

Delivering Digindy!

An unusual contracting arrangement has allowed Citizens Energy Group to deliver its \$2bn DigIndy programme under budget and – in some parts – ahead of schedule. Kristina Smith spoke to owner and contractor to find out how.

The Robbins hard rock TBM that has been working since 2013 to create the DigIndy Tunnel system boasts three world records: most mined advance in one day (409.8ft or 124.9m); most mined advance in one week (1,690ft, 515.1m) and most mined advance in one month (5,755ft, 1,754m).

It can also claim another, altogether stranger record. It has reversed further than any other machine: 40,000 feet or 12km. "We've gone further backwards than most projects have gone forwards," says Mike Miller, construction manager for underground engineering and construction at owner Citizens Energy Group.

Setting a reversing record for TBMs was not on the agenda when the project was first envisaged. It's one of the solutions that have emerged through a long-running relationship between Citizens, contractor S-K JV, a joint venture of J.F. Shea Co. and Kiewit, and designers AECOM and Black and Veatch. What started as a lowest price win for a one-tunnel contract has changed into a 14-year, six-tunnel program.

"The relationship we have had, starting with the Deep Rock Tunnel Connector, going on to White River and Lower Pogues, has been great," says Christian Heinz, project manager for S-K JV. "It's not quite progressive design build but sometimes it feels like it, with us aiding the designers and thinking about innovative ways of doing things."

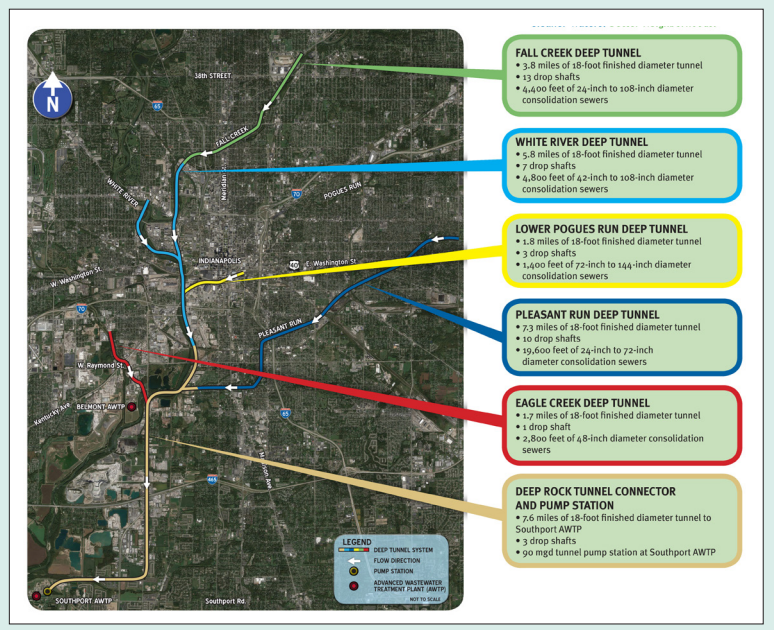
S-K JV won the contract to

Dig Indy Tunnel System

The Dig Indy Tunnel System consists of six interconnected deep rock tunnels, totalling a little over 28 miles (45km). Running 250 ft (76m) below ground level, all the tunnels have a mined diameter of 20 feet (6.1m) with a one-foot thick (300mm), unreinforced concrete liner.

Its purpose is to prevent the flow of wastewater into the area's water courses. Like many sewers in the US, the existing system, which was built over 100 years ago, carries both rainwater and wastewater. It took only 0.25 inches of rain for the system to overflow, causing overflows of stormwater and raw sewage into waterways. The US Government has mandated that these combined sewer outfalls be eliminated by 2025.

When all six tunnels are online, the system will have a resulting storage capacity of approximately 270 million gallons, preventing 5 billion gallons of sewage flowing into Indianapolis' waterways each year. The wastewater will flow via gravity to the Southport Advanced Wastewater Treatment Plant, where owner Citizens Energy Group constructed a new 90mgd pump station to pump flows from the tunnel system up to the treatment plant.



build the first of six tunnels in the DigIndy Tunnel System, the Deep Rock Tunnel Connector, back in August 2011 for a lowest price bid of \$180.2m. That contract included creating a 2,400 ft (730m) spur for the future Pleasant Run Tunnel.

"The contractor mined the spur and backed the TBM up much easier and faster than expected. They were also able to relaunch

underground very efficiently," says Miller. "Probably one of the biggest game changers for the entire program was the contractor's ability to back up the TBM."

This led S-K JV to propose an alternative construction method for the Eagle Creek Tunnel which branches off from the Southern end of the Deep Rock Tunnel Connector. Citizens had intended

to build the tunnel at a shallow alignment through soft ground, but S-K JV suggested backing the TBM right up, mining a deep tunnel for Eagle Creek and then backing it out again.

With no launch or retrieval shafts required, this option offered significant capital and program savings, says Miller. Citizens procured Eagle Creek with a \$38m change order with the designer of the Deep Rock Tunnel Connector, AECOM, having just three months to complete the designs.

Public and private

The original plan for the DigIndy Tunnel System had been to let a series of tunnel packages, starting with the Deep Rock Tunnel Connector and following with White River and Lower Pogues Run tunnels in 2016 and the remaining two tunnels in 2020. Citizens decided to rip up that plan, bundle all the remaining four tunnels into one package and let it a year earlier in 2015.

The reason, explains Miller, is that they saw the market heating up and were concerned that they wouldn't attract the right bidders if they left it too late. "The whispers were starting to become louder about impending labor shortages. Skilled trades are suffering in the US. It's hard to find people," says Miller. "Also, a couple of other major tunneling projects were going to be let in 2016. We said let's solicit early to get out of the way of those."

The solicitation process was somewhat unconventional. "We got our black books out and called our friends in the industry at reputable firms we wanted to work with," says Miller. Interested parties came for extended meetings to review drawings and plans together. From this process, two bidders emerged: S-K JV and Southland Mole JV.

S-K JV was the victor, with the \$485m contract finalised in May 2016. Miller believes that some of the bidders were discouraged by the fact that S-K JV was already there on site. "The big deterrent was we had a tunneler who had built a tunnel and who had a TBM here. But if you think about how much it costs to mobilize a TBM on this size of program it

would not have been that big an advantage."

The reason Citizens could operate in this manner is that it is not a public body. It is a charitable trust which dates back to the 1800s, set up to protect the city's natural gas reserves. Now it looks after other utilities too and purchased the clean and wastewater utility from the City of Indianapolis in August 2011, weeks after the Deep Rock Tunnel Connector contract had been awarded to S-K JV.

"It's allowed us a lot of flexibility in the program," says Miller. "We are very aware of how lucky we are."

The contract is a bespoke one, drawn up for Citizens by its construction lawyers, with each tunnel project comprising a lump sum component and a number of unit price items.

Good progress

The first two tunnels – Deep Rock Tunnel Connector and Eagle Creek – were put into service along with the new pumping station at the end of 2017. Eagle Creek was a year ahead of the 2018 date in the Consent Decree.

S-K JV made the final breakthrough for the White River and Lower Pogues Run Tunnels in April 2019; these two must be online by the end of 2021. S-K JV is already mining Fall Creek since this is a continuation of White River. The Fall Creek and Pleasant Run tunnels must be in service by 2025.

At the early stages, Citizens had imagined needing two TBMs. But now it is clear that just one machine – the 20.2 ft (6.2m) diameter Robbins Main Beam TBM – will mine the lot. Originally built in 1980, and used on at least five other hard rock tunnels, including New York City's Second Avenue Subway, the TBM was refurbished and upgraded before the start of the program.

Citizen's package approach to procuring the tunnels has also led to value engineering gains for the shaft construction, of which there are many: four of the eight large-diameter working shafts which will become drop shafts for combining flows in operations and over 50 small-diameter drop or vent shafts.



The larger shafts, which are 240 to 250 feet deep (73 to 76m) are constructed with slurry walls through the overburden and then drill-and-shoot in the rock. "The original design had two different sizes of concrete finish on the slurry wall shafts. We proposed having one size of shaft all the way down so that we only have to buy one form," says Heinz.

Most of the smaller-diameter shafts have been constructed by oscillating steel casings through the overburden and then raised-bore for their lower portions. The drop shafts extend into a deaeration chamber, offset from the main tunnel and with its own vent shaft too. They are connected to the main tunnels by traditionally-mined adits, varying in length from around 20ft (6m) to 1,700 ft (518m) in one location.

The S-K JV stands proudly in front of the cutterhead for the 6.2m (20.2 ft) diameter Robbins TBM.

Early shaft works in process

Advised by S-K JV, Citizens agreed to purchase all the steel casings for the small-diameter shafts upfront, a \$3m investment. "At the time, the price of the steel was low. It would cost twice as much to buy them now," says Heinz. "It was a good call", says Miller.

Purchasing all the casings early has also meant that the shaft construction can take place in one deployment, rather than re-paying for mobilisation in several phases. Both Miller and Heinz are very complimentary about the achievements of Malcolm Drilling which has been using its 3.8m oscillator to install the 12-foot (3.7m) diameter cans casings through the overburden and into the rock.

"The crew that Malcolm have sent are phenomenal," says Heinz. "They get on and off site, get the casings for two shafts at each site in, 100 feet deep and oscillated 5 feet into the bedrock, in less than two weeks." Equally efficient subcontractor, EZ Construction, paves the way for Malcolm, preparing the sites one week before the drilling begins.

Miller compares Malcolm's method with an alternative system used for six shafts that had to be installed earlier on sites with planned developments. "Early on in the project we had to construct six of the shafts a few years ahead of time for the White River Tunnel due to some pending development. Those shafts were excavated using a large-crane mounted drill rig which was extremely expensive, time consuming, and very inefficient."

As well as being delivered comfortably on schedule, Citizens says that the overall price tag of \$2bn is trending \$400m less than the budgeted cost, thanks to their cunning procurement strategy and successful value engineering.

For S-K JV, there aren't too many risky situations ahead. "By having the relationship we have, we have taken away what could have been the really difficult things on the project," says Heinz. "I don't want to say this project is easy but really there's nothing out of the ordinary, apart from the backing up."

The backing up process isn't too different to retracting the



cutter head for inspections, says Heinz. "You remove all your belt structures and utilities first, put in push beams and reverse the mole," he says. "We used split sets for our rock support which are almost flush with the tunnel surface. We didn't remove any parts of the cutter head which means we only have 2 inches to play with."

There are some small clouds on the horizon though, admits Heinz: "Labor shortages in Indiana are going to be coming to a head very soon. In July we will start mining Fall Creek and lining White River and Lower Pagues at the same time. With most tunnels, we mine it and then we line it. Here we are doing both things at once."

To mitigate the risk of labour shortages, S-K JV has been busy hiring people to build up a workforce. But that, too, is challenging: "For every 10 people we hire, we can keep two or three," says Heinz. "It's hard work and they need to show up every day. It takes a special type of person to like what we do on a daily basis."

New risk sharing approach

When asked what the biggest challenge on the project has been, Heinz replies without hesitation "water". Although the rock along the various alignments is favorable to tunneling, water ingress has been less predictable than the formation.

Heavy inflows of water during the construction of the Deep

Rock Tunnel Connector led to a successful differing site conditions claim by S-K JV of \$1.3m to compensate for standing time and extra grouting. It also led to Citizens rethinking the way it handled this particular risk.

"One of the outcomes of that was we leaned on the contractor to implement more of a consistent probing and grouting program," says Miller.

On Deep Rock Tunnel Connector probing and grouting had been at the contractor's discretion. The new regime, which began on the Eagle Creek Tunnel, requires that two probe holes are drilled 180ft (55m) in front of the machine. If there's more than 10 gallons per minute (0.75 litres per second), S-K JV has to stop and grout. The contractor gets compensation at an hourly unit rate plus materials, with one hour allowed to clean up.

For the contractor the requirement for probing and drilling is a good thing – and a bad thing too. It's a question of risk tolerance, says Heinz.

"It works out well, but it is one of the reasons why we won't get the world record again because we do have to shoot probe holes out every time we go," says Heinz. "One thing we have done, midway through White River is change to a different probe drill. We're using a down-the-hole hammer probe drill that can go straighter and longer. We haven't fully realised the advantage of the new system but it may come out on Fall Creek."

The winding route follows the White River overhead and contains curves as sharp as 300m (1,000ft) in radius.



Final
breakthrough of
the trusty Robbins
TBM

There may be room for compromise on Fall Creek says Miller. "If it turns out to be dry, we may hold back the probe requirement."

Citizens also decided to do away with its Dispute Resolution Board at this point. "The reason for that goes back to how we are structured as an owner. Since our solicitation involved inviting firms we wanted to work with and partner with in the long term, the idea was that we can work through difficulties ourselves without a dispute resolution board."

"We looked at the risk and our biggest risk is water. We had a great dispute resolution board on Deep Rock Tunnel Connector but when we had a conflict which was related to water they said 'you try and sort it out yourselves, we don't want to handle water and grouting.' So, knowing the biggest risk is water, it didn't make sense to keep them on."

S-K JV is happy with that arrangement, says Heinz: "A restaurant is a lot more comfortable than a court room. Since we have been on White River and Lower Pogue, it truly has been a partnership. There's been no yelling or screaming it has just worked."

Art of the curve

One word to describe the DigIndy Tunnel System would be 'curvaceous'. The Deep Rock Tunnel Connector has a 45 degree turn, two 90-degree ones and a small S curve, where the tunnel veers round an extra 10 foot strip of land owned by a local quarry. The White River and Lower Pogue Run sections also feature

two 90-degree bends where the machine had to turn off to create the two branches (see map). "It's a very unique design, one that I have never seen in any CSO tunnel," says Heinz.

While the curves do not present a problem for the TBM, they do present challenges for the conveyor system. According to Robbins, which supplied the conveyor system, the Deep Rock Tunnel Connector boasted the longest continual belt in alignment with so many curves. "We have to give a lot of credit to Robbins and Dean Workman," says Miller. "This was his baby."

Workman, who heads up Robbins' conveyor business, also advised on what was possible on future sections. The branch off the White River Tunnel was originally a loop that turned through 90 degrees and then a further 90 degrees to rejoin the main tunnel alignment. "Dean was in town, consulting on the Deep Rock Tunnel Connector," recalls Miller. "He said 'no way' to two tight 90 degree turns but that he could absolutely get to the end of the spurs," says Miller. The ability to back the TBM up allowed the White River Tunnel alignment to be redesigned with a dead end spur, eliminating the back to back 90 degree turns.

The many curves are negotiated with the help of Robbins' self-adjusting idlers which sense changes in load on the belt and adjust accordingly. And with lots of hard work. The contractor had to maintain the belts diligently, checking and replacing rollers, looking at boosters and monitoring oil levels.

The belt on the White River and Lower Pogue runs took a good beating, says Heinz: "We don't have that belt anymore."

Unique relationship

Miller describes the relationship between Citizens and S-K JV as "very unique". "It takes time, but we have been able to develop a strong mutual trust. This allows us to work through tough issues, as well as negotiate fairly," he says.

Since contractor and designer have no contractual relationship it is up to the client to manage aspects such as how constructability is incorporated into the design. "There have been times when Citizens have stepped in and encouraged the designers to be open to certain things. We have had to encourage the contractors to be open to certain things sometimes," says Miller.

"We are not too scared to change things," he continues. "We try not to have too much pride in authorship."

However, with changes in scope come some of those "tough issues" he mentions. "Every now and then, when we eliminate scope, the credit does not come back as we think it should," says Miller. "We do have some arm wrestling over credits."

S-K JV on the other hand, does have uncertainty to deal with. For instance, it looks like 3,000 ft (914m) could be eliminated from the end of Fall Creek, although this had not been confirmed as tunneling of that section was beginning. "That's probably one of the frustrations of having the procurement done years before it was supposed to be," says Heinz.

There are still a lot of reasons for S-K JV to preservice its unique relationship with Citizens. "Contractually we awarded the four contracts, but we have a clause that says we can buy Pleasant Run out if, for some reason they don't perform," says Miller. "However, we have issued a partial purchase order for the Pleasant Run shafts in order to capitalize on Malcolm's presence in town."

Heinz is confident that SKJV will get to finish the whole Dig Indy Tunnel System. "I have moved my family here," he says. "I'm staying until 2025." 