discharge points to the river, and three of these discharge points will be connected together with a 15-inch gravity interceptor, which has already been constructed in anticipation of construction of a wastewater treatment plant (WWTP). The interceptor has not yet been placed in operation, so the existing sewers continue to discharge directly to the river.

The furthest upstream portion of the existing sewer system could not be connected to the rest of the system by gravity, so will require a small pump station to connect to the rest of the system. The upstream portion of the system serves about 100 families and 20 small restaurants. The small community of Chicon is located a little further upstream, and sewage from their system is transported to Urubamba's system through an 8-inch gravity sewer.

There is a perception issue regarding wastewater treatment lagoons in the area. This is apparently the result of a large failed lagoon system near Cusco, and smaller lagoon system for the town of Pisac which was abandoned after just a few months of service. From the descriptions, these were facultative lagoon systems and were likely overloaded, which resulted in considerable odors when they were operational. John indicated that lagoon systems do not have to have odor problems if they are properly designed and maintained. John also indicated that the potential for odor problems is insignificant with aerated lagoon systems because the aerators can maintain the system in an aerobic mode.

Lucho Acuña is in the process of preparing a preliminary engineering report for the sewer system, which is to include an evaluation of treatment options. At the moment, Lucho is considering treatment systems using aerated lagoons/polishing lagoons and Imhoff Tank/Rotating Biological Contactor (RBC) technologies.

The larger hotels are required to provide their own sewage treatment systems as part of the permitting process for their construction. The only hotel in Urubamba that currently has its own WWTP is the Tambo del Inca (see information below on that WWTP).

The regional government (Departamento de Cusco) is providing funding for upgrades to the Urubamba wastewater system and for construction of the WWTP. The total budget is 35 million soles (about 13.5M USD), of which 10 million soles is earmarked for the WWTP.

March 6, 2013 Morning

In the morning, John and Lou visited one of the new community septic tanks that has been recently constructed for the community of **Pumahuanca**. Our guide was Hernan Concha, who is the president of the association, organized and recognized in Peru as a JASS (Junta Administradora de Servicios de Saneamiento).

Pumahuanca Septic Tank System

This septic tank is one of three new treatment facilities that have been recently constructed; however none of the facilities has yet been put in operation. They are all of the same basic design with the following features:

- Headworks with two bar screens (the first with larger openings than the second) and an overflow weir with overflow discharge directly to the river.
- Grit trap.
- Scum/oil/grease trap. Both the grit trap and scum/oil/grease trap have valved drains for cleaning/maintenance. Hernan did not know where these drain to.
- Septic Tank. The septic tank is reinforced concrete with dimensions of approximately 8 meters (m) long X 4 m wide X 3.5 m deep. The tank includes an internal baffle constructed of concrete walls to preclude short circuiting and a sump at the downstream end from which sludge can be pumped to drying beds. There are two outlets from the tank located at each side of the tank at the downstream end. The outlets are overflow weirs about 1.5 meters long. Because of the gradient of the site, the water within the septic tank will only be about 2 meters deep, which means that there is a large air space above the water surface (about 1.5 m from the water surface to the ceiling of the tank.
- Sludge drying beds. There are two sludge drying beds, each about 4 m X 2 m in plan view. They are filled with gravel and underlain with a perforated drain system. The drain system discharges to the river.

Sludge Drying Beds

John asked about the design criteria for the septic tanks in the Pumahuanca system, but Hernan did not have much information. He indicated that the septic tank we visited will serve about 430 families now, but that it was ultimately sized to serve 800 families. This seems like a lot, and Hernan may have meant that the three septic tanks in combination will serve that population. We also discussed two potential improvements to the septic tank designs:

The first design improvement involves corrosion protection. Because the tanks are reinforced concrete, the concrete above the water surface would potentially be subject to corrosion due to hydrogen sulfide generation. John recommended that the concrete surfaces above the water line (and extending approximately 30 cm below the water line) be coated with a coal-tar epoxy paint. This product can likely be obtained in Cusco, but may require a primer over the concrete surface prior to application. The paint manufacturer should be consulted for the precise application instructions. Hernan indicated that the town had no more budget with which to purchase the coal-tar epoxy paint. Lou offered that WEFTA could provide funding for the paint if the town crews could perform the paint application. Hernan was amenable to that solution, and it was agreed that Hernan would consult with a paint supplier in Cusco, and get back with Lou with the information about the cost. Lou would then have WEFTA provide the funds for the paint.

The second design improvement involves the outlet weirs. These are essentially broad-crested weirs about 1.5 meters long X 20 cm wide that are formed as openings in the walls of the septic tanks. They will act as overflow weirs. An overflow weir like this would potentially compromise the scum layer in the septic tank. The scum layer is needed to control odors and to help maintain anaerobic conditions to optimize the anaerobic treatment process. To improve this portion of the design, John suggested re-constructing the outlets using a standard septic tank outlet arrangement utilizing tees. The tees could be laid on top of the existing outlet weirs and grouted in place using additional concrete or grout. Each tee would have a 50 cm piped extension to draw the discharge water from beneath the scum layer. Three 4-inch tees constructed like this at each of the discharge weirs would handle the design flows. John later drew up a sketch of this improvement and left it with Hernan on March 8.

March 6, 2013 Afternoon

In the afternoon, Lou and John met with Oscar Olazabel to visit the site of the proposed wastewater treatment system for the town of **Ollantaytambo**. Ollantaytambo has about 4,500 permanent residents and can have up to 2,000 tourist visitors daily. There are about 800 connections to the system currently. Residents pay between 2 and 5 soles/month ($0.75 to $2.00) for water/sewage service, and commercial connections pay between 30 and 80 soles/month (~$11.00 to $30.00). These rates are probably indicative of what most communities in the region charge, and represent a significant challenge to the sustainability of the proposed WWTPs. Without a constant influx of revenue, either via taxes assessed or from other sources, the cost of operating and maintaining a WWTP at each community will not be possible to cover.

The existing sewer system of Ollantaytambo discharges directly to the Urubamba River at four outfall locations. All of these outfalls could be combined with a gravity interceptor located adjacent to the river.

We visited the furthest downriver outfall, which is an 8-inch PVC pipe. It used to discharge into a reinforced concrete settling tank before discharge into the river, but the settling tank silted in due to high flows in the river, and the discharge is now from the last manhole on the sewer line directly into the river.

Discharge from one of Ollantaytambo outfalls

We also visited the proposed location for the WWTP, which is about 1/2 kilometer downriver from the outfall noted above. It is an existing corn field located between the railroad and the Urubamba River. The site is about 400 m X 40 m and is outside of the normal river flood plain. The site is large enough that it could potentially accommodate a lagoon treatment system.

Proposed Site for Ollantaytambo WWTP

Later in the afternoon, the team visited the WWTP at the **Hotel Tambo del Inca**. It is a small activated sludge plant with no primary treatment. It consists of four aeration tanks, each about 3 m wide X 8 m long X 3 m deep discharging to rectangular clarifiers, then to an effluent holding tank. The aeration system includes two 7.5 HP blowers distributing compressed air through a series of piping and diffusers (type unknown) in each aeration tank. The effluent is chlorinated by a small hypochlorination unit before discharge to a holding tank. Effluent from the holding tank is used to irrigate the landscaping around the hotel. Sludge can be pumped from the clarifiers either to recycle pipes to the upstream end of the aeration tanks or to sludge drying beds. The effluent from this small treatment plant reportedly achieves better than 90 percent removal of BOD_5.

It occurred to John that this facility could be used as a good example of what odors can be expected from a properly functioning and properly maintained aerated lagoon system. This should be something we consider promoting as some reticent locals express concerns about the notion of aerated lagoons being installed in the valley, based on perceptions discussed elsewhere in this report.

Aeration Tanks for
Tambo del Inca Hotel WWTP

In the early evening, the WEFTA team visited the two septic tank systems that were installed in 2006 at the **Habitat for Humanity Community**, with assistance from WEFTA. Both septic tanks have recently had failures of the seepage pits where the effluent is discharged. It appears that the failure of the seepage pits was due to solids being discharge in the septic tank effluent. This may be due to several factors:

- The septic tanks may be somewhat undersized for the population served, at least by typical conservative design standards used in the USA.
- The outlet from the septic tanks reportedly do not utilize a tee to assure that the effluent is drawn from beneath the scum layer.
- The septic tanks have never been pumped. This is apparently due to lack of appropriate equipment to pump out the grit and sludge that collects in the septic tanks. There are no trash pumps available in the Urubamba valley, and there are no commercial septic tank pumping operations in the vicinity.

The WEFTA team discussed potential solutions to the issues noted above. These included:

- Constructing additional seepage pits. These pits do not necessarily need to be lined because the pits are located far enough from the Urubamba River, such that the risk of polluting the river is minimized.
- Retrofitting discharge tees into the existing septic tanks to draw effluent from beneath the scum layer.
- Purchasing a portable trash pump that could be used to pump out the accumulated grit and sludge. It is possible that this pump could also be used for O&M on the Pumahuanca septic tanks once they are placed into operation. Lou indicated that WEFTA could potentially supply funds for purchasing the trash pump.

The president of the community board, Guillermo Atayupanque, also explained that the recent extraordinarily heavy rains caused a portion of the site near the larger septic tank to subside resulting in a crack in the main trunk line leading to the tank. Guillermo indicated that they intend to borrow machinery from the municipality to excavate the area where the break took place and make the necessary repair.

Later that evening, the WEFTA team was treated to a marvelous dinner at the Habitat community. Many of the leaders of the community brought local dishes for a “family-style” pot-luck dinner. All of the dishes were delicious, including the local delicacy known as “cuy” (guinea pig).

WEFTA team enjoying local Quechua dishes

March 7, 2013

In the morning, the WEFTA team decided to visit the town of **Calca**, located about 16 km upstream from Urubamba. This was essentially a “cold call” because nobody from WEFTA had previously contacted representatives from Calca. We were able to meet with Gerardo Orcon Nuñez, the public work director for Calca, and we explained our purpose in visiting the Urubamba Valley in general and the town of Calca in particular. Gerardo indicated that our visit was very timely because Calca is in the process of developing plans for their wastewater treatment system, and in fact, their engineering consultant from Cusco was scheduled to be in Calca that afternoon (and on March 8) to discuss the progress of the planning for wastewater treatment. After lunch, we met with Gerardo, his staff, and two gentlemen from the consulting firm, Ernesto Malpartida Corrales (civil engineer) and Javier Turpo Briceño (architect).

Calca is a community of approximately 12,000 population currently, and they are planning their wastewater treatment system to accommodate a population of 16,000 within the next 20 years. They do not have direct measurements of current sewage flow, but their design is based on a water usage rate of 200 liters/person/day, and they have assumed that 80 percent of the water usage will end up as wastewater. These assumptions have resulted in an assumed current peak flow of 31 liters/second of domestic sewage, with an additional 10 liters/second of storm drainage, for a peak current flow of 41 liters/second (this calculates as a 1.4 peaking factor for the domestic flows, which seems a little low given the small size of the community). They are planning to construct two WWTPs because their existing sewer system is divided into two systems based on topography and they prefer two treatment plants, rather than constructing a large pump station to connect the two systems. Approximately 60% of the flows will report to the upstream WWTP and 40% will report to the downstream WWTP. The existing sewer system will also require several small sewage pump stations to allow the use of only two WWTPs.

Ernesto presented his plans for one of the WWTPs. These plans were essentially working drawings (i.e. 80 to 90 percent complete with many details and structural drawings included), which seemed unusual, given that Calca is in the preliminary planning phase. One would expect that their consultant would be investigating several options for treatment with only conceptual drawings at this phase of the project. The treatment process shown on the drawings included the following:

Primary treatment through use of a large septic tank. The septic tank was essentially square in plan, using reinforced concrete. The overflow from the septic tank was a weir arrangement, so would potentially compromise the scum layer.

Secondary treatment in an "aerobic" reinforced concrete tank. The concept for this secondary treatment system is to fill the tank with cobbles (around 10cm maximum size) and introduce air into the tank through the use of a "venturi" system. The maximum water depth in the tank is to be 2.5 m. Ernesto was not able to explain how the venturi system would introduce air into the tank under sufficient pressure and volume to maintain aerobic conditions throughout the "aerobic" tank; however, the venturi would be located in the pipeline transferring water from the septic tank to the "aerobic" tank, and this pipeline would utilize gravity flow, so the velocities through the venturi would not be that great. Ernesto promised to provide additional information on how the venturi system would operate. At the bottom of the "aerobic" tank would be a system of sloped drains to collect sludge, which would then be pumped to sludge drying beds. Ernesto indicated that this system had been utilized in communities in the northern part of Peru.

We discussed the concepts for the sewage pump stations, but Ernesto did not have the details on the pump stations. He indicated that he would return to Calca on March 8 and bring his mechanical engineer to discuss the pump stations.

March 8, 2013

The WEFTA team travelled to Calca again on March 8 to continue the meetings with town officials and their consultants. Ernesto brought his mechanical engineer, Jorge Azpiloueta Yanez, to explain the concepts for the sewage pumping stations. They are proposing using dual submersible pumps in a single wet well. The pumps would be mounted on a rail system to allow removing the pumps for maintenance, similar to that used in standard submersible pump stations in the US. There is a pump manufacturer in Lima that makes these types of submersible pumps (the design appears similar to that used by Flygt). This design appears to be appropriate for the proposed use. John suggested some minor alterations to the design to make the pump stations function better.

We then continued the discussion of the treatment system. Ernesto had not yet had the opportunity to provide additional information on the functioning of the venturi system to introduce air into the "aerobic" tank. We suggested that Calca consider the use of a conventional activated sludge system or rotating biological contactors (RBCs) for the aerobic portion of the treatment system. John indicated that he would try to locate some design guides for these two treatment systems to send to Ernesto's team (preferably in Spanish using metric units) when he returned to the US.

The WEFTA team then visited the sites for Calca's proposed WWTPs with representatives from the town of Calca. The upstream site is located at an old landfill, and it appears that there may be

sufficient space for an aerated lagoon system at this location, if Calca wishes to consider that as an alternative. The downstream site is located at an old farm site, and space is limited at this location, so this site would not lend itself to consideration of a lagoon system. Photos of the two sites are included below.

Calca Upper WWTP Site

Calca Lower WWTP Site

We returned to Urubamba that afternoon to meet with Raul. We agreed that we would send him the FTP site directions to load the WW collection system drawings to. We later ran into Victor Acuña, Lucho's brother, who was surveying the existing WW collection system together with some municipal personnel. He shared with us the fact that the entire system was really in poor shape and desperately in need of renovation.

The team then visited the **Santa Rosa de Lima School** where WEFTA assisted with funding for the bathroom facilities a few years ago. We were invited to a lunch that they were having for the staff in celebration of International Women's Day. The general structure of the bathrooms appeared sound and the facilities seemed to be in relatively good working order. The administrative staff was effusive in their thanks for helping make the project possible. They asked if we could assist with the construction of a small shower facility next to the bathrooms. They explained that many of the kids come from very isolated rural homes with no access to running water, and that the showers would be their only access to such facilities. They will work with a local engineer in developing a proposal and present to WEFTA.

That evening, after dinner, Lou met with Bertha Ramirez of Corazones Caminantes, a Peruvian NGO with links to the Heart Walk Foundation based out of St. George, Utah. Bertha spoke about the work she is involved with at some very remote **Q'ero Communities** in the province of Paucartambo, near Ocongate, Peru, at between 3,800 and 4,000 meters (~13,000 feet) above sea level. The families grow mainly potatoes, raise llamas, and now farm trout. This is truly subsistence living, they do not market their goods and have no income. The Heart Walk Foundation has assisted with construction of green houses and trout farms, as well as with salaries of teachers to work in the area. The communities have access to clear water, and are asking for assistance from WEFTA with latrines at each home.

According to Bertha, Ocongate is about 3.5 hours from Cusco in bus, then 3 hours in car from Ocongate to Ritti Coasa … the end of the road (350 soles to hire car), then from Ritti Coasa it's about 5 to 6 hours hiking to Yapu (50 homes), then from Yapu it's another 5 hours or so hiking to Yanaruma (25 homes), Huallabamba (15 homes), Cocha Marco (20 homes) … then do it all again in reverse. To visit these communities will be a real trek, not for the faint of heart! We've provided Bertha the initial project questionnaire that she will complete with leaders from each of the communities and will return to us.

Future WEFTA O&M specialist showing how it's done!

"I know if I just pull hard enough I can get this open to show you all how it works."