propeller

Cut and Fill Calculations in Drone Surveying

The largest use case for drone surveying on worksites is calculating volumes. For those in the industry who rely on accurate cut and fill calculations, this won't be surprising. Small differences in cut and fill volumes of earth over large sites can make for huge changes in overall quantities, which is why cut and fill quantities are so vital for on-site personnel.

In this ebook, we'll discuss how drone surveying and cloud-based data processing can revolutionize your cut and fill calculations—from getting data faster and more frequently to surveying at lower costs and getting more intuitive visuals to work from.

We'll be covering the following and more:

- How cut/fill quantities are captured traditionally
- The ways drone surveying changes the game
- How these quantities are calculated
- Ways different industries use drones to do their cut/fill drone surveying

Small errors can snowball into big losses

When you're calculating cut/fill on your worksite, you know that even small deviations in cost estimating can snowball into big margins of error when applied over your whole site. This can cause variances in your budget. Unsurprisingly, getting accurate quantities is one of the most important tasks when it comes to surveying on site.

No matter what industry you're in, you're likely using cut and fill numbers in one way or another. Maybe your construction site is moving earth to level out a road build. Maybe your mine is planning a blast and you need to know how much material it will yield. Maybe your landfill needs to know how much remaining airspace a cell has. Maybe your quarry needs to know how much material went from the stockyard into the crusher.

Before drones came on the scene, making surveying faster and simpler, these values were calculated the traditional way—with a surveyor and a base and a rover, walking the site. So how did they do it? What were the capabilities and limitations of the traditional method?

Calculating cut and fill quantities the traditional way

Before you could expect to see a drone flying over a worksite and think nothing of it, surveying was a boots-on-the-ground activity. It meant a surveyor traversing a site with a base and rover, shooting individual points. From that data, surveyors got accurate positions, made designs and site models, and used tried and true formulas to calculate volumes.

As many industry veterans know, this process could take days or weeks to complete. Much slower than the work on your site itself was moving, which meant you were often looking back at past quantities on site, rather than having data that reflected what was on your site today, be it a quarry, mine, construction site, or landfill.

Regardless of what you're moving, cut/fills affect the everyday work of many people on site.

Getting cut and fill calculations using drones

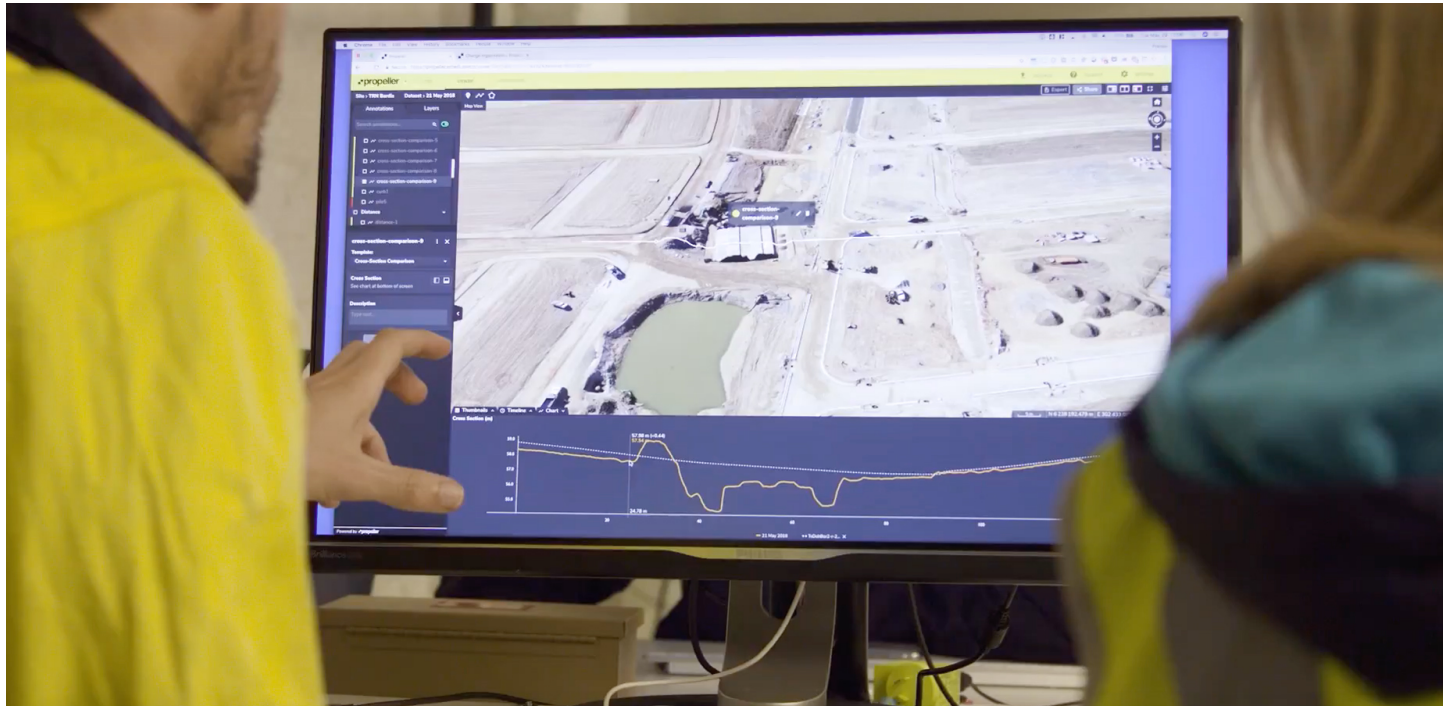
Drones change the game when it comes to surveying your site and getting cut and fill numbers. They're faster. They're easier. They're more affordable.

Since the hardware and processing costs less money than traditional surveying, you can get updated data as often as you want to fly. Drones are pretty user-friendly, so you don't have to hire third-party surveyors to walk your site.

While every site is different, you can expect your own drone surveying workflow to look something like this:

- Preplanning
- Ground control placement
- Launching your drone and flying your mission
- Landing and wrap up

While some newcomers to drone surveying often place a lot of emphasis on the data-capture side of things, they can forget about what comes down the line: analyzing that data. After all, that's why you went through the effort of flying the drone in the first place.



Once you've captured your data and it's been processed by Propeller, that's when you can start analyzing and measuring.

It's as easy as drawing a shape around the region in question on site—just a few clicks and the computer calculates your cut/fill, and if you know your material type, you can calculate the density too.

Now, let;s explore how the Propeller Platform calculates those cut and fill values from your drone imagery and ground control data. Then, we'll jump into how you make those calculations on your particular worksite.

How cut and fill calculations work in the Propeller Platform

Illustration of a consistent flight path and good camera positions for drone photogrammetry.

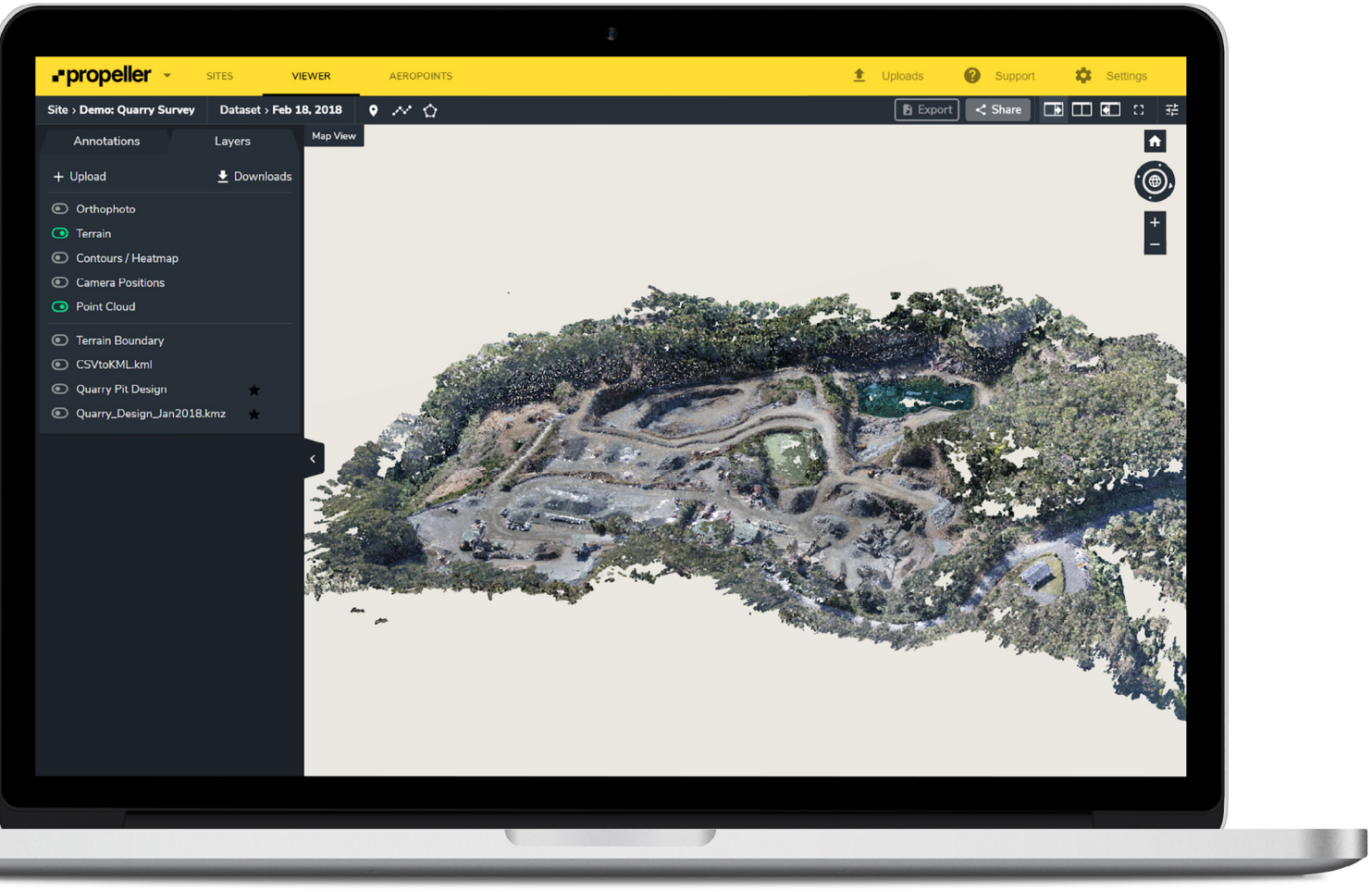
Propeller uses photogrammetric surveying to build your 3D site surveys, which means we combine aerial photos and ground control data to stitch images together to make your site model.

At its most basic, “photogrammetry” is measuring via photos. It might sound dry and complex, but its inner workings define the way we fly.

When you send your drone up, it photographs your site with lots of overlap. The 80% overlap on each image is necessary for two reasons:

- For the computer to stitch images together to make the orthophoto.
- To capture enough angles of each feature to model it in 3D.

We can’t overstate the importance of steady, consistent flight in getting these photos right, so we recommend using a flight planning app like DJI’s Ground Station Pro. (You can read more about flying tips in our Beginner’s Guide to Drones series.)



Point cloud view of a quarry site

The gist of the science

If you see the same feature from three or more known positions, you can triangulate its location in space—nail down those exact X, Y, and Z coordinates. A feature is any distinct point in an image.

If you took a couple average images from your survey, you'd easily be able to pick out many "features" between images. The more features you match, the better you can relate images to each other and reconstruct objects within them. This is exactly what photogrammetry software does for one feature, and the next, and the next, and so on, until it's covered your entire site.

Once you have a lot of these features—think millions—you can create a "cloud" of points. You can then turn your point cloud into any regular outputs used in geospatial software, like a 3D mesh or digital elevation model (DEM).

Quarry volume measured in 3D using drone photogrammetry software

You're using photogrammetry right now

The best way to visualize this is to use your eyes—literally. Your eyeballs are using photogrammetry all the time.

You have two eyes (cameras), processing a live feed of your surroundings. Because they're slightly apart, you get two different inputs at slightly different angles. (Test this yourself by holding up a finger and looking at it with one eye closed, then the other. You'll notice your finger jumps relative to background objects.)

Your brain knows how far apart your eyes are, which allows it to process this info into a sense of distance by merging both feeds into a single perspective. (If you've ever tried to catch a ball with one eye closed, you know it's difficult because you have no depth perception.)

Your mind is rendering a live depth map of the 3D world from two 2D inputs—just like how Propeller renders a 3D survey from many 2D photos.

How does stitching work?

Once you know the shape of something in 3D (from the features and points above), you match that up with its visual appearance. This is where image stitching and "ortho-rectification" come in. Stitching is like putting together a jigsaw puzzle. When you assemble one, you look for common features—corners, bright shapes, etc.—to fit together everything more easily.

Now imagine trying to do that if the puzzle was facedown or all shades of brown. Much more difficult, but that's how complex it is to stitch photos of physical terrain and why we used computers to do it. When we have multiple images of the same feature from different angles, computers can compile the finished picture—the orthophoto—easier and faster than a human ever could.

Get the best cut and fill software for your worksite

Every site is unique and has job- and project-specific needs when it comes to cut and fill calculations and cost estimating. Since everyone is starting from a different place, we thought it'd be useful to outline a few different cut and fill use cases in different industries.

Below you'll find workflows and report examples for cut and fill volumes for a construction site, quarry, mine, and landfill. Skip ahead or read them all.

Calculating cut and fill quantities on your construction site

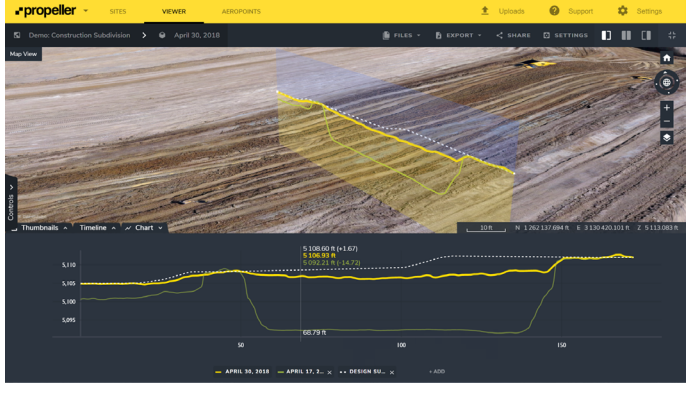
When it comes to construction, sites can vary widely in their plans and look. To illustrate the benefits of drone surveying in calculating cut/fill quantities, let's look at a housing development site.

For a project like this, adherence to design is a big issue. Specifically, getting those housing plots dug out and leveled according to the linework. For repeated, fine-grained cut/fill work like this, 3D visualizations can be more helpful than ever in giving you a bird's-eye view of your whole site or individual plots.

Of course, you're also looking to track individual progress and productivity on active areas of the site. With simple tools, you can set up measurements that show you volumes for as many areas as you choose to highlight. On-screen calculators instantly show you the cubes for that region.

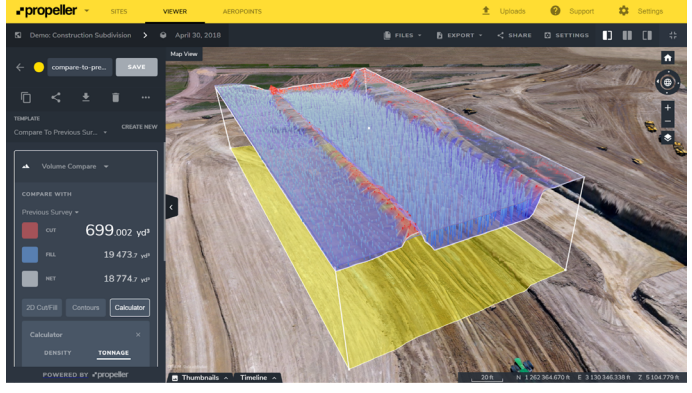
If you want to compare to a previous survey or to the linework itself, you can do that two ways.

Cross-section view:



These colored lines correspond to each survey or surface you've uploaded into Propeller. As you move your mouse along those lines, you also get elevations.

Or in 3D:



Sometimes you want to see that virtual-reality look of 3D. For that you can also view the site with 3D overlays of past surveys or your design to see how things are progressing—get a visual read on how much work's been done and how much is left to go, all without looking at a single spreadsheet.

Never move someone else's dirt again

Cut and fill quantities go far beyond simple, important volumes you need to take out or put back in the ground. They also determine how you're billed for moving earth and contractor work. Sadly, too often on construction sites you can get stuck moving someone else's dirt because the recordkeeping was sparse or you couldn't prove or disprove the amount of dirt a contractor said they moved.

Using Propeller in combination with the more frequent surveys drones allow you to get a paper trail with rock-solid quantities you can use to mitigate such claims. Whether that's moving someone's dirt or realizing an initial topo gave inaccurate quantities of how much dirt would need to be moved, you can get the objective numbers on your job and not be surprised when you walk on site.

Cut and Fill Case Study: Lange Land Surveying

One of our customers ran into just this issue. Lange Land Surveying, a full service land surveying company in Arvada, Colorado, had conventional, GPS, and now drone-mapping and analytics capabilities.

They flew a development for their client Remington Homes. Normally a 25-acre lot would mean three days spent in the field.

> "With Propeller's AeroPoints ground control hardware, and drone-mapping and analytics software platform, we're able to fly the entire site in just half a day, so it's saving us two and a half days of boots on the ground," Jon Lange of Lange Land Surveying said.

With the existing 3D surface in Propeller, the LLS team uploaded and compared their data against the design and preliminary development surfaces.

The drone flight captured more dirt on each lot than was originally budgeted by Remington Homes. But with this new data, the builder was able to build the additional dirt movement cost into the price of a home, amounting to a $2,000–$3,000 savings per lot.

All in all, their client recouped roughly $187,000 of savings.

> "Propeller is helping us with land surveying—we're able to manage our time more wisely," Lange said. "We're saving our clients tons of money and making our investment in Propeller back quickly."

Cut and fill software helps at every stage of construction

As we've seen, having accurate numbers on hand at any stage of a construction project means potentially reducing costs, smoothing over future disputes, and getting everyone on the same page. When you need to relate these earthworks calculations, platforms like Propeller have easy-to-use reports in both CSV and PDF.

Measuring cut and fill quantities on your quarry or mine

The aggregates and mining industries are all about quantites—how much is sitting in your stockyard to how much is going in your crusher or mill to how much you need to extract. Cut and fill volumes are used in almost every stage of the quarrying and mining processes, and while any calculation errors are a problem, these have the potential to carry over and affect your business in myriad ways.

Since these two industries have similar workflows, we're going to tackle both here because no matter what material you're getting out of the ground, you need know know how much you've got in stock, how much is going into the mill or crusher, and how much you need to blast.

To see where cut and fill software can improve mine and quarry management and efficiency, let's follow the material from extraction to the stockyard.

Visualize your blasts with 3D blast planning

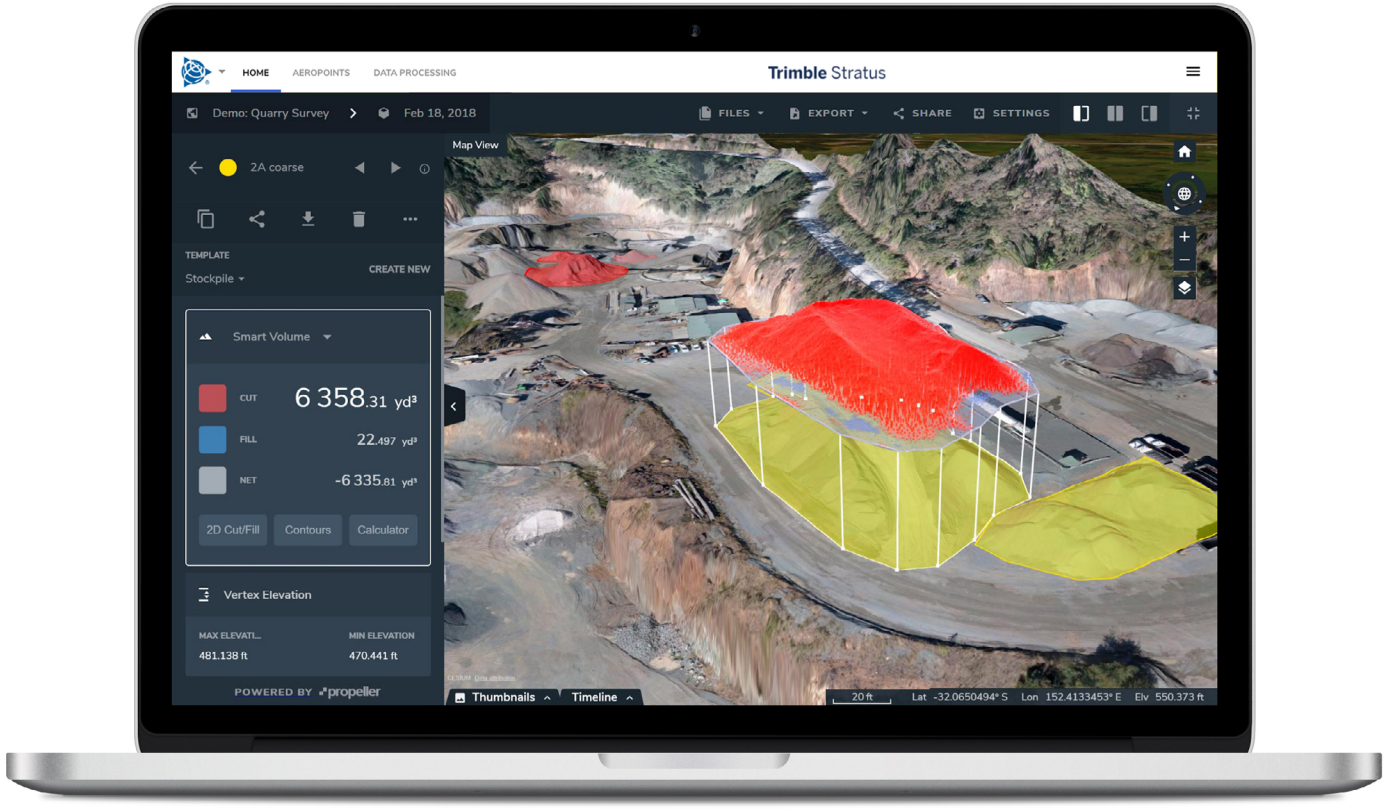
Before you can build up your stock, you need to extract it. Making decisions with the most up-to-date and reliable information is critical for any site manager, especially when planning and executing blasting work on a mine or quarry site. Keeping your site survey and bench level plans updated and accurate can dramatically improve blast results and significantly reduce drilling and blasting costs.

Any area of interest on your mine or quarry can be easily and inexpensively surveyed with drones. Once your drone-captured photos are uploaded to Propeller you can generate centimeter-accurate 3D models and georeferenced orthophotos of the blast area for further measurement and analysis.

When planning blast works to fill a specific customer's order, a volume can be easily identified on the 3D model using the Volume to Reference Level measurement tool. You simply draw a shape around the blast area, set the bench level to "blast to," and the computer crunches the numbers.

These images also provide good source of data for visual assessments of blast results like muckpile shape, back damage, distribution and fragmentation. Plan your postblast logistics better using the fragments size and location data. You can also measure pile volume, fragments size, add annotations, and share blast reports with the stakeholders directly from the Platform.

With the Volume Compare feature, the blasted volume can be compared against the plan to ensure the right amount of material was extracted. If you have any design or linework, you can overlay that into the model to help with accuracy and quality—and make sure you're not leaving resources in the ground, a.k.a money on the table.



Quick pit and stockyard volumes

Similarly, pit volumes are quick and simple to complete. With additional calculators, you can take the guesswork out of tonnage measurements, and thus the value of your stockyard. (If you want to learn more about stockpile measurement and reporting, check out our ebook on the topic.)

Ensuring you have the correct grade blends going through your mill or crusher is essential to success. Too often, insufficient input grades are only discovered after the fact, when the final material doesn't add up to what went in to your processing plant. Instead of backtracking to see what went wrong where, you can use Propeller to monitor your stockpiles before something goes wrong, and see what's been taken from where.

We know waste dump surveys, too, can be difficult. It's nearly impossible to send someone out to walk those piles, but with drone surveying you can capture the data you need in hours not days without sending someone to walk over dangerous piles.

No matter what area of site you're surveying, once you send your data to Propeller for processing it only takes 24 hours for your survey to be rendered and ready for use—reports and all.

Waste Stockpile (polygon)

Map Key	Annotation	Template	Material Type	From Dataset
A	Composted Soil Cover	Waste Stockpile	SOIL Soil (non-contaminated)	Mar 14, 2018
B	Concrete	Waste Stockpile	AGG Aggregate	Mar 14, 2018
C	Fine Sand	Waste Stockpile	VENM Virgin Excavated Natural Materials	Mar 14, 2018
D	Soil Cover	Waste Stockpile		Mar 14, 2018
E	Woodchips	Waste Stockpile		Mar 14, 2018

Composted Soil Cover

Created by Francis Vierboom on 05/10/2018 4:51 PM

VIEW IN PROPELLER

https://propeller.prpellr.com/p/viewer?share=9oX8WMjLhyEDtm

MATERIAL TYPE	SOIL Soil (non-contaminated)
FROM DATASET	Mar 14, 2018
TO DATASET	smart volume level
SMART VOLUME FILL	0.535 yd³
SMART VOLUME NET	-166.166 yd³
SMART VOLUME CUT	166.701 yd³
NOTES	

Calculating cut and fill quantities on your landfill

Each industry has their own jargon and use cases, and in the waste management industry what others might think of as cut/fill volumes are airspace calculations and provide a method for finding your compaction rates.

Landfills get paid per ton of waste. With a set amount of airspace you can fill, the amount of waste you can get into that airspace defines the performance of your landfill—this is the compaction rate.

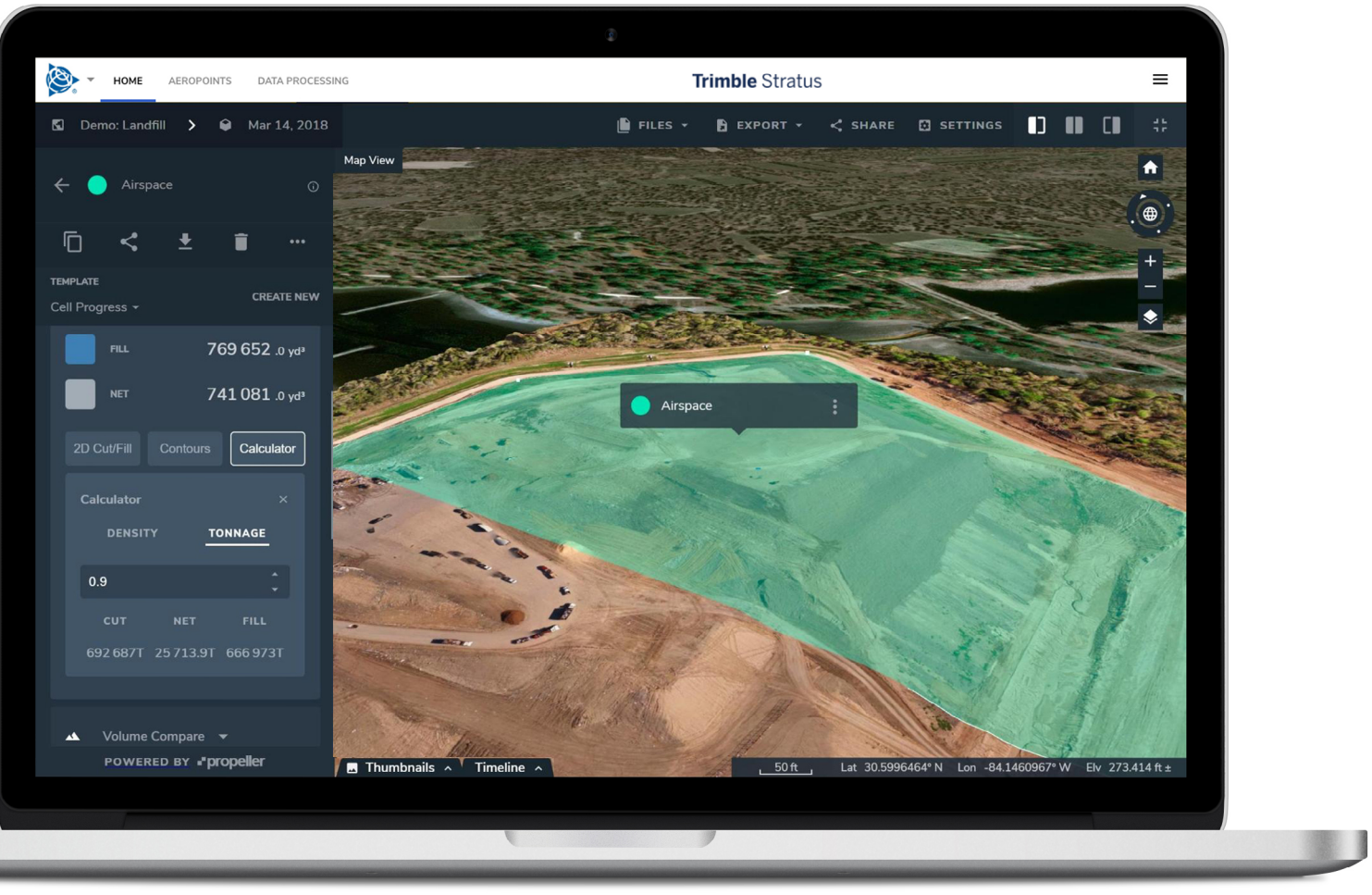
If you have a weighbridge, drone, and access to Propeller, you can easily measure your compaction rate every time you fly. It's as easy as drawing or importing your cell boundaries, comparing volumes between different surveys, turning on the on-screen density calculator, and adding in weighbridge data.

But that's just one way cut and fill calculations play into landfill and cell management. Another way is during the high-cost building of new cells. A huge—both physically and cost-wise—undertaking for a landfill and often involving many contractors.

When you are surveying via drone you can do so more often at better cost, thus getting more up-to-date data.

Similar to other industries, being able to track accurate volumes of earth moved allows you to better track contractor work and ensure that you're being charged for the work that was actually completed.

Let's start with airspace and compaction, two of the most important numbers on any landfill.



Find remaining airspace in seconds

When it comes down to it, you just need to know how much airspace is left. Whether it's for a specific cell or your entire landfill, but too often isn't accurate enough when using traditional surveying methods. When compaction-rate estimates go awry, not knowing can cost you big.

Aside from the drone surveying benefits gained from having up-to-date information more frequently, with processing platforms like Propeller you can calculate remaining airspace in seconds. It's just a matter of a few clicks.

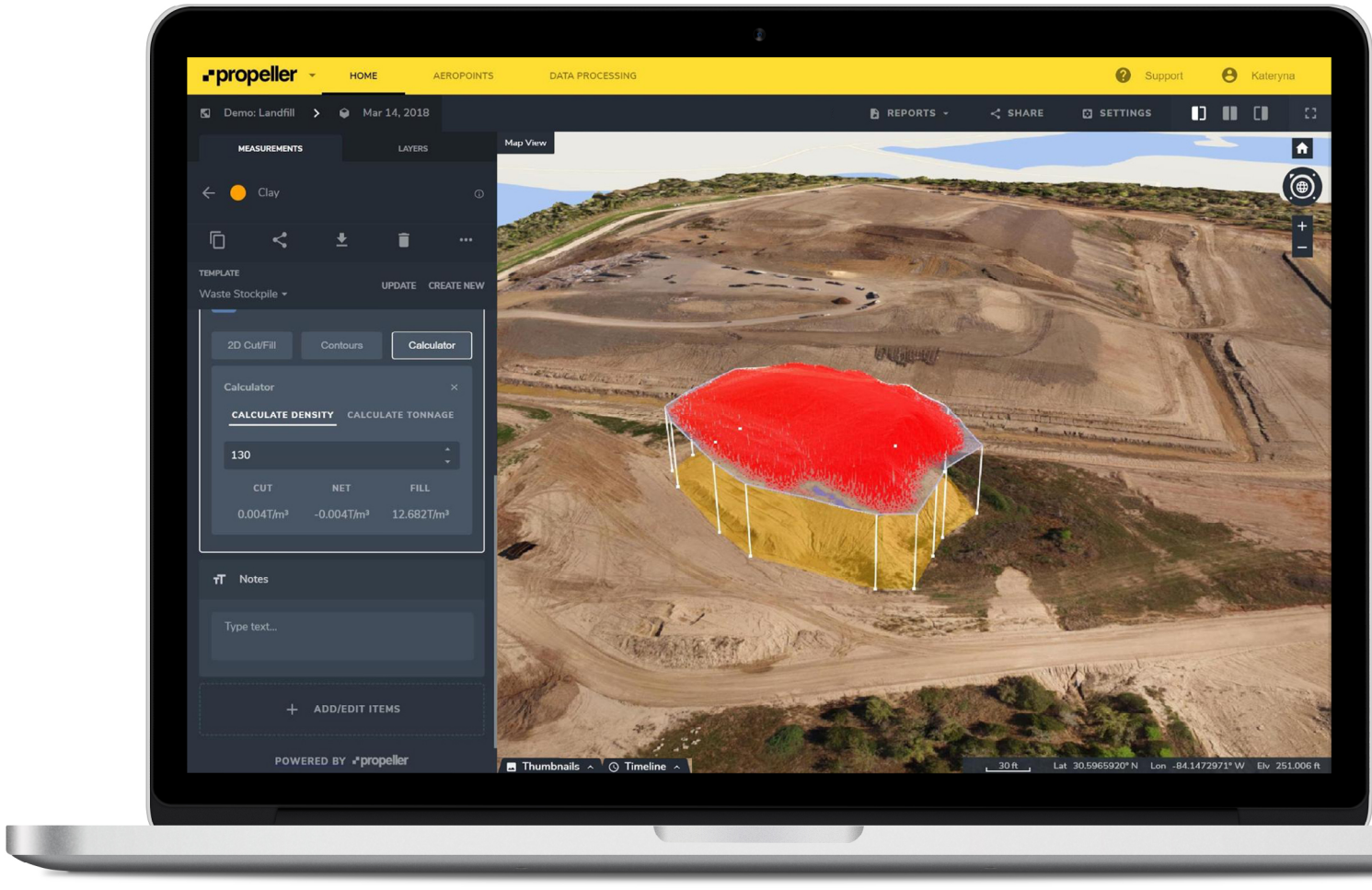
To make this calculation even more useful, you can also upload top-of-waste design. Easily view your site today compared to its TOW, all in 3D. With these parameters, spot where you've overfilled.

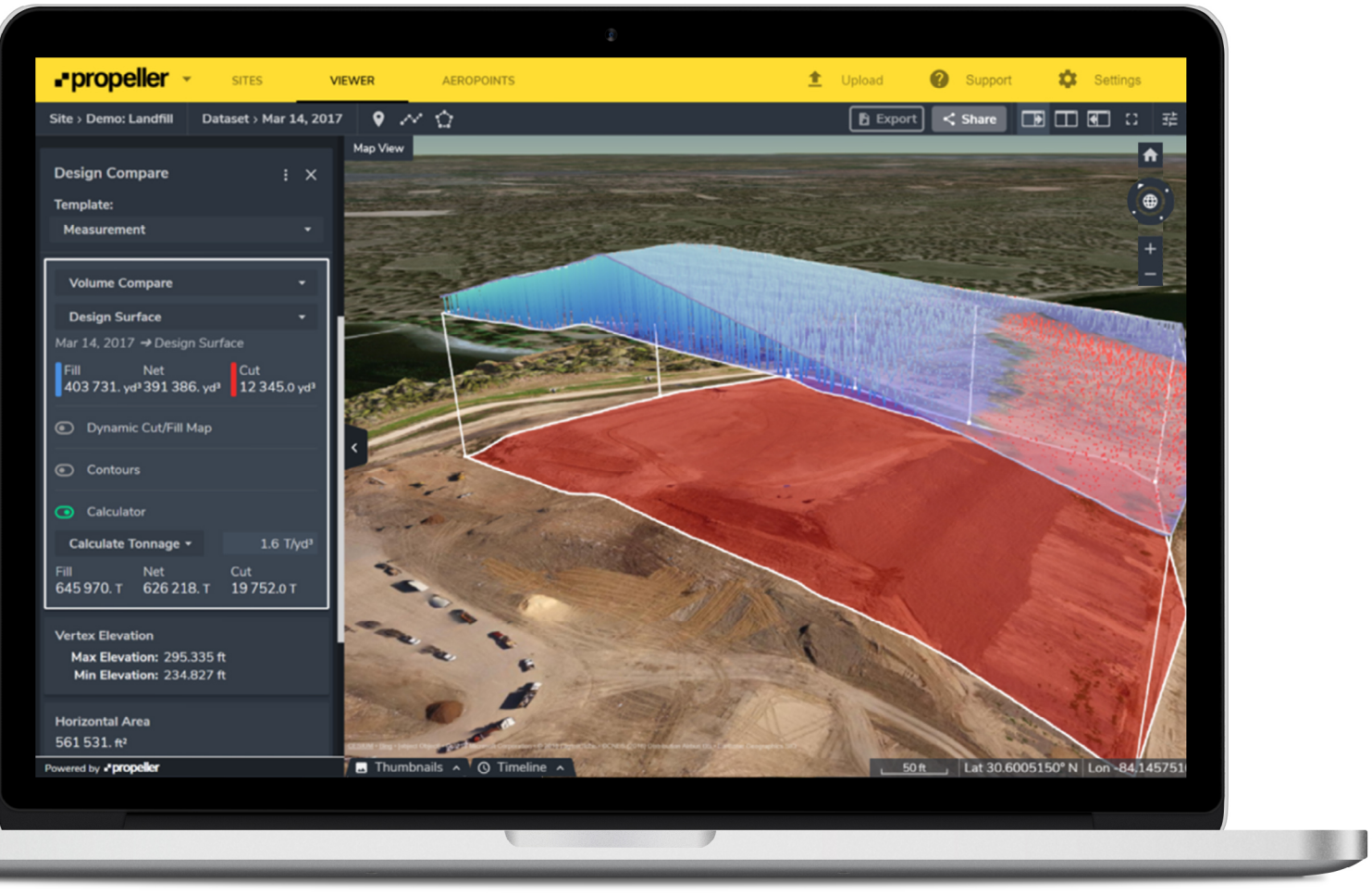
All the relevant numbers are automatically calculated, and display on the calculator on the left-hand side of your screen.

Track landfill density accurately and quickly

If we're talking density, you can also use drone data and a processing platform to calculate compaction rates and densities in a fraction of the time. Easily compare rates between surveys or with the design itself, then add in weighbridge data, and let Propeller do the math.

Similarly, when you fly frequently, you build up a visual history of your landfill. This drone data timeline lets you see and measure settlement over time and place. Is one part of your landfill settling faster than the rest? Drone imagery rendered into a measurable, 3D site visualization makes it easy to spot that—and communicate it to the people who need to know.





Monitor landfill productivity and quality

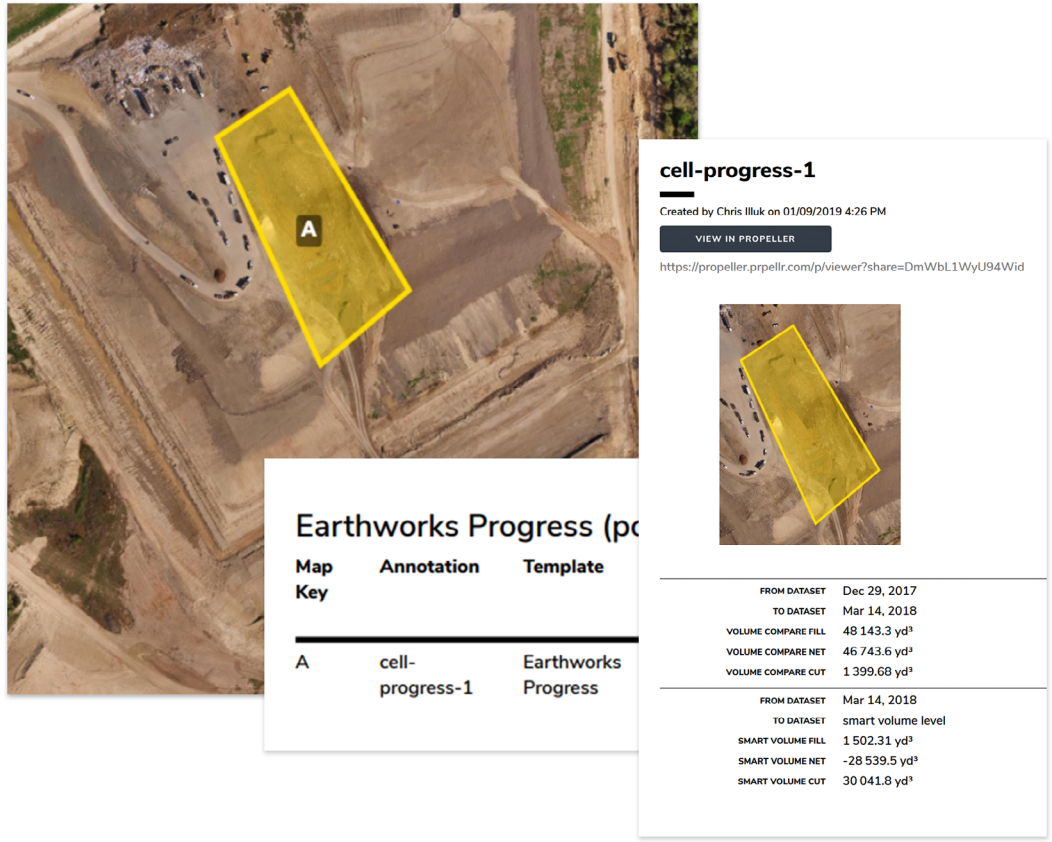
Of course, knowing how you're faring against top-of-waste design is a big focus. To describe an entire landfill, you would usually need to walk multiple lines across the waste, use those points to interpolate an approximate elevation model, and then compare that model against the TOW design.

In Propeller, this workflow is significantly shortened: you can simply upload your TOW design. This gives you an overlay on the 3D site survey, which instantly highlights how you're progressing. It takes the guesswork and abstraction out of the process, and lets you have a visual conversation with your team or your boss.

Each of the measurements we've been talking about can also be individually exported in to reporting formats for your monthly or quarterly reporting. Having this data up-to-date, easily readable, and linked together on a site timeline allows for better landfill management.

Cut and fill software helps at every stage of landfill management

As we've seen, having accurate numbers on hand means thoroughly tracking remaining airspace, maximizing compaction rates, and getting your whole team on the same page. When you need to relate these calculations, platforms like Propeller have easy-to-use reports in both CSV and PDF.



Worksite cut/fill calculations are streamlined with drone surveying

No matter what industry you're in, cut and fill quantities likely play a pivotal role in your day-to-day business. With drone surveying and Propeller, you can get those numbers faster and more affordably than ever. Because the survey processing takes hours not days, you can survey more often and get data that's as up-to-date as you want to fly.

Data processing takes 24 hours, after that your 3D site survey is rendered and ready to access from your browser. From your screen, you can calculate cut/fill accurately on your site in just a few clicks.

From mines to quarries to landfills and every construction site in between, having access to updated data and accurate cut/fill quantities means saving time and money.

Using drone surveying and Propeller means no more guessing, no more working from twice-yearly surveys. You're site is changing every day, so make sure you've got data that can keep up.

If you want to see Propeller in action,

Check out a demo

or read more about volumetrics in our ebook on stockpile measurement and reporting.

Read more