

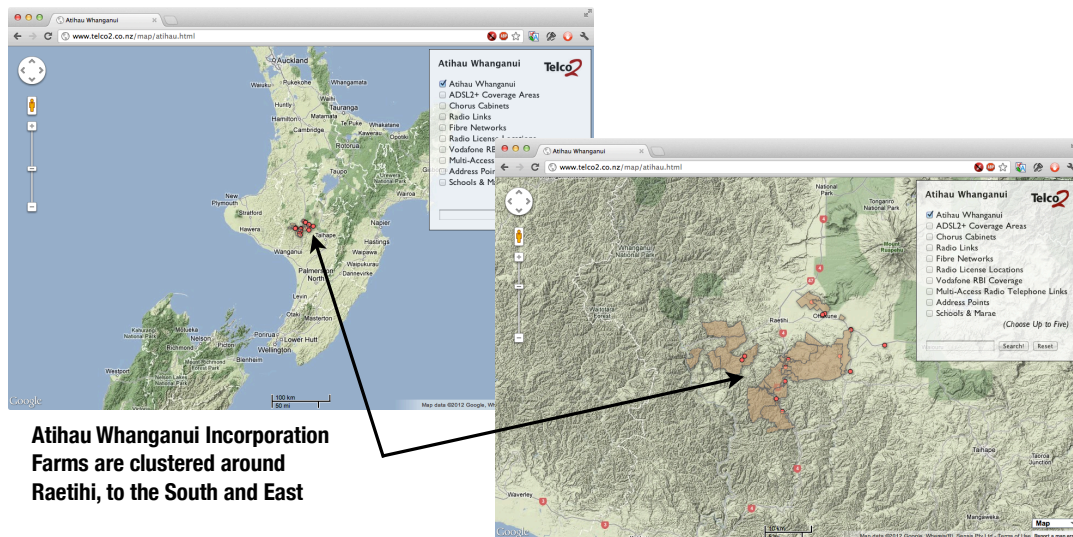


Improving Telecommunications for Atihau Whanganui and surrounding rural communities

30 June 2012

Atihau Whanganui Incorporation

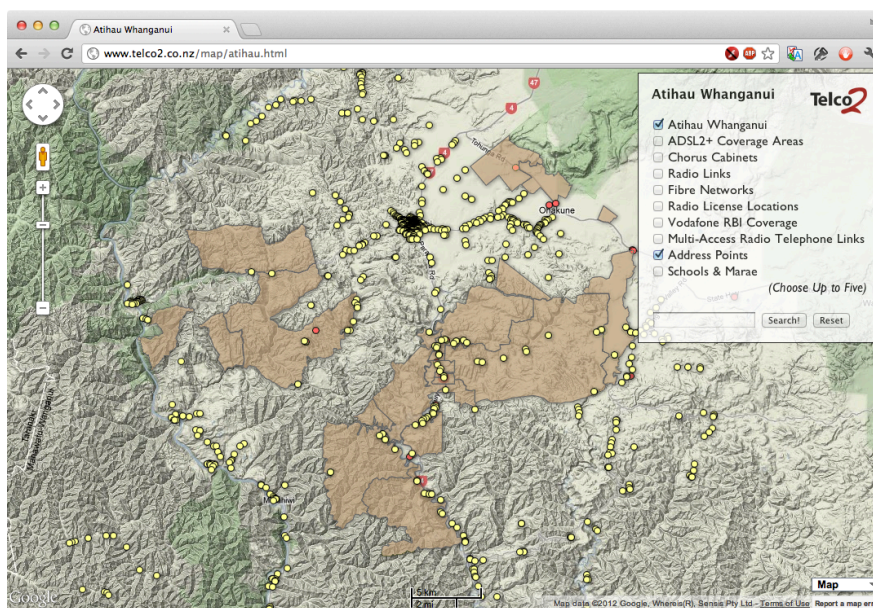
Māori owned Atihau Whanganui Incorporation has been farming Māori land in the Whanganui River Valley since the 1970s. The group manages nearly 42,000 hectares of land used for pastoral farming, forestry, and dairy, and maintains more than 110,000 stock units. Some sites have RFID enabled technologies such as automated weighing crates and drafters, and all use the FarmIQ system “in the cloud” for farm management. A satellite system connects eight Atihau farms, but does not connect to or otherwise benefit the surrounding communities. Four Atihau locations have ADSL broadband connections.



Atihau Whanganui Incorporation Farms are clustered around Raetihi, to the South and East

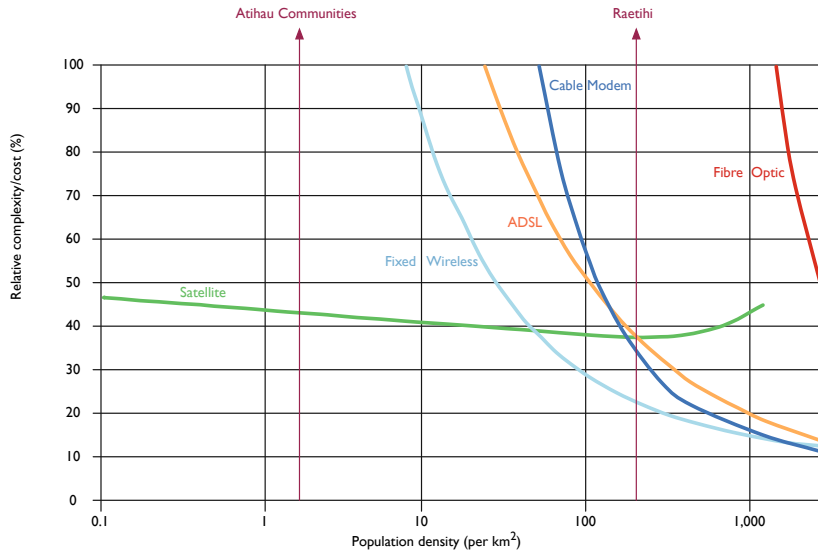
Atihau’s Community

The majority of people in Atihau’s Community live in Ohakune and Raetihi. Smaller settlements around the farms include Rangatata, Tohunga Junction, Waimarino, Pipiriki, Ranana, and Matahiwi, and groups of people live in houses along Whangaehu Valley Road and State Highway 4. Considering meshblock level data from the 2006 census, and excluding Ohakune, there were only 1,100 people living in 390 households in meshblocks on or adjacent to Atihau land. All households in the area (including those outside the scope of this study) are indicated with yellow dots in the image below.



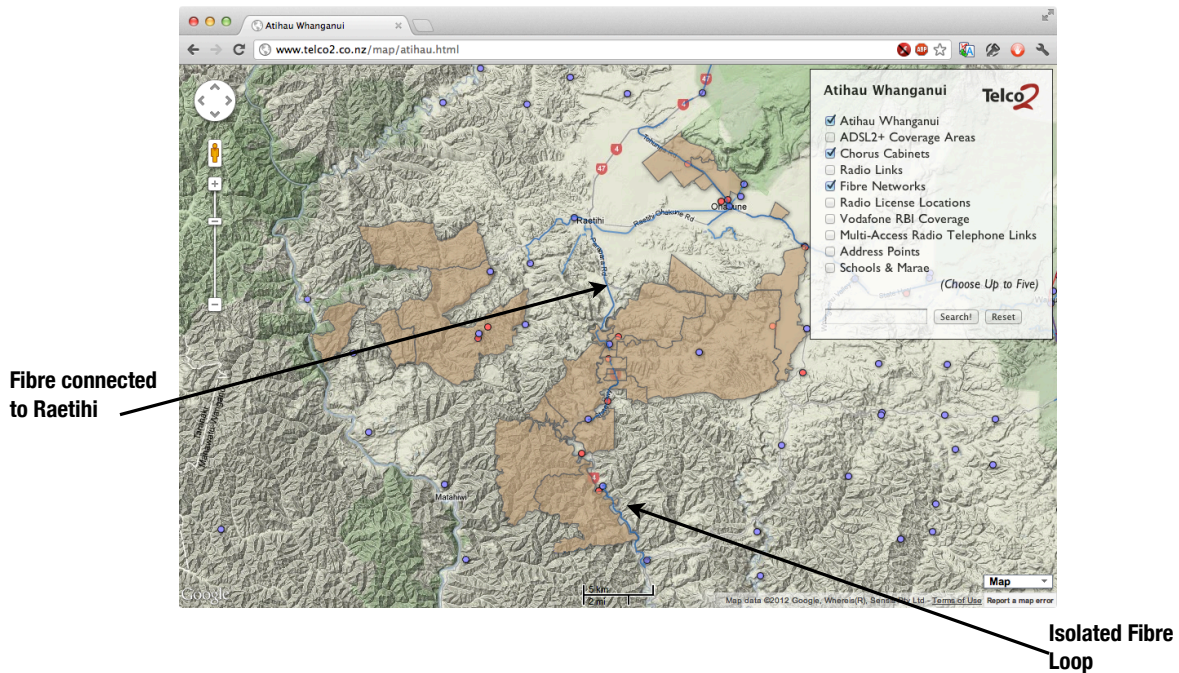
Telecommunications Services for Remote Communities

With around two people per square kilometre across the region, providing telecommunications services to Atihau and their rural neighbours is difficult. The chart below, derived from a 2003 submission to the IEEE by Canada's Communications Research Centre, shows relative cost and complexity curves of delivering service by various technologies. From their findings, we can infer Raetihi is around the smallest community for which providing fixed line telecommunications services is a viable commercial, and most other households would be best serviced by fixed wireless or satellite.

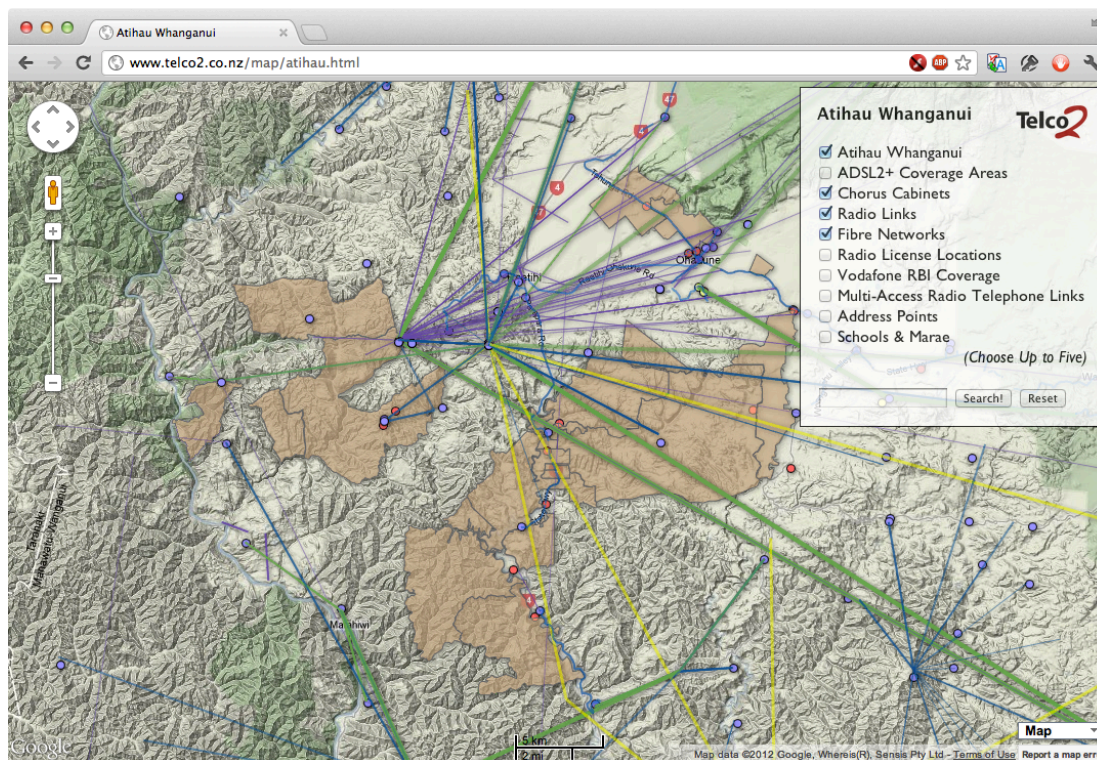


Existing Fixed Line Infrastructure

Telephones had been installed in Raetihi by the time of the 1918 bush fire, but it took until the 1980s before most remote communities received modern single-user systems. Since the privatisation of Telecom in 1990, these systems have been well maintained, but not necessarily upgraded to support broadband. Fibre optic cables have been installed in some locations, but are not always configured for high bandwidth use or even connected to a national fibre backbone. The image below shows fibre availability, and points out a section of fibre that is isolated from the backbone by a radio link.



While telephone service is delivered to these communities via copper local loops, the backhaul in place for these loops is most often not fibre, but copper or radio. Chorus does not publish maps of their copper backhaul links as they do for fibre, but when radio links are used, the details are published by the Ministry of Economic Development’s Radio Spectrum Management group. The image below shows all radio links licensed in the area, and some unlicensed links operated by a local wireless provider. Purple coloured lines are low-frequency radio links, yellow are unlicensed wireless links, and green are high frequency microwave links. Line thickness relates to the amount of spectrum in use; narrow lines indicate a low capacity link and wide lines indicate high capacity links.



Communications over radio and isolated fibre loops does not generally support broadband, and in fact Chorus do not claim broadband availability across any of the Atihau area. In cases where high capacity microwave links are licensed, broadband is sometimes supported by a “Conklin-Intracom FASTmux”, also known as a Conklin, and pictured to the right. These small, rack mount devices are modular and each module supports four ADSL1 circuits, allowing the regulated BUBA product, but not the regulated EUBA product. Chorus have around 2,200 Conklin deployments in rural areas, but do not have coverage information and will not release details on where they are deployed. In an email to the Commerce Commission in May 2012, Craig Young of Chorus indicated that some of these details may be released in October.

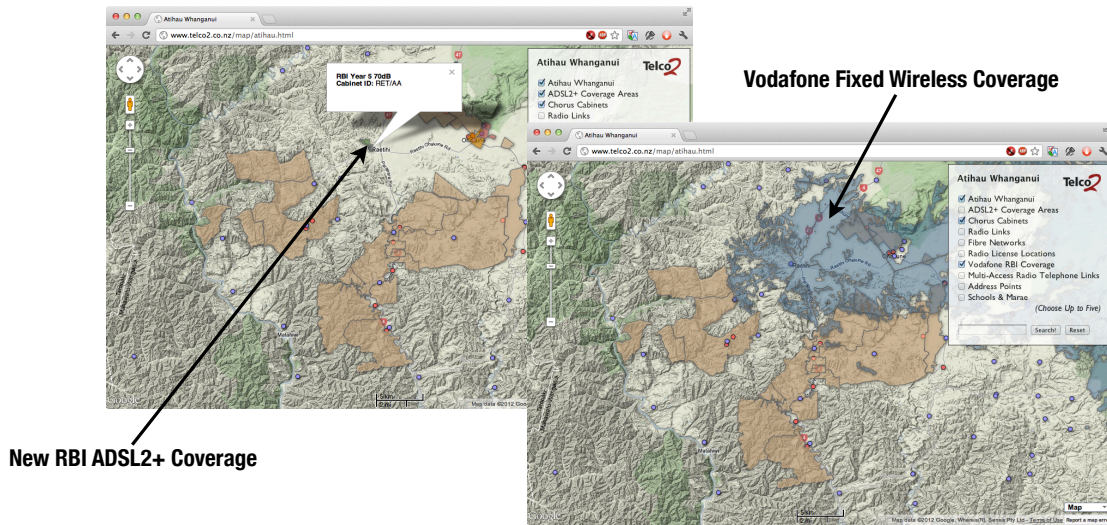


Rural Broadband Initiative

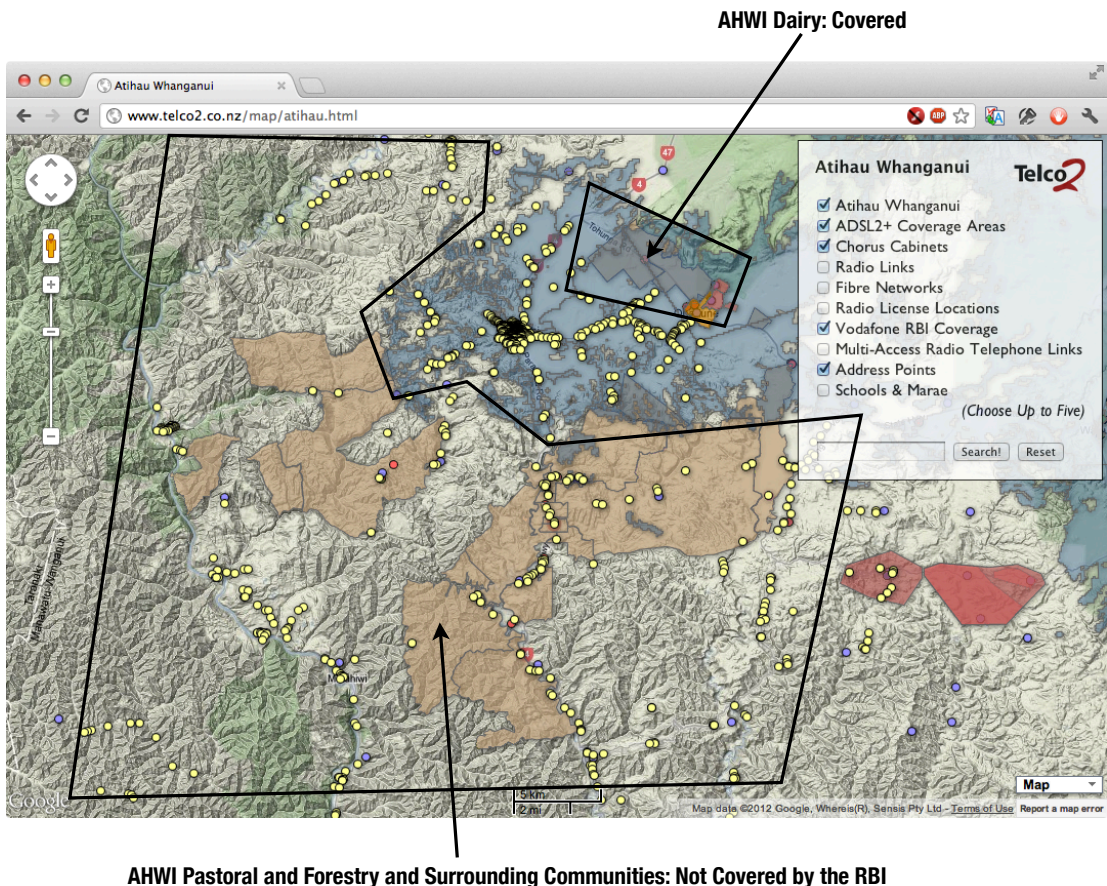
The government’s Rural Broadband Initiative (RBI) was designed primarily to improve broadband connectivity to rural schools, and is providing Chorus funding for installing around 3,100km of new fibre optic cables. A secondary goal of the RBI is improving broadband connectivity to the communities surrounding these schools, and improving cellular coverage to rural areas in general. Vodafone has been funded to build 154 new cellphone towers and upgrade an additional 387 towers to support fixed 3G broadband for houses beyond the reach of ADSL, and through the RBI Chorus will connect these towers with fibre and high capacity Microwave radio.

In addition to RBI funded improvements, many communities will receive upgraded ADSL2+ broadband as Chorus upgrades cabinets passed by new fibre. Around 1000 cabinets will be upgraded, delivering better service to nearly 105,000 lines.

Only the town of Raetihi and immediate neighbourhoods will receive an upgrade of ADSL2+ broadband as a part of the RBI. Vodafone fixed wireless upgrades and new cellular coverage will be much more significant, but still geographically limited by the rough terrain of the area. The next images show ADSL2+ in green and cellular and wireless coverage in blue.

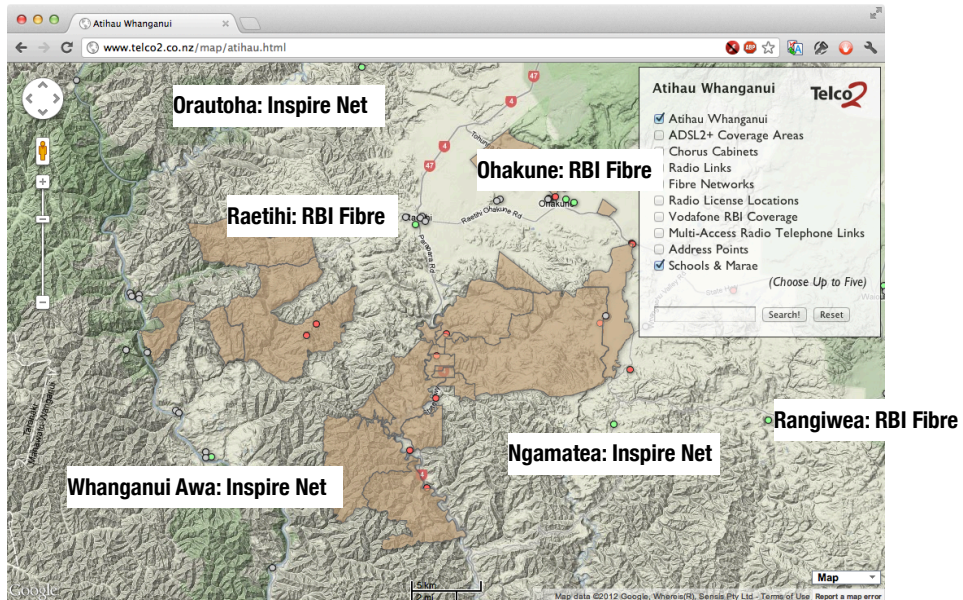


Not all schools will be receiving fibre through the RBI, and not all communities will be able to take advantage of upgraded ADSL or Vodafone wireless, or new cellular coverage. The following image shows households superimposed on a coverage map which includes the Atihau properties. Only the AWHI Dairy property West of Ohakune will be completely covered by RBI and cellular coverage broadband, while the majority of Atihau's farms and neighbouring communities will be missed.



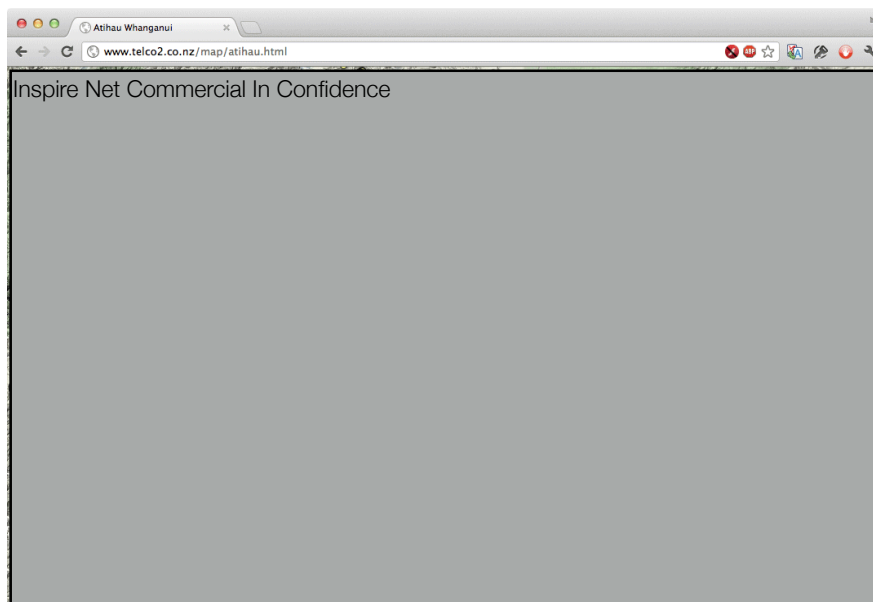
A separate program exists to connect the most remote 60 schools in the country via alternative wireless providers, called the "Remote Schools Broadband Initiative" (RSBI). Araneo, Gisborne.Net, and Inspire Net were selected to connect schools with 10Mbps symmetric wireless - a modest speed but far faster than satellite options.

The next image shows the schools (green dots) in the Atihau area, and notes the provider for each.



RSBI Spill Over

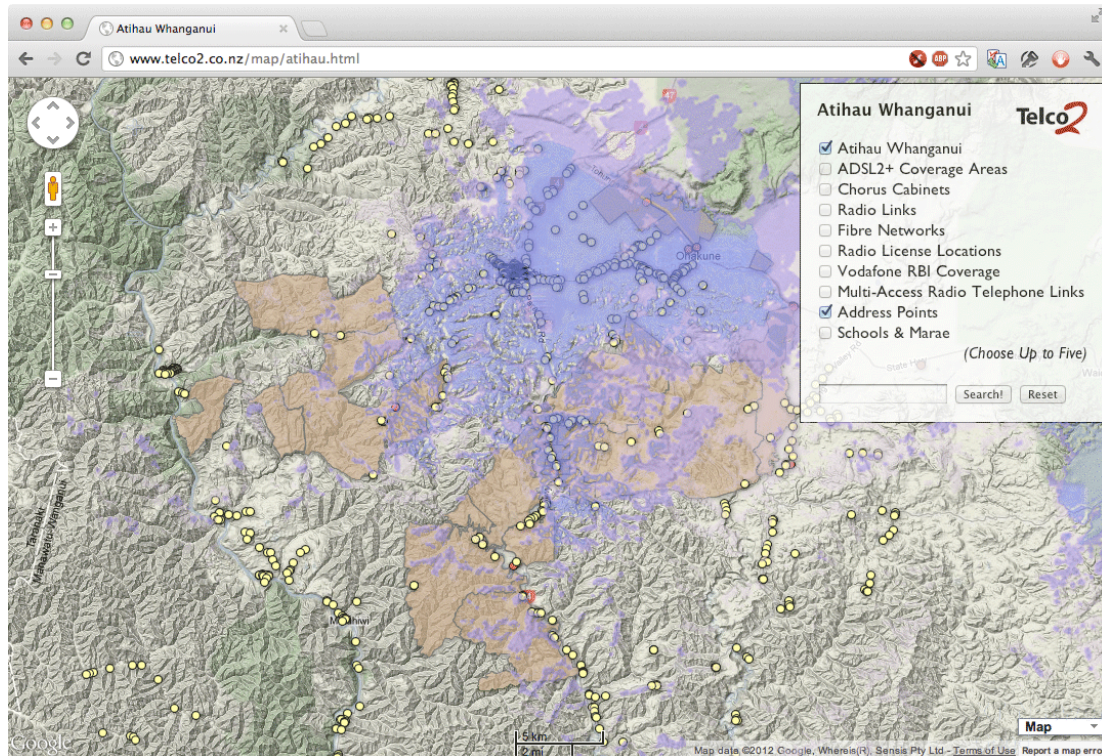
The RSBI program does not provide for connectivity to communities, but some providers have decided to bring consumer level services in to the areas around RSBI schools. The map below displays the coverage Inspire Net expects to be provided as they build new infrastructure to cover Whanganui Awa, Ngamatea, and Orautoha Schools. This coverage is confidential and commercially sensitive, and use has been granted by Inspire Net for viewing by Nga Pu Waea and Te Puni Kokiri only.



The red areas outlined above are where new coverage will intersect with area residents. Of note to AWHI, two properties currently on satellite could potentially be serviced by Inspire Net's existing network. This could provide a quick and easy trial of the service while meeting an immediate need.

Cellular Coverage

Both Telecom and Vodafone have existing cell sites providing excellent coverage of the Waiouru to Raetihi corridor, with fair to good coverage continuing North to National Park. Telecom's footprint, displayed below in purple, dips slightly further South than Vodafone's, but coverage by Vodafone is set to catch up with the installation of their new RBI towers.



Both carriers provide coverage of Atihau farms and communities restricted to hilltops and major roads, with minor roads, houses in valleys, and all communities along the Whanganui River valley missing out on cellular service.

Where To Improve?

Upcoming network build by Inspire Net will bring high speed wireless broadband to some of the communities surrounding Atihau Whanganui. New Vodafone RBI towers will bring good cellular coverage and fixed wireless broadband to the northern ends of Tawanui and Ohotu farms. Unfortunately large blocks of farmland and many communities will be left without broadband or cellular coverage. Given the growing use of technology on the farm, and the great benefits to the health and safety of workers who have mobile coverage in remote areas, improvement should concentrate on bringing high speed broadband to all farm offices and staff homes, and mobile coverage to as much of the farms as financially viable.

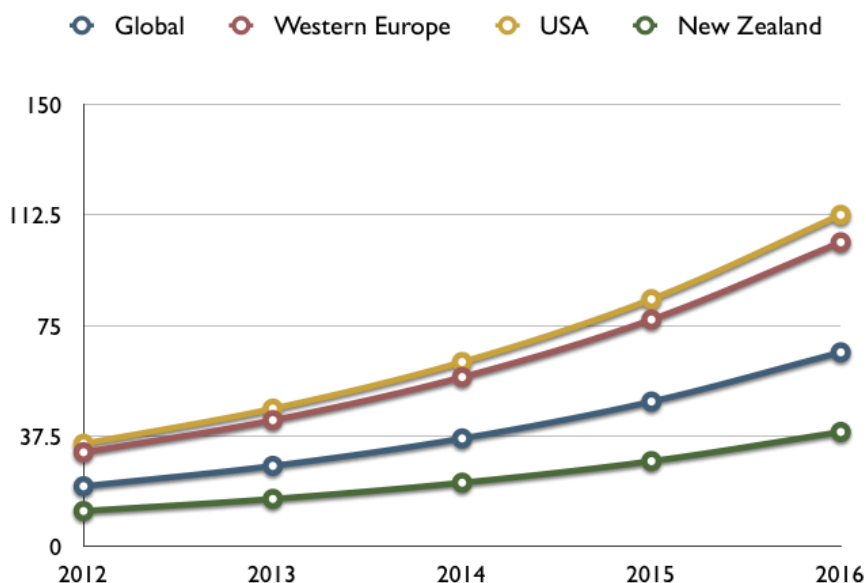
Principles of Remote Communications

Tens of millions of dollars have been poured in to rural and remote communications projects over the last decade, and one by one those projects have been abandoned. Kordia's Extend, Woosh's Southland network, and Counties Power's Wired Country networks were all nearing obsolescence by the time they were deployed, both in terms of technology and configuration. Expensive, proprietary infrastructure was installed on towers with the expectation that hundreds of subscribers would connect to each sector and pay a premium to use a small amount of data. Today none of these networks are in widespread use or even being upgraded to modern standards.

A new model for remote communications should learn from both the technical and commercial failings of these projects, and design for decades of use. This section will deal with solution principles - the essential issues to consider when designing remote communications networks. These principles are important to acknowledge when contracting or cooperating with a provider of remote communications.

Plan for Growth

Over the last decade, Cisco's Visual Networking Index has tracked the growth of Internet traffic around the world. It has consistently predicted year-on-year growth rates, and has never been shown to over-estimate growth. It shows New Zealand traffic growth tracking that of the US and Western Europe at a 34% compound annual growth rate, but with average utilisation four or five years behind the US. The model below shows New Zealand four years behind the US, with 2012 average utilisation of 12GB per month.



Given a demand for 12GB/month/user, and with the understanding that around 18% of monthly traffic caps will be consumed during “peak hours” of 8-10PM, a network engineered to keep up with today's loading requirements must have around 75kbps of capacity per user to start, a figure that will grow 34% year on year, with no end in sight.

Any network design must take into consideration both its predicted loading and a 34% compound annual traffic growth rate.

Eight Year Upgrade Cycles

2004 saw the first mass production of 802.11a/g Wi-Fi chipsets, with their revolutionary peak speeds of 54mbps. Many are still in operation today, but are beginning to show their age. 2012 will see the first mass produced 802.11ac chipsets operating at 867mbps. In eight years the speed of wireless technologies has increased by more than an order of magnitude.

Cellular technology operates on similar time spans. Telecom's CDMA network was launched in 2001 and it's XT network was launched eight years later in 2009. The difference in their capabilities is tremendous.

A network deployed today should be designed to cope with peak loads in its last year before retirement. For a broadband network deployed in 2013, that means 2021 capacities of just over 1mbps per subscriber will be required to meet demand during peak hours. Access equipment has a finite lifespan, but rural telecommunications requirements do not.

Build Long Lasting but Inexpensive Infrastructure

A piece of steel pipe, a couple of sacks of concrete, stock fencing and some number 8 wire is the standard for most rural wireless operators in New Zealand. Unfortunately such a strategy often fails within a few years. Wireless network equipment may only have a useful lifespan of eight years, but the infrastructure around it should last much longer. Utility poles and towers should last between 25-40 years, as should equipment enclosures. Photovoltaic panels, rectifier systems, and high quality batteries should all last through at least two eight year network hardware cycles, if not three. Stock fencing and access tracks should be built with the assumption they will be used for decades. Building proper infrastructure can double the initial cost of a rural telecommunications site, but will pay dividends over the long term.



Araneo at Centre Hill

Scorch at Mt. Alex

Primo at German Hill

All sites approximately 3M at highest point

The three radio towers pictured above have roughly the same type and value of wireless and installed on them. The Scorch and Primo sites use two 80W solar panels to Araneo's one 160W panel. Charge controllers and battery banks for the Scorch and Primo sites are unknown, but the Araneo site has 17 days of battery capacity, and a panel that will provide a charge even in cloudy weather. Around \$3k was spent on the Araneo structure of utility poles and 76M galvanised steel and another \$3k on the power system. The Scorch tower and enclosure was welded together with free bits from a scrap yard. Taranaki's Primo used a 50mm diameter steel water pipe mast and 34mm steel pipes for bracing.

All three sites will perform equally well in the first few years of use, but the while the first was designed for thirty years of operation, both the second and third will be struggling in five. Even though the Primo site is tidy, their light weight assembly will flex and vibrate in high winds, leading to problems with equipment and eventual failure of the tower.

Key to the economics of remote communications, all three examples come in at under \$10,000 per site as deployed. This amount is around 10% of the least expensive rural site built by 2Degrees, Kordia, Telecom, Vodafone, or Woosh, and can be recovered over the long term on remote sites with only a handful of users.

Use Licensed Fixed Wireless for Backhaul

Traditional cellular access networks, and large wireless networks like Woosh and Kordia use fibre or licensed microwave for backhaul. In remote networks, both are impractical. Fibre is expensive to deploy for just a few people. Licensed Microwave can require large antennas that can mean significant investments in tower engineering and installation, and uses licenses resulting in additional fixed operational expenses. Unlicensed linking is used by most rural carriers, but while appropriate for general broadband use, is not able to provide the quality of service required by cellular providers.

Fixed wireless spectrum is plentiful in 2GHz, 2.2GHz, 2.3GHz, and 2.5GHz TDD bands, and the 3.5GHz FDD band. A broad selection of multi-access equipment exists in 2.3, 2.5, and 3.5GHz and can be had in proprietary systems, WiMAX (802.16) systems, or TD-LTE systems. Antennas can be relatively small and easy to align, and a number of small repeater towers can be fed from a single high site. Should licensed fixed wireless spectrum be available to a provider, it is the best choice for providing backhaul to remote tower sites.

Build Access Networks With Standards Based Equipment

Rural access networks built by Woosh, Kordia, and Wired Country were locked in to expensive, proprietary subscriber units. Adding new subscribers to those networks today would be difficult, if not impossible. Conversely, rural networks built by ThePacific.Net, Inspire Net, and Araneo around the same time were built on standards based equipment. Hundreds of vendors around the world make subscriber units that could be used with these networks today.

The specific standards recommended for a new rural network are the IEEE 802.11 series, GSM technologies, or 3GPP technologies in common band plans; for example UMTS or FD-LTE equipment in Bands 1 or 3, or TD-LTE in band 40.

Solution Options

Four options are presented below, ranging from a strict hands-off contract model through to a scenario where AWHI would build, own, and operate its own telecommunications infrastructure. A basic evaluation is made of the strengths and weaknesses of each model, and capital and operational expenses are discussed.

Engage a Regional Wireless Internet Service Provider (WISP)

Almost every region of New Zealand has a local or regional wireless WISP. They range in size from a guy and his dog to teams of dozens of employees. The following list provides the largest WISP in each region, from North to South.

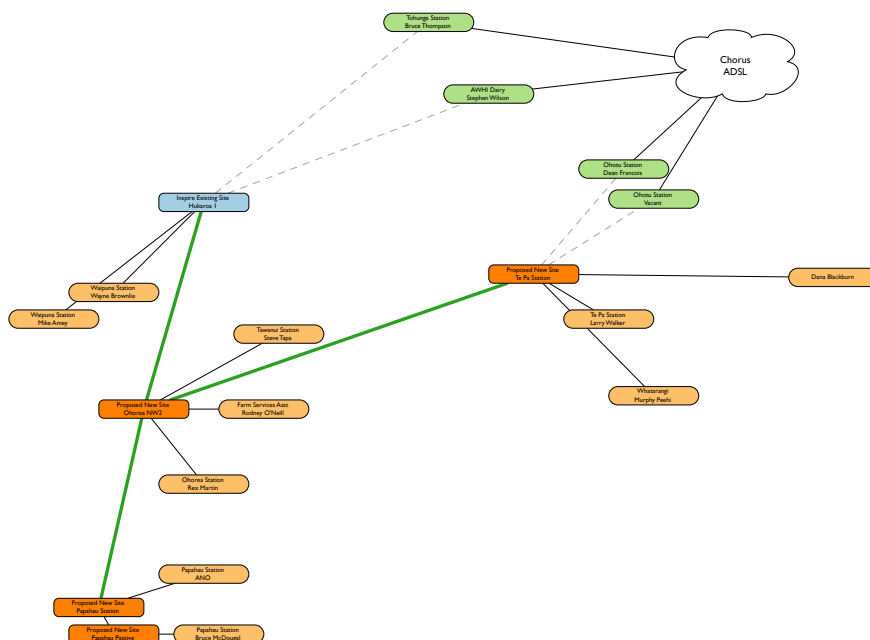
- Northland: Uber Net
- Auckland: Bush Wireless
- Waikato: No8 Wireless (nee Ruralink)
- Bay of Plenty: NetSmart
- Gisborne: Gisborne.Net
- Hawke's Bay: Now (nee Airnet)
- Taranaki: Primo Wireless
- Manawatu-Whanganui: Inspire Net
- Wellington/Wairarapa: Wiz Wireless
- Tasman/Marlborough: NetSolutionz (nee ThePacific.Net)
- West Coast: Zelan Wireless
- Canterbury: Amuri Net
- Otago: WIC (Wireless Internet Connections)
- Southland: Woosh Wireless

Across the Whanganui River Valley and Atihau properties, Inspire Net is the only established provider. Inspire are a full-service telecommunications provider offering Internet and phone service over their own fibre and wireless based network. Their rural wireless network is unlicensed, based on hardware from manufacturers Mikrotik, Trango, and Ubiquiti, and is run from more than 150 tower sites across the Manawatu, Wairarapa, and Whanganui regions. Inspire's voice offerings are based on Voice over Internet Protocol (VoIP). They are also a reseller of Chorus, and can provide connectivity via Chorus ADSL or fibre.

Inspire offer peak-rate connectivity of 5mbps/1mbps, or 5mbps/5mbps with low but unpublished contention rates, and data caps of between 1-2000GB/month. Business wireless plans start at \$170/month, and include 20GB of data. While this monthly charge is 40% higher than Atihau's existing satellite service, it is lower than Farmside's nearest equivalent current plan (Satellite 2012 Pro), which offers only 1/3 the data cap.

A radio tower operated by Inspire at Hukaroa has the ability to connect the AWHI Dairy, Tohunga, and both Waipuna Station locations. A forest interrupts an otherwise good terrain path to the two Ohotu Station locations. As all except the Waipuna locations have existing ADSL broadband, Inspire service from an existing tower will only be attractive in two cases.

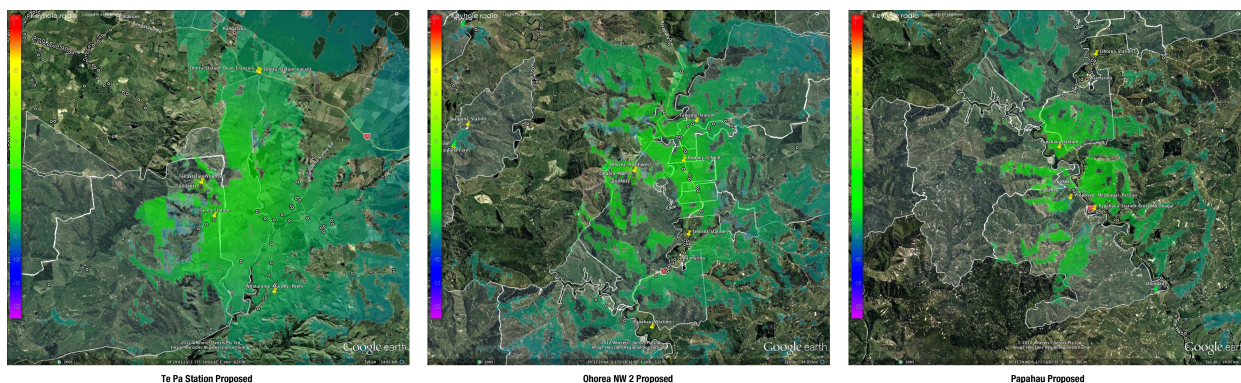
Three more new radio towers would be required in order to provide basic broadband service to the eight other Atihau locations on satellite plans, as shown in the illustration below. Blue ovals are existing sites, light orange ovals are Atihau sites currently on satellite, green are sites on ADSL, and bright orange ovals represent required new towers.



In discussions with James Watts at Inspire, I was informed that Inspire will build a new radio tower in any location that sees their existing network where they are guaranteed a minimum revenue stream that meets their internal financial targets. This typically means twenty residential broadband connections, five business connections, or some balance of the two for each tower. They require free or near-free access to land to build their rural towers, but provide their own quad bikes for maintenance and use solar power for their sites. In order to secure new towers to service Atihau locations currently on satellite, the company has three likely options, all subject to negotiation:

- Sign up enough Atihau neighbours to Inspire’s service to meet Inspire’s financial targets
 - 15 new subscribers at \$37.50/month might be required on top of Atihau’s 10 business connections
 - Atihau’s up-front commitment would be \$3k, OpEx would jump from \$1220/month to \$1700/month ex GST
- Connect 14 locations to Inspire’s business broadband plan
 - Atihau’s up-front commitment would be \$4.2k and OpEx would jump from ~\$1460/month to \$2380/month
- Subsidise Inspire’s tower build
 - Ten sites would connect to Inspire. OpEx on these sites would jump from \$1220/month to \$1700/month ex GST
 - Inspire would likely seek around \$10k in build subsidy in addition to up-front installation charges.
- Inspire’s published rate card shows a 12 month minimum contract period for business connections
- Given average NZ traffic use, Atihau should budget for a \$20/month/farm data cap upgrade in years 2 & 3

Of the three new sites required, only the one at Te Pa Station provides significant community benefit, with around 30 properties covered in addition to those required by AWHI. The site designated Oheia-NW-2 covers fifteen properties in addition to the three Atihau locations. The site at Papahau covers only Papahau Station, and with a passive repeater (around \$1,500 installed) will cover Bruce McDougal’s office. The image below shows the coverage of the three required sites.



Inspire’s service, like that of most regional WISPs, is vastly superior to even the best of satellite broadband, and usually outperforms rural ADSL in cases where the exchange or serving cabinet is more than 2km away. It is still a traffic-limited service, which while acceptable for some businesses, may not be acceptable for companies who move their businesses in to the cloud. For that, a solution with dedicated bandwidth and no caps is required.

The Inspire service as discussed above provides little spill-over benefit to the community in terms of increased access to services. Only the fifteen properties around Ohorea have no other access to broadband. It also does not bring the possibility of mobile coverage.

Inspire design for growth by installing access and backhaul equipment far faster than the 5mbps circuits they sell. They have progressively upgraded the equipment on their older wireless sites in cycles quicker than eight years to keep pace with their customers’ ever growing demand for data. They have not however invested in long-lasting sites with utility grade power infrastructure or licensed backhaul, as the cost of such an investment would limit their growth. While Inspire provides a great level of service to its business and residential customers, none of the mobile carriers are interested in cooperating with Inspire or using their sites or backhaul for providing rural cellular coverage.

Engage an Open Access Wireless Carrier

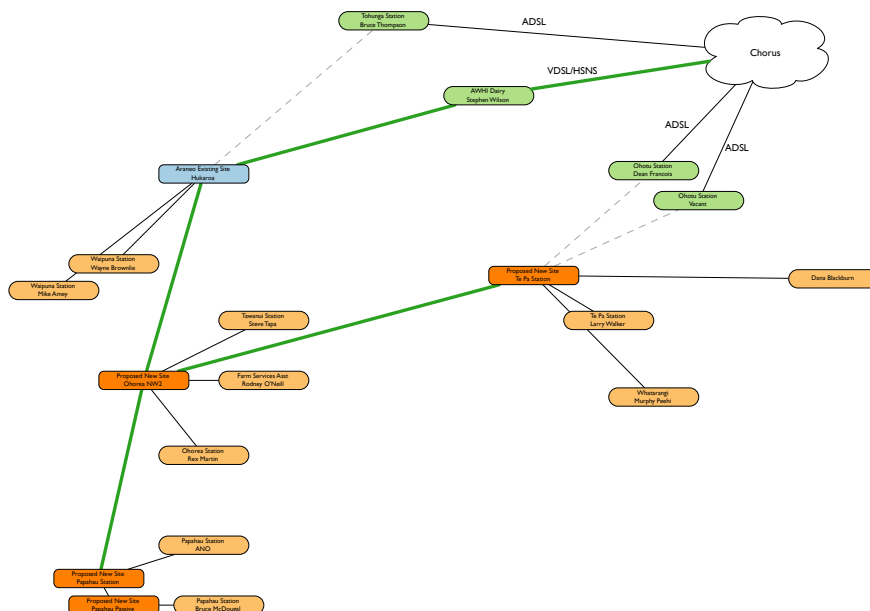
State Owned Enterprise Kordia and Araneo, a subsidiary of sharemarket listed TeamTalk, are New Zealand’s two open access wireless carriers. They both provide wireless access unbundled from Internet and telephone access, a product suited mainly for resale by Internet Service Providers or integration by large companies. While Araneo provides a generally available rural focussed product, Kordia do not have a current rural product since withdrawing their Extend product from the market.

Such wireless services are sold with committed information rates, typically between 2mbps and 100mbps. Committed rates are offered for businesses who require the full capability of their service to be available all the time. The table below compares committed rates between services.

Service	Peak Download Rate	Peak Upload Rate	Committed Rate Up/Down
Araneo 2mbps Rural	2,000 kbps	2,000 kbps	2,000/2,000 kbps
Araneo 5mbps Rural	5,000 kbps	5,000 kbps	5,000/5,000 kbps
Chorus EUBA180 ADSL	up to 24,000 kbps	up to 1,400 kbps	180/180kbps
Chorus UBA ADSL	up to 24,000 kbs	up to 1,400 kbps	45/45kbps
Farmside Lite Satellite	2,000 kbps	1,000 kbps	N/A
Farmside Regular/Plus/Pro	Unknown	Unknown	N/A
Inspire Lite	5,000 kbps	1,000 kbps	N/A
Inspire Faster Upload	5,000 kbps	5,000 kbps	N/A
Vodafone RBI Wireless	5,000 kbps	512 kbps	45/45kbps

New Zealand’s largest corporate farmer, State Owned Landcorp Farming, contracts Araneo to provide 2mbps and 5mbps connectivity for all of its farms nationwide. Given CEO Chris Kelly’s public comments about budgeting \$500k for broadband connectivity for Landcorp’s Farms, it can be concluded they spend around \$400/month per farm for what is essentially a private network between the sites.

A network for Atihau would, similar to the Inspire solution discussed above, use Araneo’s site at Hukarua as a linking platform. Unlike Inspire’s site, Araneo’s Hukarua installation has mains power and licensed microwave backhaul, and has a four hour fault response time in place for its primary user, NZDF. Since Araneo is a wireless provider and not an ISP, a likely configuration would have the area’s farms linked to a central hub at the Dairy Unit, where an ISP connection via Chorus VDSL or HSNS could provide Internet connectivity for all of the facilities. The diagram below presents such a topology.



Araneo’s latest published rate card (Effective 1 October 2010) lists regional 2mbps circuits at \$350/month and 5mbps circuits at \$500/month. Both services have a \$1000 installation fee. Cost savings could be achieved by connecting only ten of Atihau’s 14 sites, however the scenario below considers connecting all sites. While special deals can be negotiated, the realities of providing high service levels to rural networks mean that for the network above, likely costs would be:

- Thirteen remote sites: \$13k installation fee and \$4,550/month
- One hub site (AWHI Dairy Unit) \$1k installation fee and \$500/month
- Araneo requires a 36 month contract term for rural circuits
- An ISP connection would be required for any Internet traffic, budget \$500/month for VDSL or HSNS + 200GB/data
 - Data between farms is unlimited, only Internet bound traffic would exit the network via an ISP
 - Given average data use, a \$100/month ISP data cap increase should be budgeted for in years 2 & 3

Araneo design for growth by installing access and backhaul equipment far faster than the circuits they sell. Their committed information rate service agreements require them to upgrade infrastructure as necessary to always provide the contracted amount of bandwidth. They invest in long-lasting sites with towers and power infrastructure rated at 20 years of life or better. All primary tower sites (~100 nationwide) use microwave or fibre backhaul. Many carriers are comfortable using Araneo services to provide connectivity to hospitals, power stations, airports, and as in the case of Waiouru, defence applications. It is reasonable to expect that a cellular carrier would cooperate with Araneo on remote build in Atihau’s community if it were incentivised to provide coverage of this otherwise uneconomic area.

Joint Venture with a Wireless ISP, Wireless Carrier, or Cellular Provider

Wireless ISPs are a recent phenomenon in telecommunications. Ten years ago only a handful existed in the world, while today there are more than twenty in New Zealand. As a new technology and business model, they have attracted investors with an eye towards short term gain. Early commercial failures such as Woosh and Indranet have suppressed investor appetite for providing favourable finance to wireless ventures, making it difficult for them to think about building for the future.

Tower and Cabinet

A tower for a remote site can be as simple as a steel pipe and a bag of concrete, or as complex as a lattice tower. Several options are listed below, costs as installed during actual projects across rural New Zealand, with all designed for a minimum of twenty years lifespan.

- 6M wooden pole hand-dug 1M in the ground with concrete. Ladder access. \$1000
- 6M wooden pole + steel gantry hand-dug 1M in ground. No concrete required. Ladder access. \$3,580
- 13M wooden utility pole buried 2M in the ground with concrete and rubble. Climbing pegs. \$6,000
- 20M guyed mast, with professional installation. Crane + man cage access only. \$8,000
- 6M steel monopole for 1.2M microwave dish, galvanised and painted. Ladder access. \$12,000
- 6M Steel gantry to suit 1.8M + 1.2M Microwave Dishes. Ladder access. \$17,000
- 13M Spun-Lite tapered steel monopole suitable for cellular antennas. Climbing pegs. \$28,000

Cabinets can be mounted on a poured concrete pedestal or directly to a tower. They should be watertight to IP66 or better, yet have some heat protection and ventilation sufficient for housing batteries which can emit gasses and fumes.

- Generic powder coat metal IP66 cabinet, 300x300x600, passive ventilation, ex Australia: \$290
 - \$100 miscellaneous mounting hardware from Multistrut required per cabinet
 - 2x cabinets required if 4 batteries are used
- General Electric 1000x800x300mm Aria outdoor cabinet, uPVC, passive ventilation: \$1300
- Pole-mount broadband cabinet with active DC powered ventilation, A.L.T. Thailand: \$2200

Given the use of a wind turbine and a solar panel, and the potential exposure to harsh weather, it is recommended that a wooden pole plus steel gantry design be used, along with the Thai cabinet which is designed to withstand Southeast Asian monsoon conditions. An example of a gantry is shown below, but coupled with the lowest-cost generic powder-coat cabinet option and using 4.5M poles buried 700mm into the ground, instead of 6M poles buried 1M into the ground. The cabinet shown is unsuitable for use with the charge controller specified, which should have an enclosure with active ventilation.



The total estimated cost for a single tower and cabinet as installed is \$5780. Five towers and cabinets would be required for a total of \$28,900. A special passive repeater site will be required to provide service to Bruce McDougal. This will consist of a fence post with two antennas connected by a cable to channel the signal from the access point down in to the valley where his office is located. This site will require around \$1500 in materials and will not need power or radio equipment.

Power System

The equipment proposed will operate at 24V and will consume a peak of 8W for backhaul, 3W for site management and routing, and 5.5W for access, and will have use 50% or less of peak power during off-hours. Total power draw is expected to be around 300 Watt hours per day, which is 12.5 Amp hours per day from a 24V system.

Given the Whanganui River Valley's comparatively low winter sunlight hours, a solar panel plus a small wind turbine will be the most reliable solution for providing continuous power. The turbine will generate 50W in a 24kph wind, rising to 500W in winds of 50kph, then providing only 50W in winds above 30kph. The panel will provide around 20W in cloudy weather or 160W in full sun. The charge controller can handle 60 amps of current, which is twice the power that would be provided by both devices operating at full capacity. Batteries will provide 104 Amp hours of capacity at 24V, or around 2,500 Watt hours, allowing for a period of eight days of full system operation with no wind or sun.

- AirX Wind Generator, 400W, 24V: \$1600
- Generic 160W Solar Panel @ \$4.50/watt (2x wholesale cost): \$720
- Solar panel mounting frame: \$150
- TriStar TSMPPT60 Charge Controller: \$700
- Relay Gel 12V 104Ah Batteries, 2 @ \$380 each: \$760
- Cables, connectors, terminals: \$100

The total cost for a system with a basic amount of autonomy suitable for easily accessible sites is \$4030. In the case a site is difficult to access, it is recommended battery capacity be doubled for 16 days autonomy at an additional \$760. One spare should be purchased for each component, so the total power system cost for five sites will be \$23,800 if planned for eight days of autonomy, or \$27,600 if planned for sixteen days.

Backhaul

For a private system limited in use to Atihau Whanganui, unlicensed spectrum in the 5.8GHz range is the most practical option. Suitable low power systems range in cost from \$300 per link up to \$8,000 per link. Given the low bandwidth requirements the 12 Atihau sites, the Ubiquiti PowerBridge M5 system has been selected, as it can reliably provide between 20-100mbps across long distances. The same units will be used at subscriber locations, allowing for common spares. A router will be deployed at each hub site to allow for network management and power monitoring. The Mikrotik RB750UP has been selected as a robust but low cost device capable of routing 100mbps of traffic. One at each tower plus one at the Dairy Unit will be required.

- PowerBridge M5, eleven units at \$400 each to provide five backhaul links and a spare: \$4,400
- Mikrotik RB750UP, seven units at \$100 each to provide six routers and a spare: \$700
- Cable, connectors, and lightning Arrestors: \$500
- Total backhaul cost: \$5,600

Using a different model of the same Ubiquiti equipment, this system could be operated in the licensed 3.5GHz band at a premium of less than 30%. This would enable the quality of service required by a cellular provider who might allow use of a femto or micro cellular site.

Access

As with backhaul, for a private system limited in use to Atihau Whanganui, unlicensed spectrum is again the most practical option. The same model access point can be used throughout the network, with four APs operating in the low power 5.4GHz band, and two APs operating in the high power 5.8GHz band. Because of the properties of their linking situations, both Dana Blackburn and Bruce McDougal will require their units to operate in the 5.8GHz band. The Ubiquiti NanoStation M5 has been chosen as an appropriate access radio, and PowerBridge M5 as a good subscriber unit. Six access radios plus a spare, and ten subscriber units plus a spare will be required.

- NanoStation M5, nine units at \$160 each to provide six access points and a spare: \$1,440
- PowerBridge M5, 14 units at \$400 each to provide for ten end users and a spare: \$5,600
- Cable, connectors, and lightning arrestors: \$1,400
- Total access network cost: \$8,440

Should 2.3GHz licensed spectrum be made available to Atihau, a different model of the same Ubiquiti equipment could be operated in the band, allowing higher bandwidth links at longer distances and higher quality of service.

Engineering and Installation

Once materials are delivered to a site, an engineer with the assistance of three competent farm staff can build a tower in a day. With the site built, antennas are initially aimed by sight or compass. Once all towers are built the backhaul links are aligned using a light indicator on the radio. Home installations can be contracted to a local Sky or wireless installer once the towers are in place. Budgeting for some bad weather days and use of farm staff and vehicles for materials transportation, engineering and installation charges should be as follows:

- Consulting Engineer: \$1000/day * 10 days: \$10,000
- Engineer expenses, mileage, hotel nights: \$2,000
- 3x labourers at internal rates * 10 days: \$9,000 (internal expense)
- Use of tractors, utes, quad bikes to deliver materials and assemble towers: \$5,000 (internal expense)
- Installation charge per house from private installer, \$250/house * 14: \$3,500
- Stock fencing per tower location, \$1000 * 5: \$5,000
- Total engineering and installation charges: \$34,500

Ongoing Maintenance

Open source network monitoring tools, once correctly configured, can keep tabs on a network and alert its manager of problems before they affect service. Such tools can be configured to run in a virtual machine on an existing server.

Staff should visit each of the towers at least twice a year to inspect them for any damage from the elements or animals, cut the grass inside the stock fence, and make sure seals and connections are still water tight.

Two days a year of engineering time should be set aside for network monitoring, consulting, and/or a site visit in the event of a problem that can't be resolved by local staff.

- Configure and install monitoring system, document and train IT support staff in its use: 2 days: \$2,000
- Contingency for engineering visits per year, 2 days @ \$1,000 + expenses \$200/day: \$2,400/year
- Staff visits to towers, 2 days per year plus use of resources: \$1,000/year
- Total Maintenance over 36 months: \$12,200

Summary of Costs

Land, towers, power systems, backhaul radios, access radios, installation, and maintenance are all required for a successful network. The elements discussed above are summarised below:

- Land: all towers are on Atihau properties: \$0
- Towers: five towers plus a passive repeater will be constructed for: \$30,400
- Power: for sixteen days of autonomy, the cost will be: \$27,600
- Backhaul: links and controlling routers will be: \$5,600
- Access Network: all house and office connections: \$8,440
- Engineering and Installation: including estimated internal resource costs: \$34,500
- Maintenance: 36 months of charges: \$12,200
- Internet connectivity per month \$500, 36 months: \$18,000
- Total cost for 36 months: \$136,740

Comparing Options

The table below outlines speeds and costs for various broadband options at 36, 60, and 96 months, for services generally available to rural businesses. It includes satellite, Vodafone's RBL wireless, Inspire, Araneo, and self-build costs. The Vodafone option is present only for comparison, it is not available at eight of Atihau Whanganui's fourteen locations. 96 months is the latest point at which a technology should be refreshed. Atihau would likely need to spend another \$15k on upgraded backhaul and access equipment and \$10k in engineering and installation after eight years.

Data caps in this comparison are left at default. For Farmside and Vodafone services, exceeding or increasing them during the first 36 months could lead to significant additional charges. For Inspire and Snap (used by Araneo and own-network) additional required data in the first three years should not change the overall cost by more than 2%. It is expected that data caps will rise for Inspire and Snap connections at little or no cost with the opening of new undersea cables to Australia and the US. Neither Farmside nor Vodafone have the radio spectrum resources available to keep up with this demand using their current systems. They would need new satellite or cellular systems before they could offer significantly increased data caps.

Service	PIR/CIR	Cap/Site	Startup	Monthly	Month 36	Month 60	Month 96
Farmside Satellite 2012 Plus	PIR: 3/1mbps CIR: NA	4GB	NIL	\$1,386	\$49,896	\$83,160	\$133,056
Farmside Satellite 2012 Pro	PIR: ?? mbps CIR: NA	7GB	NIL	\$2,646	\$95,256	\$158,760	\$254,016
Vodafone Wireless Broadband 4	PIR: 5/0.5mbps CIR: .045/.045mbps	10GB	\$598	\$1,540	\$56,038	\$92,998	\$148,438
Inspire Business Lite	PIR: 5/1mbps CIR: NA	20GB	\$4,200	\$2,380	\$89,880	\$147,000	\$232,680
Inspire Business Faster Upload	PIR: 5/5mbps CIR: NA	20GB	\$4,200	\$3,290	\$122,640	\$201,600	\$320,040
Araneo 2mbps with Snap Internet 200GB	PIR: 2/2mbps CIR: 2/2mbps	14GB	\$14,000	\$5,550	\$213,800	\$347,000	\$546,800
Araneo 5mbps with Snap Internet 200GB	PIR: 5/5mbps CIR: 5/5mbps	14GB	\$14,000	\$8000	\$302,000	\$494,000	\$782,000
Own Network with Snap Internet 200GB	PIR: 20/20mbps CIR: 2/2mbps	14GB	\$106,540	\$839	\$136,744	\$156,880	\$187,084

Discussion

Of viable long term alternatives given Atihau's likely network demands, only Araneo, Inspire, or a self operated network are viable from a technology standpoint. All are likely to provide a similar quality of experience for the end user. At the 36 month point, both of Inspire's solutions are less expensive than Araneo or own network scenarios, and at the end of 60 months, Inspire's Business Lite product still edges out an Atihau-owned network in terms of cost.

After cost, the most positive benefit of outsourcing the work to Inspire would be the fact that the service will be made available to Atihau's neighbours at rates as low as \$37.50/month. A joint venture arrangement with inspire as proposed above could potentially reduce costs or improve service quality at the same cost. The drawback of this scenario is that cellular companies are unlikely to want to host infrastructure on Inspire's network.

With either the Araneo service or an Atihau owned network on licensed spectrum it should be possible to engage a cellular provider to supply a femto or micro cell for each of the towers involved. Alcatel-Lucent's 9364 Metrocell, under consideration for use by both Telecom and 2Degrees Mobile would be compatible with the infrastructure detailed above at a cost of around \$10k per site, and would provide line of sight coverage at up to ten kilometres from each tower.

Conclusion

Atihau's existing broadband situation is barely adequate today, and insufficient for its future needs given the rapid pace of farming automation and its demands on broadband systems. By surveying available services, it was shown that the four properties already connected via ADSL could now connect via Vodafone's RBI wireless product, but given its performance and costs this is unlikely to be an improvement. Two Atihau properties currently on satellite or 3G can be serviced by Inspire, via coverage that can in part be attributed to spill over from the government's Remote Schools program. The remaining eight properties will not receive upgraded coverage from the RBI or RSBI spill-over, and a solution must be developed for them.

Several solutions capable of meeting Atihau's needs were presented with various capabilities, benefits to the local community, price points, and commercial models. Telco2 looks forward to discussing these solutions with Atihau Whanganui in order to clarify or expand on any of the topics presented in this report.

Engineering Notes

The following 26 pages are path plots showing the availability of microwave or wireless line of sight between Atihau's fourteen sites, existing Inspire towers, existing Araneo towers, and the new towers that would be required to provide service to all properties. Appropriate sites and working paths were identified using a combination of tools including AWE's WinProp, Google Earth, and Micropath's Pathanal. Dozens of potential paths were discarded due to terrain and or vegetation issues preventing line of sight. None of the paths proposed are difficult or exceptional in any way except the link to Bruce McDougal's house. That path is considered below.

Proposed Papahau Passive Repeater

An active base station will be passively repeated in order to provide service to Mike McDougal at Papahau Station. The link will be designed as a point to point backhaul link in order to provide maximum radio and spectrum resources to the task. As designed, 16dB of fade margin is available, and data rates of around 50mbps half-duplex should be available. Should the link fail to achieve expected signal levels, dishes could be installed at the tower and/or user sites to increase system gain.

PTx = Power of the Transmitter: **27dBm**

LTx = Loss at the Transmit End: **-1dB**

GTx = Transmit Antenna Gain: **25**

LFS1 = Free Space Loss $20 \cdot \log_{10}[4 \cdot \text{distance}/\text{wavelength}]$: **-107dB**

GP = Gain of Passive 34dBi x2 - 4dB **62dBi** (2dB cable/connector loss)

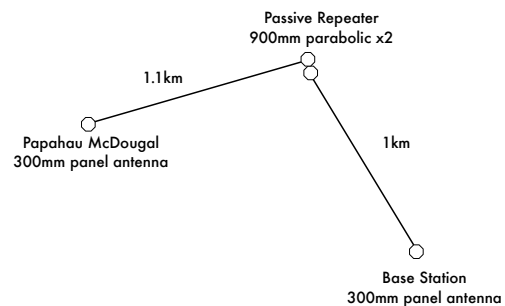
LFS2 = Free Space Loss $20 \cdot \log_{10}[4 \cdot \text{distance}/\text{wavelength}]$: **-108.5**

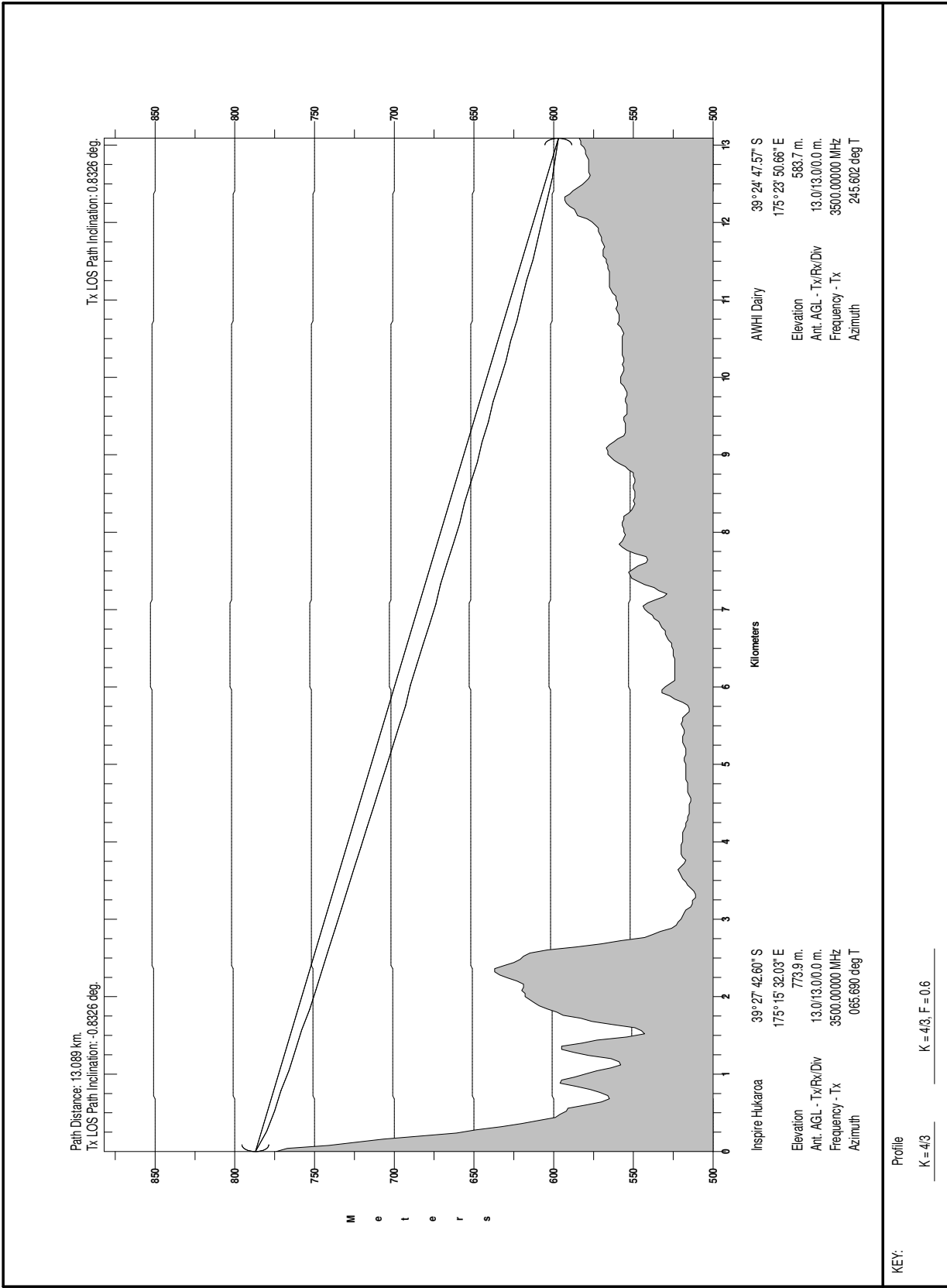
LM = Miscellaneous Loss: **-2dB**

GRx = Receive Antenna Gain: **25dBi**

LRx = Loss at the Receive End: **-1dB**

PRx = Power received at remote: **-80.5dB**

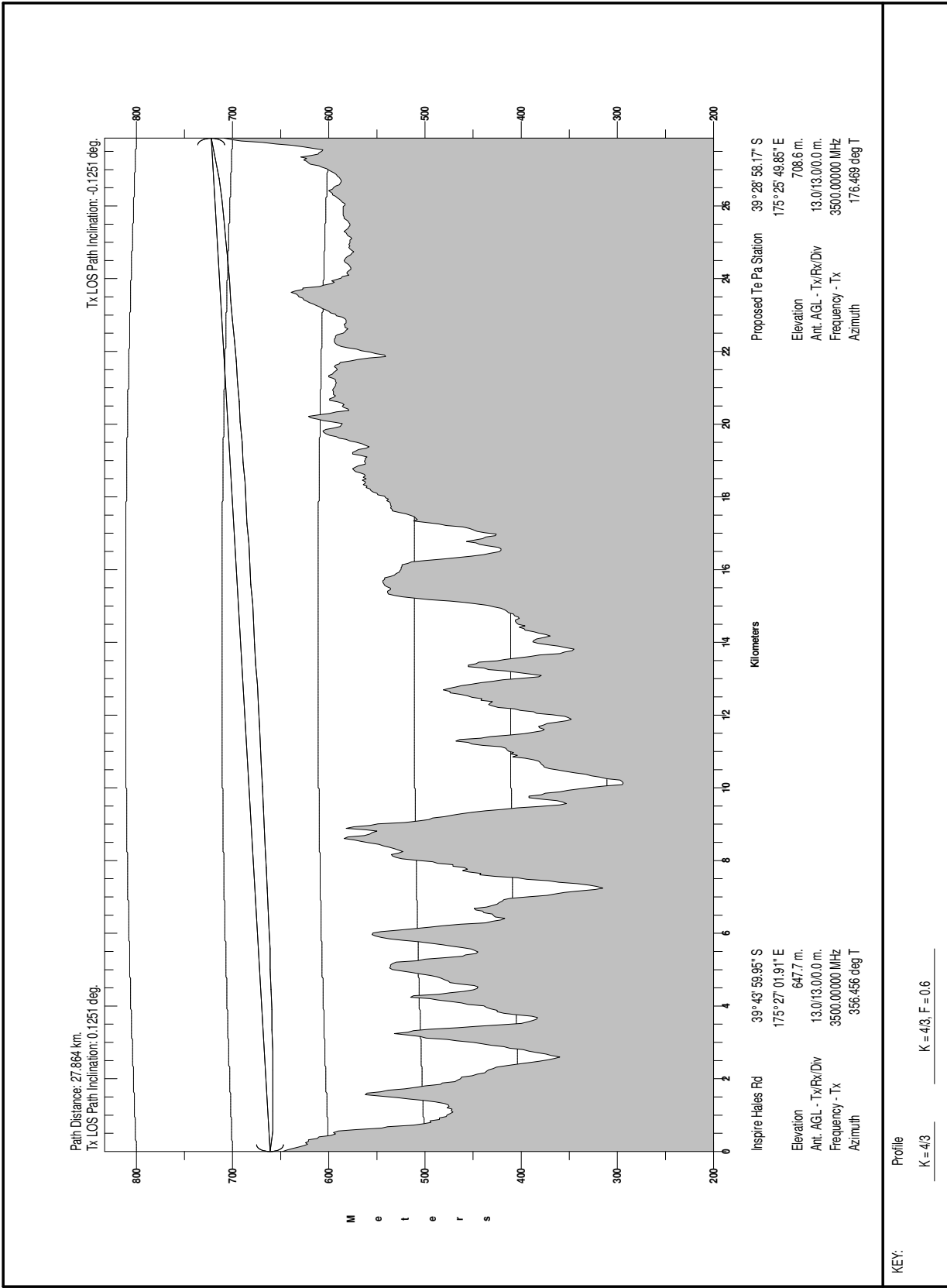


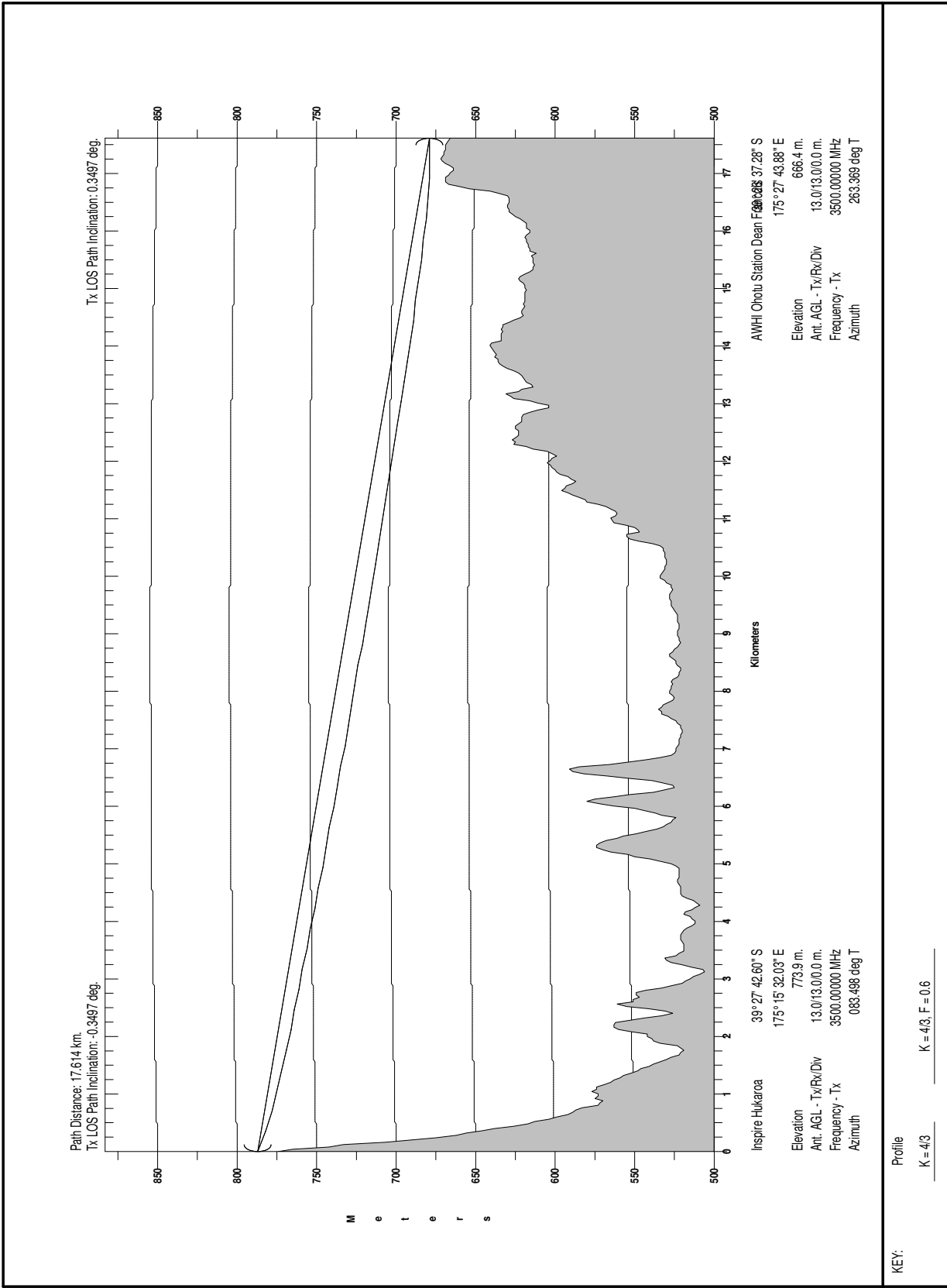


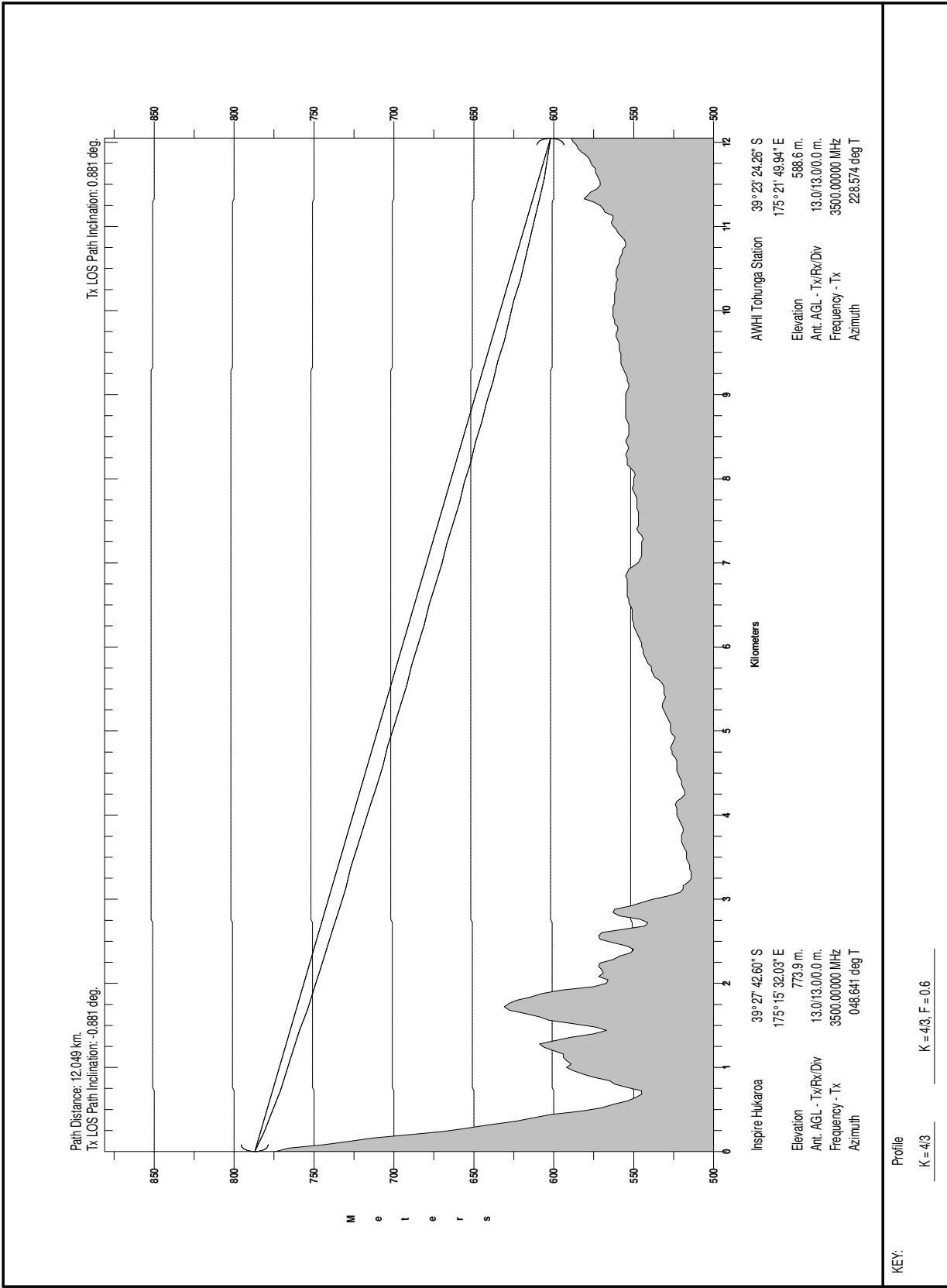
Profile

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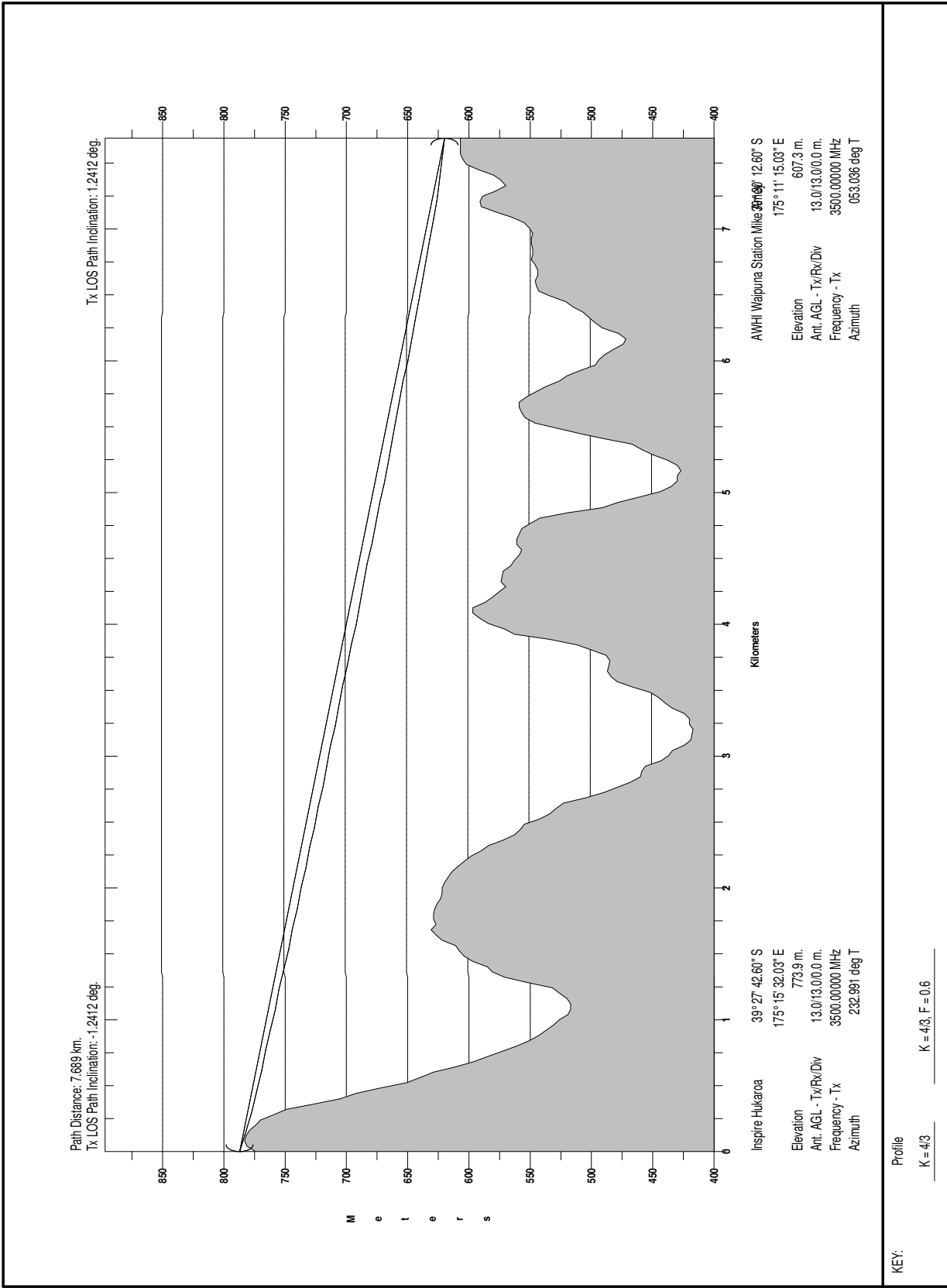




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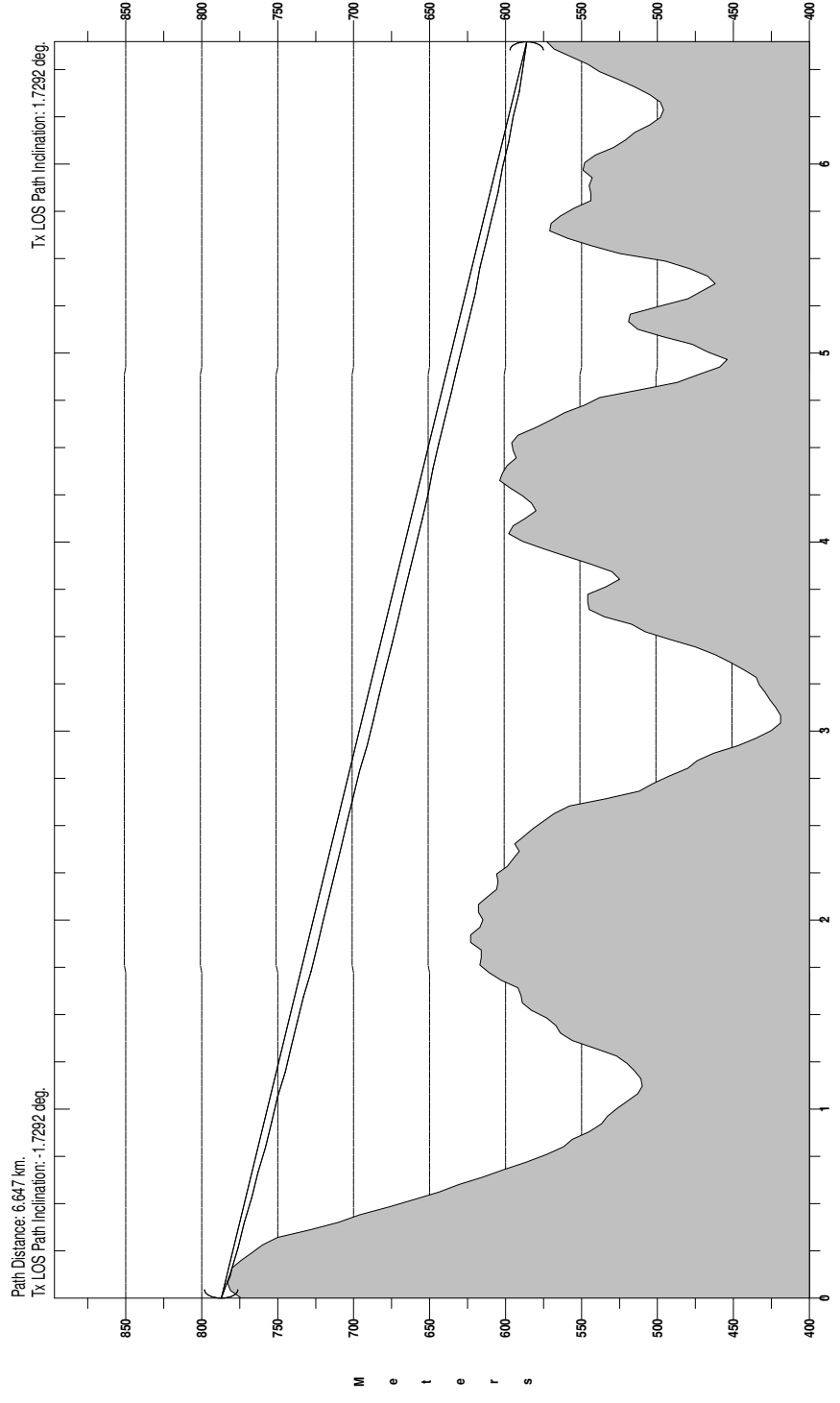
Profile

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K = 4/3, F = 0.6

AVHI Waipuna Station Mike 30090° 12.60" S
 175° 11' 15.03" E
 Elevation 607.3 m.
 Ant. AGL - Tx/Rx/Div 13.0/13.0/0.0 m.
 Frequency - Tx 3500.00000 MHz
 Azimuth 053.036 deg T

Inspire Hukarua 39° 27' 42.60" S
 175° 15' 32.03" E
 Elevation 773.9 m.
 Ant. AGL - Tx/Rx/Div 13.0/13.0/0.0 m.
 Frequency - Tx 3500.00000 MHz
 Azimuth 232.991 deg T

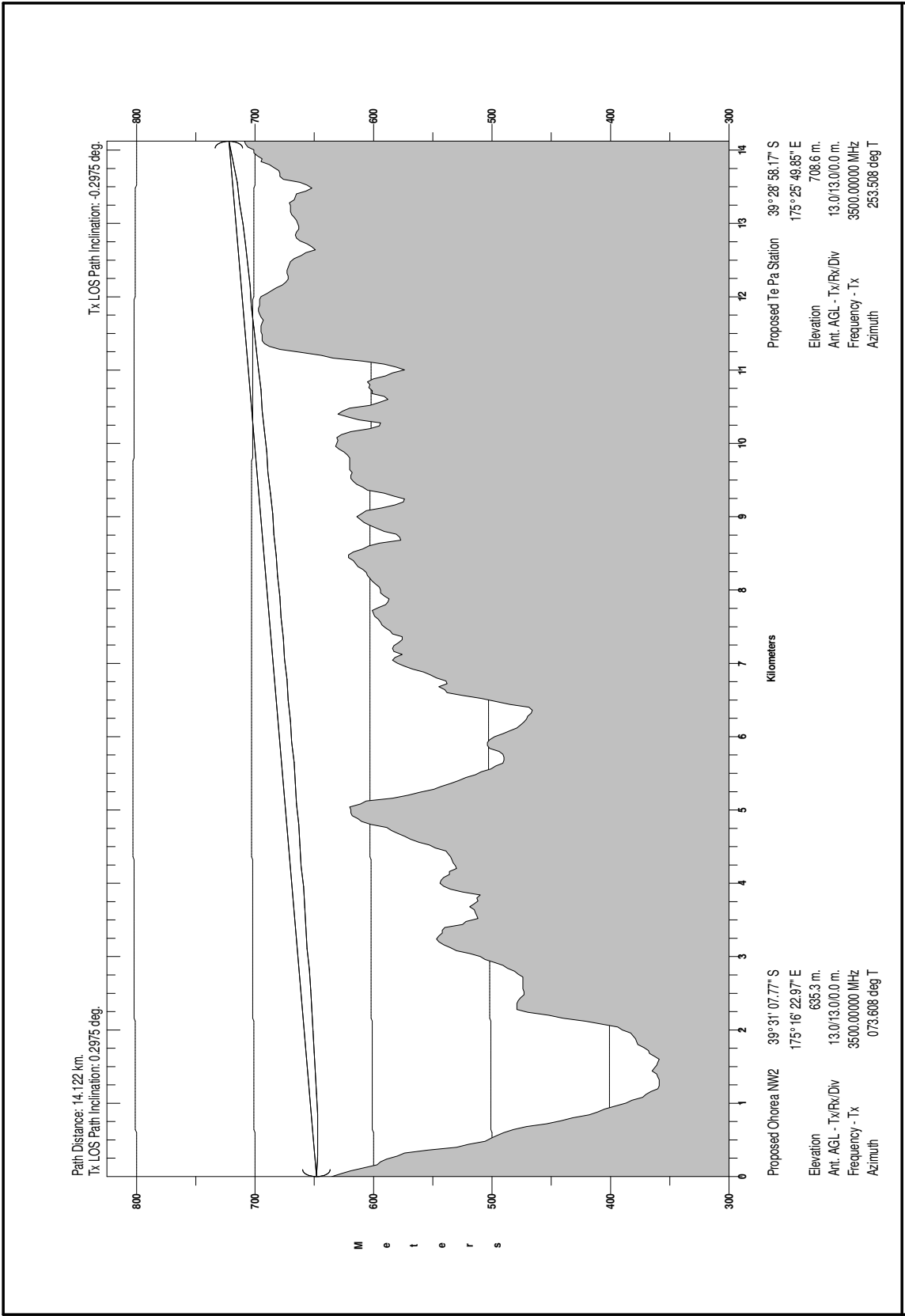


Inspire Hukarua 39° 27' 42.60" S
 175° 15' 32.03" E
 Elevation 773.9 m.
 Ant. AGL - Tx/Rx/Div 13.0/13.0/0.0 m.
 Frequency - Tx 3500.00000 MHz
 Azimuth 235.342 deg T

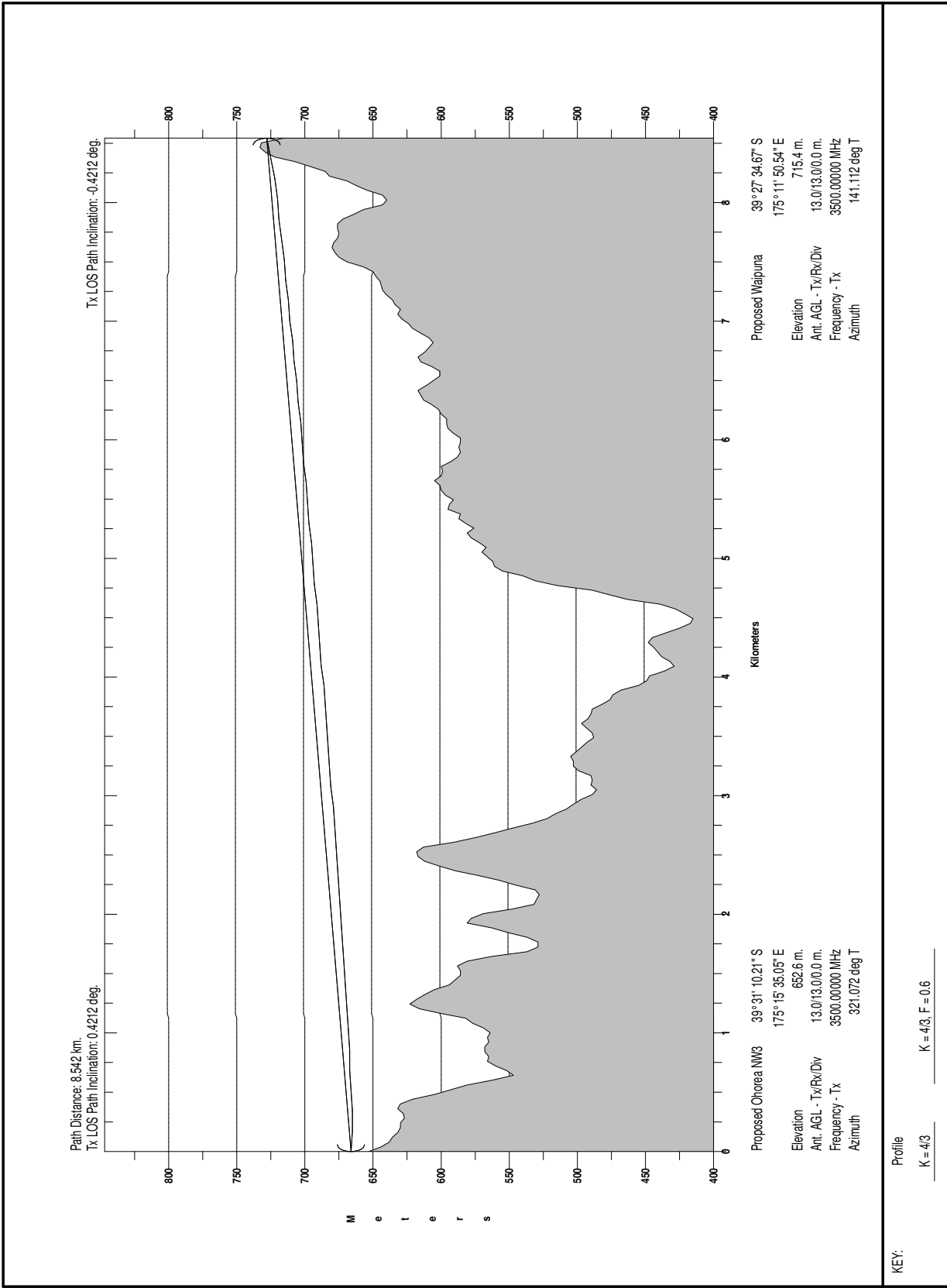
AVHI Waipuna Station Way 88980411" S
 175° 11' 43.19" E
 Elevation 573.2 m.
 Ant. AGL - Tx/Rx/Div 13.0/13.0/0.0 m.
 Frequency - Tx 3500.00000 MHz
 Azimuth 055.383 deg T

Profile
 K = 4/3 K = 4/3, F = 0.6

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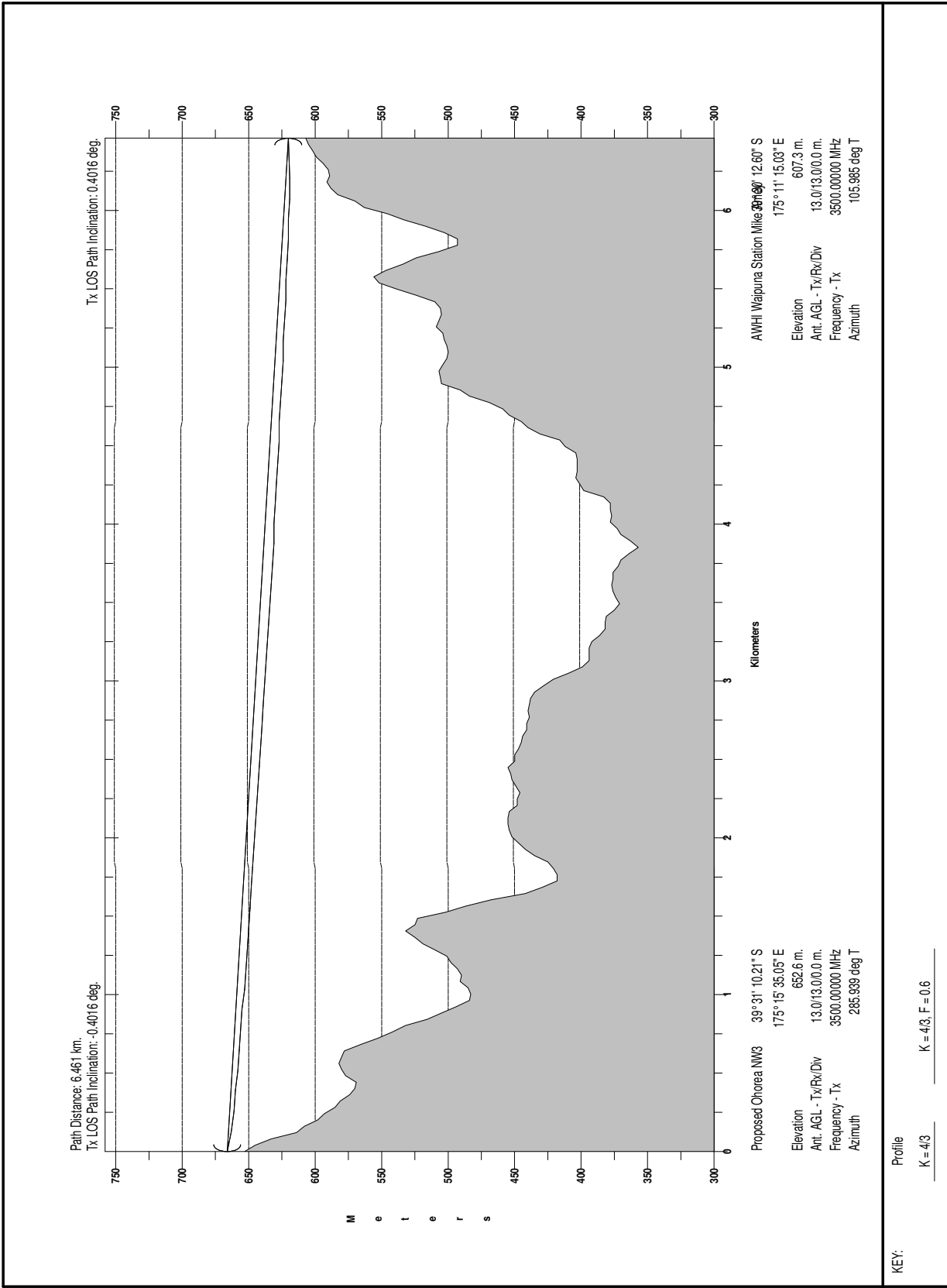


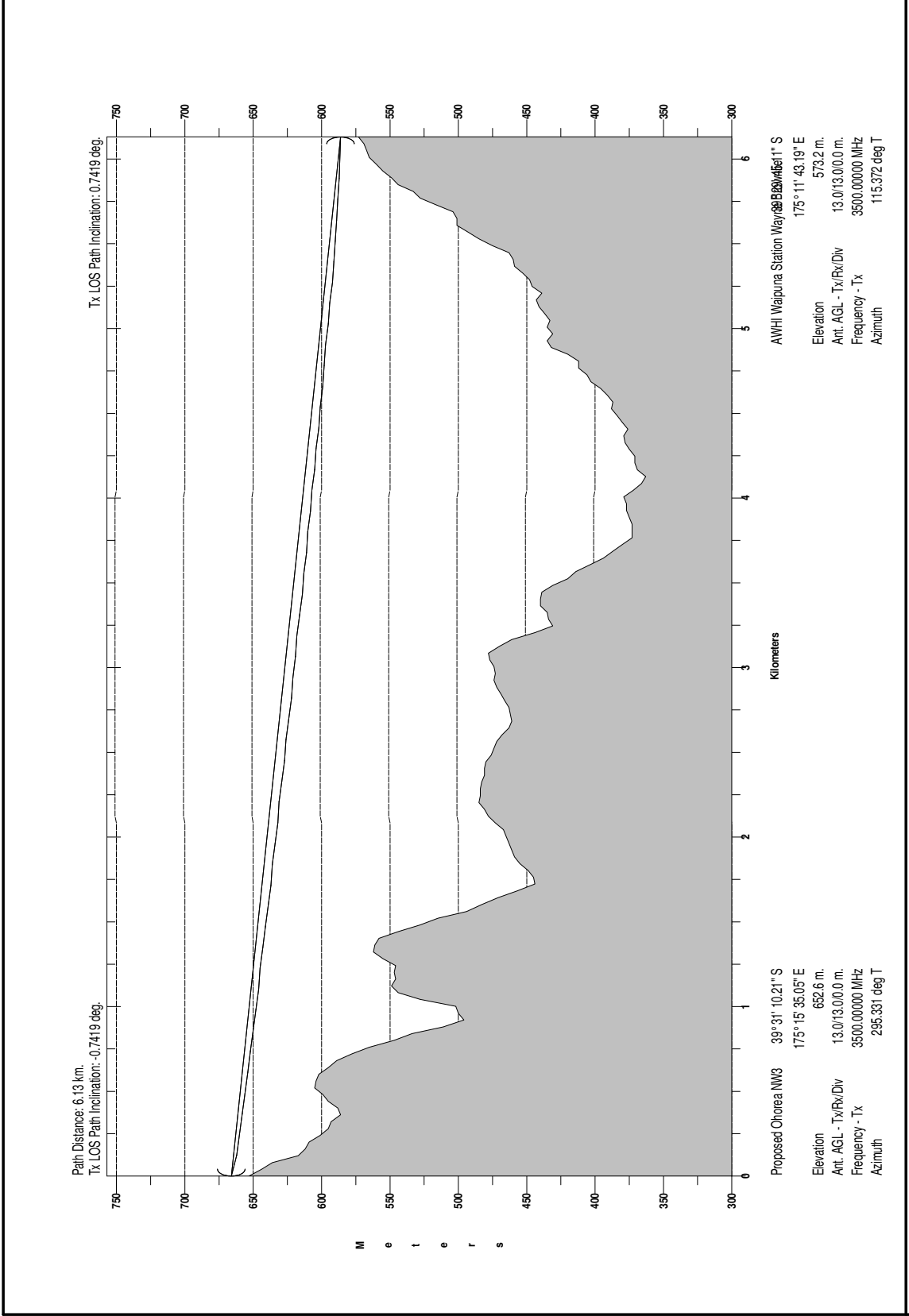
KEY: Profile
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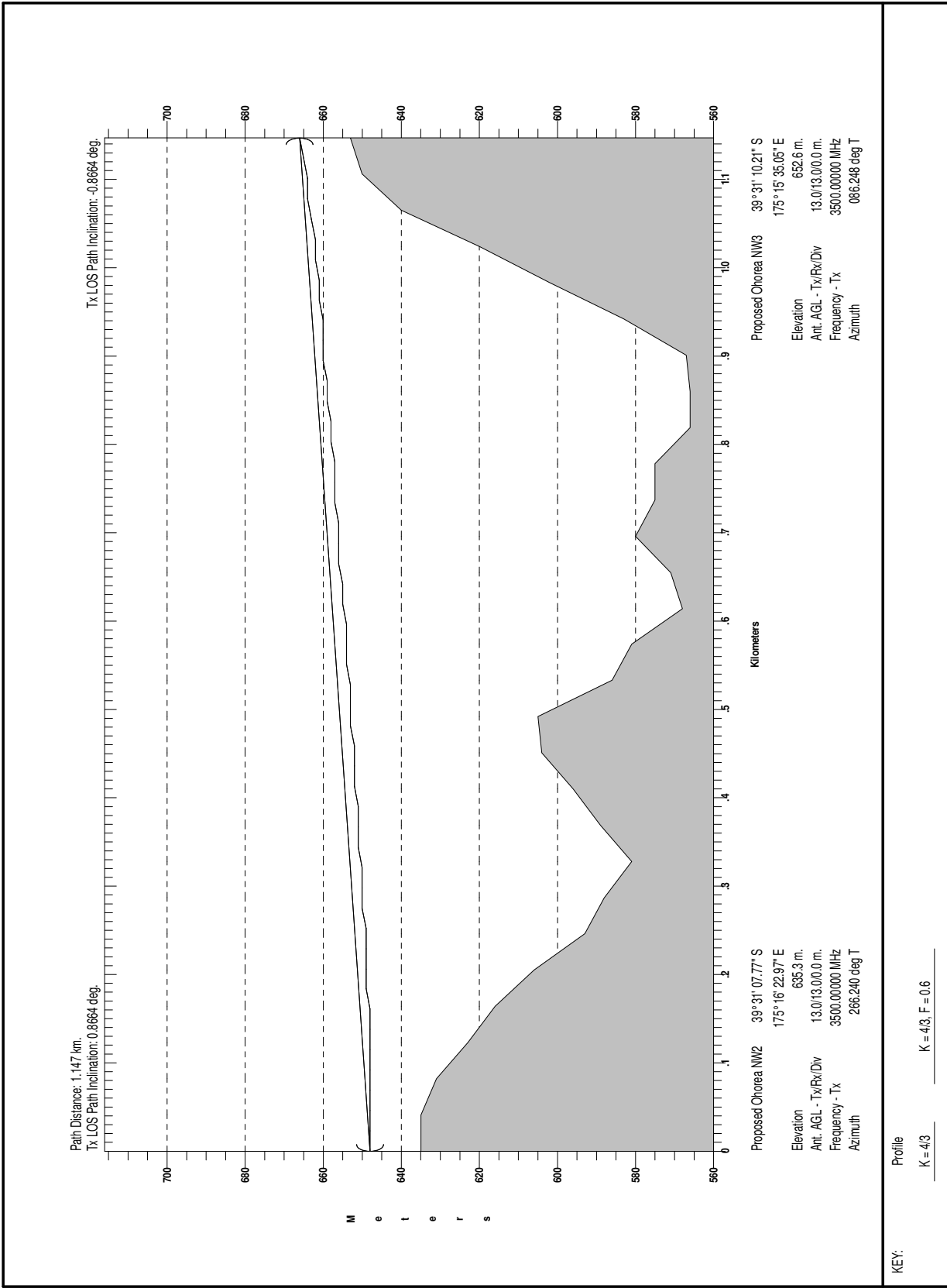
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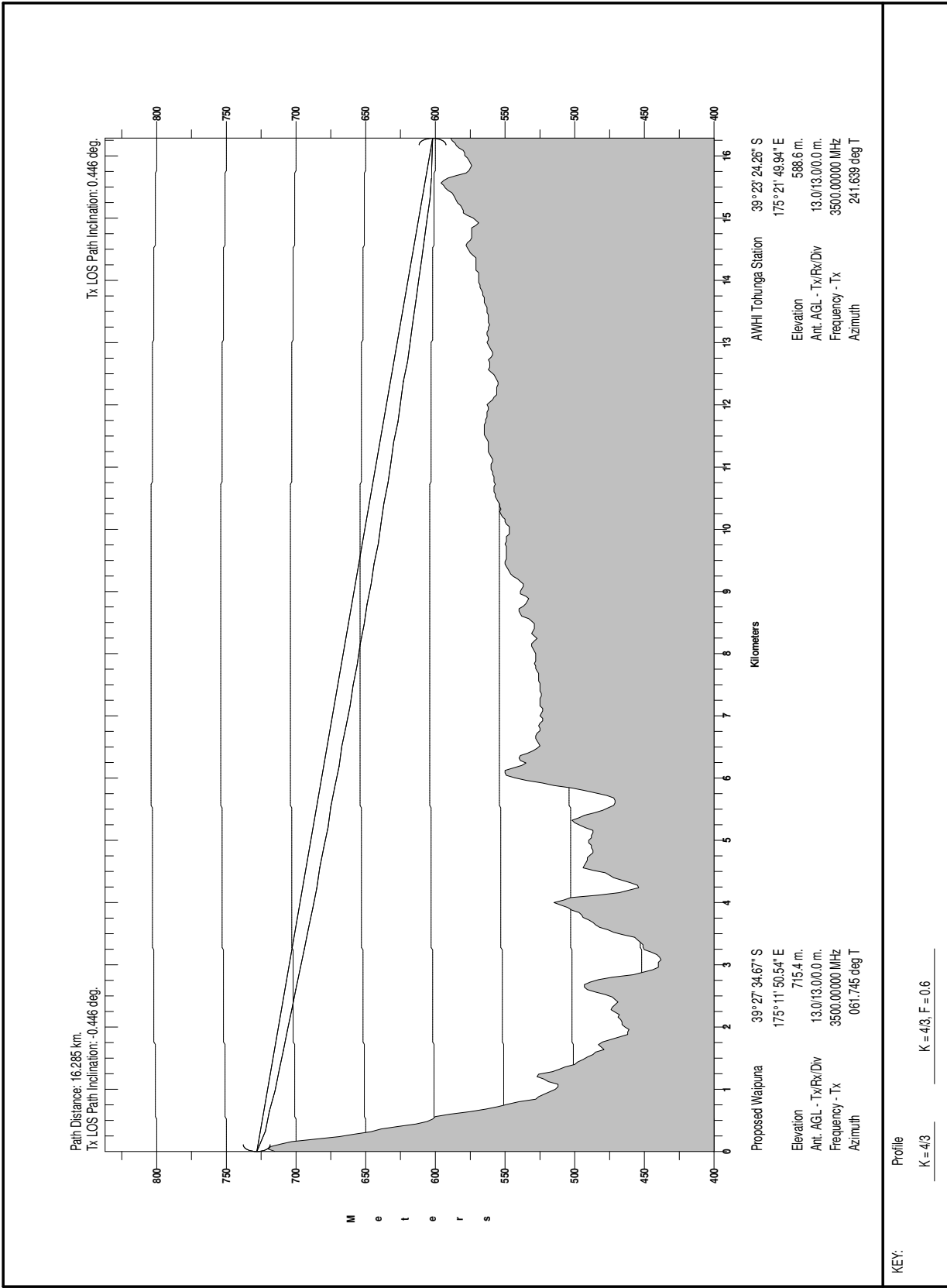
Profile
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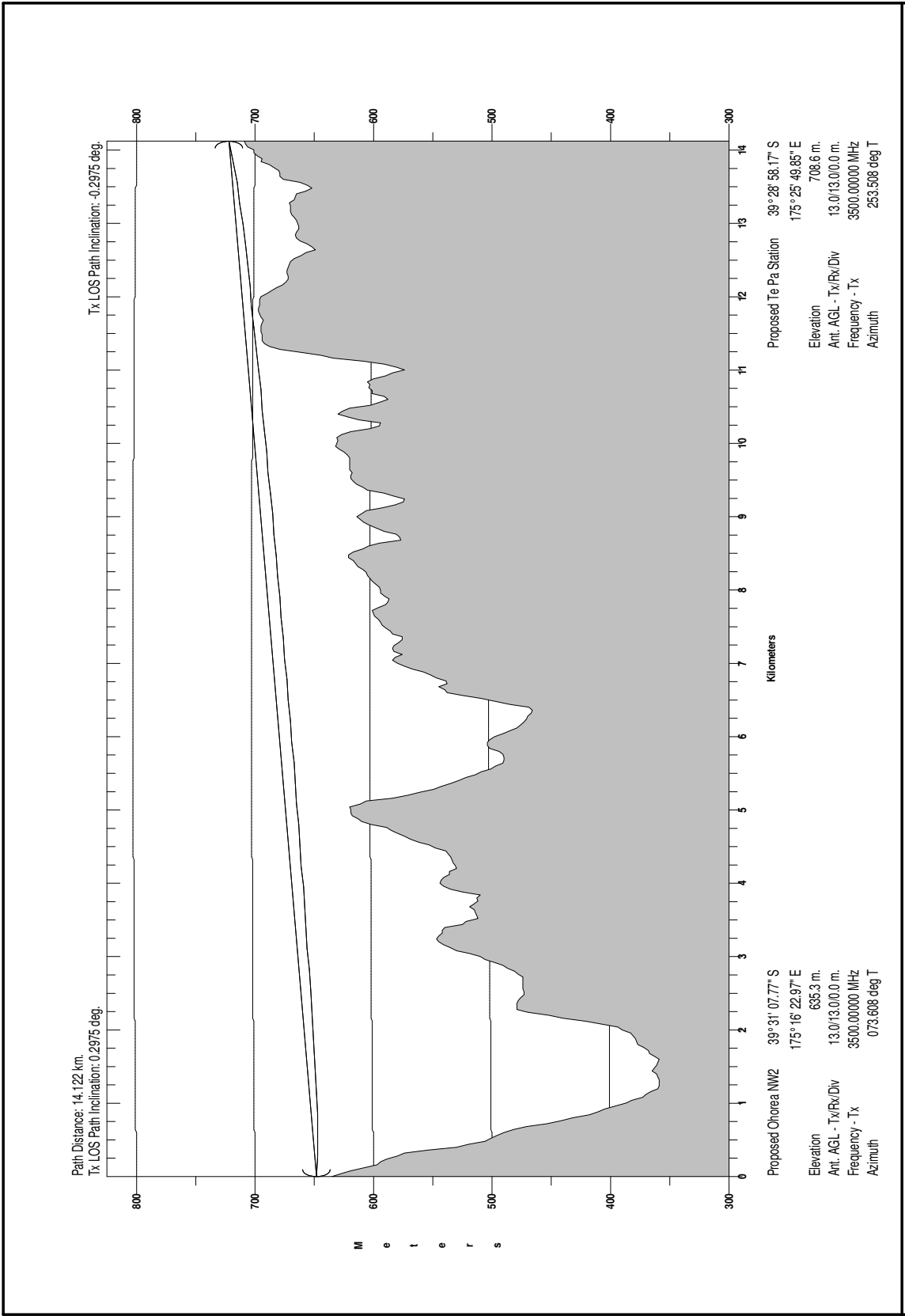




M e t e r s
 Kilometers
 Profile
 K = 4/3 K = 4/3, F = 0.6

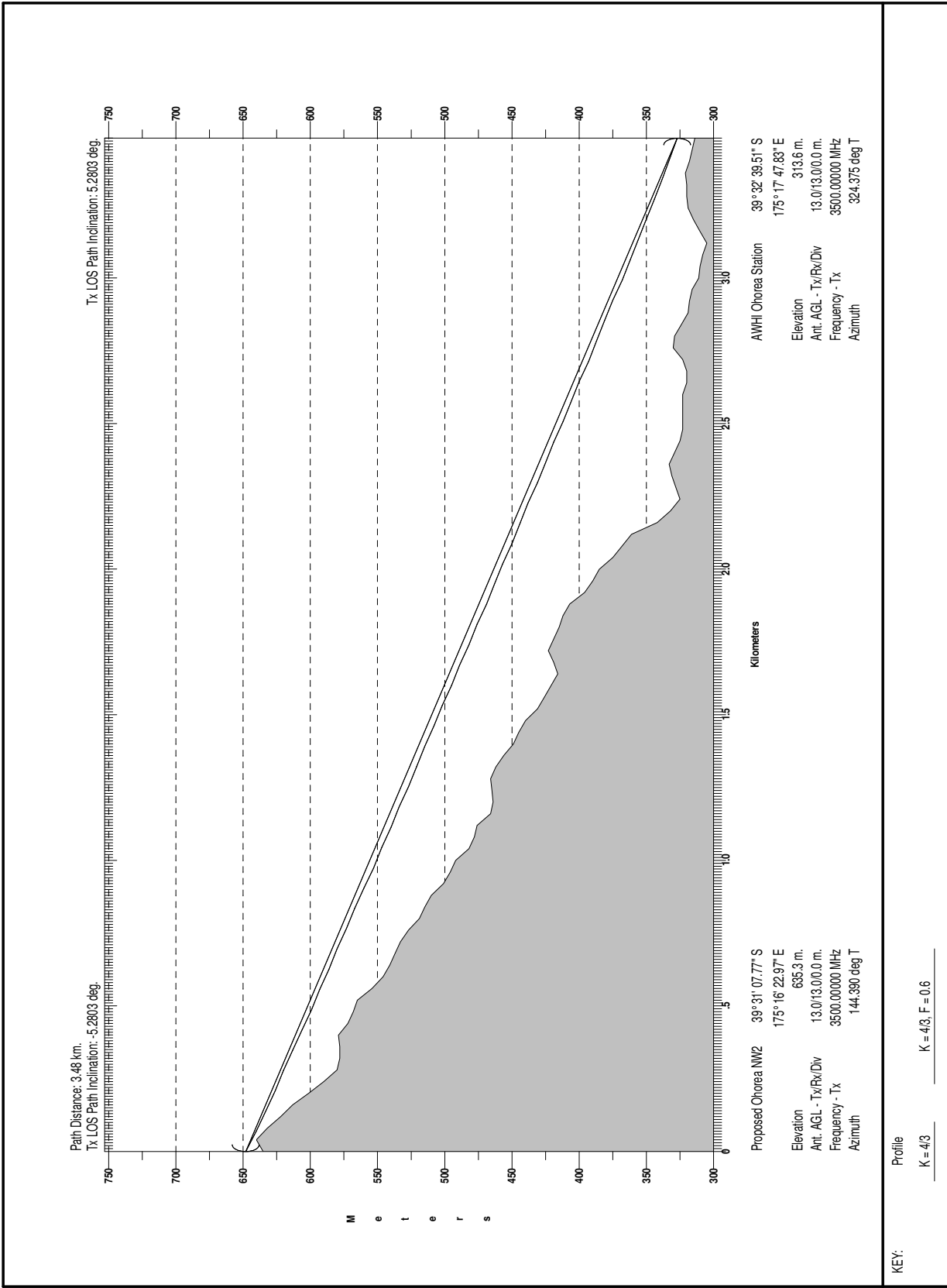


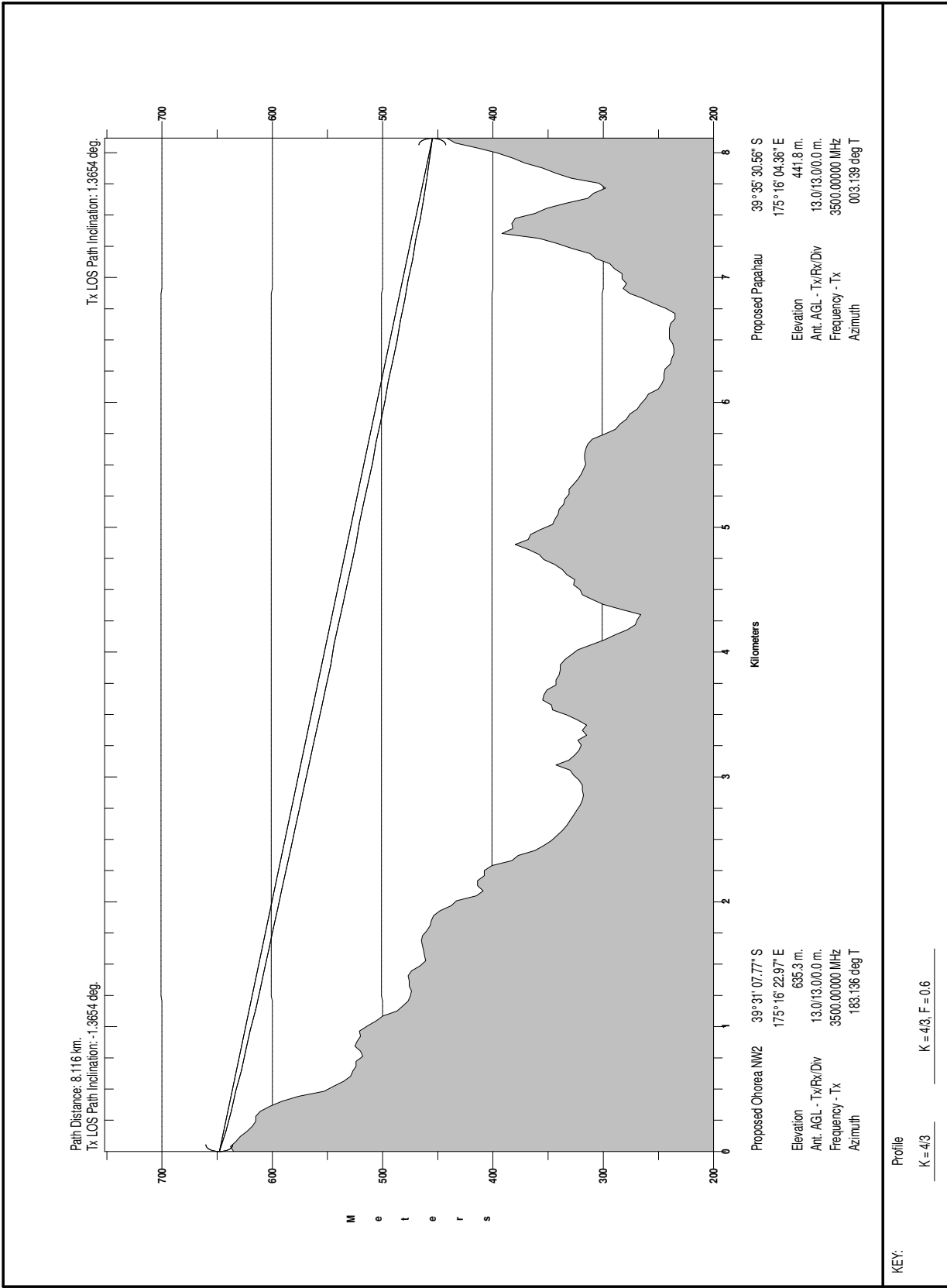




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Profile
K = 4/3 K = 4/3, F = 0.6



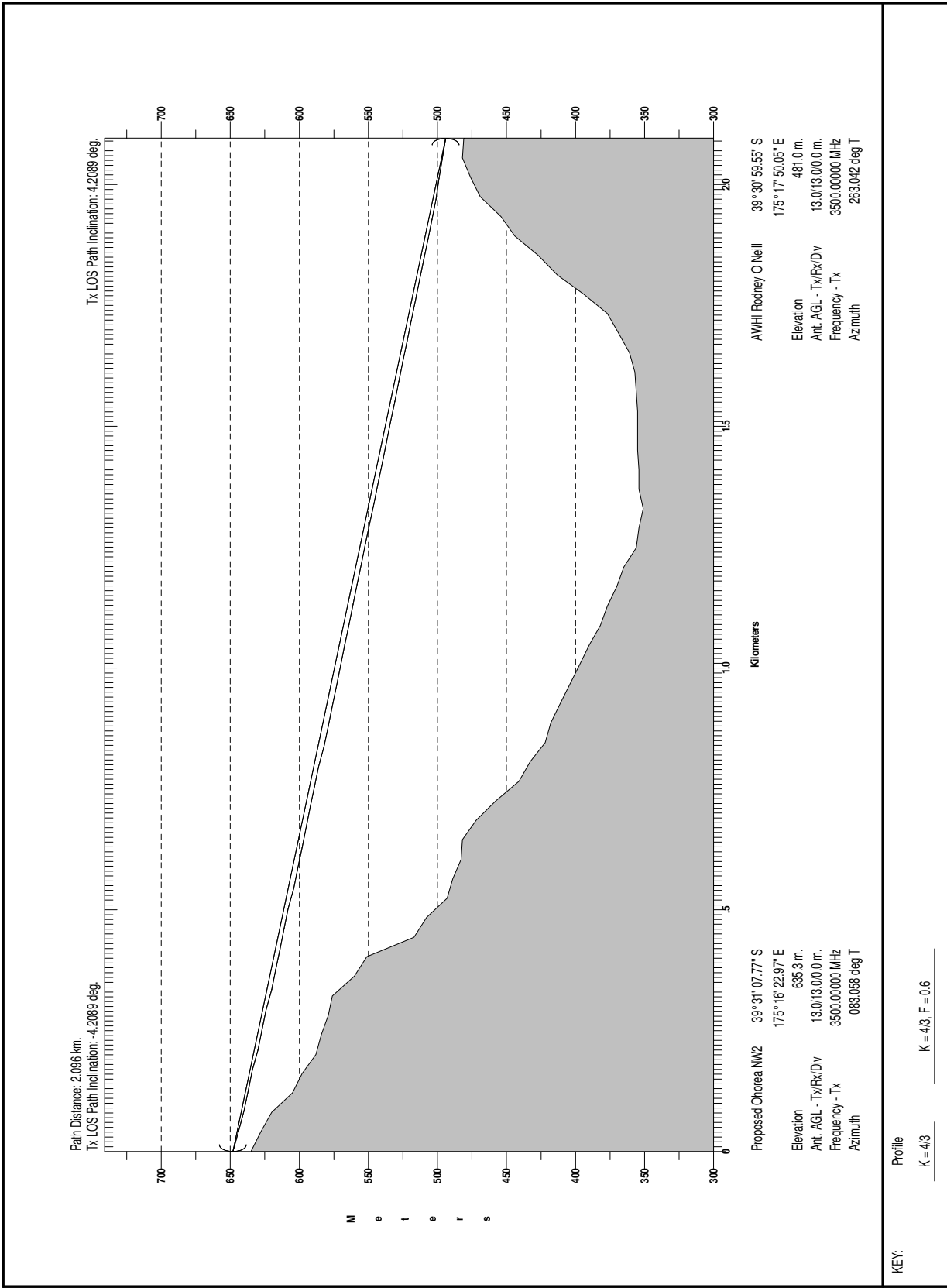


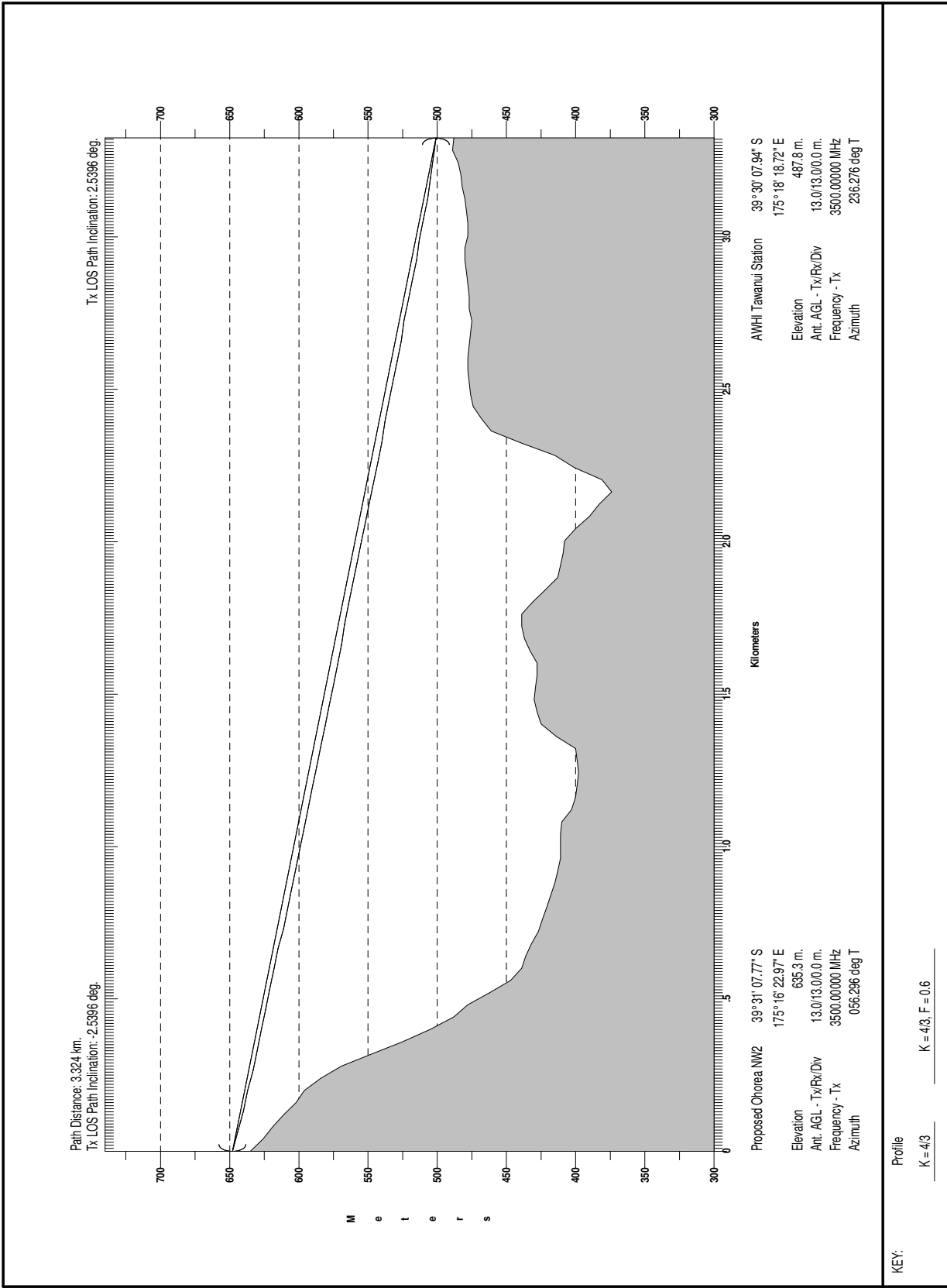
Path Distance: 8.116 km.
 Tx LOS Path Inclination: -1.3654 deg.
 Tx LOS Path Inclination: 1.3654 deg.

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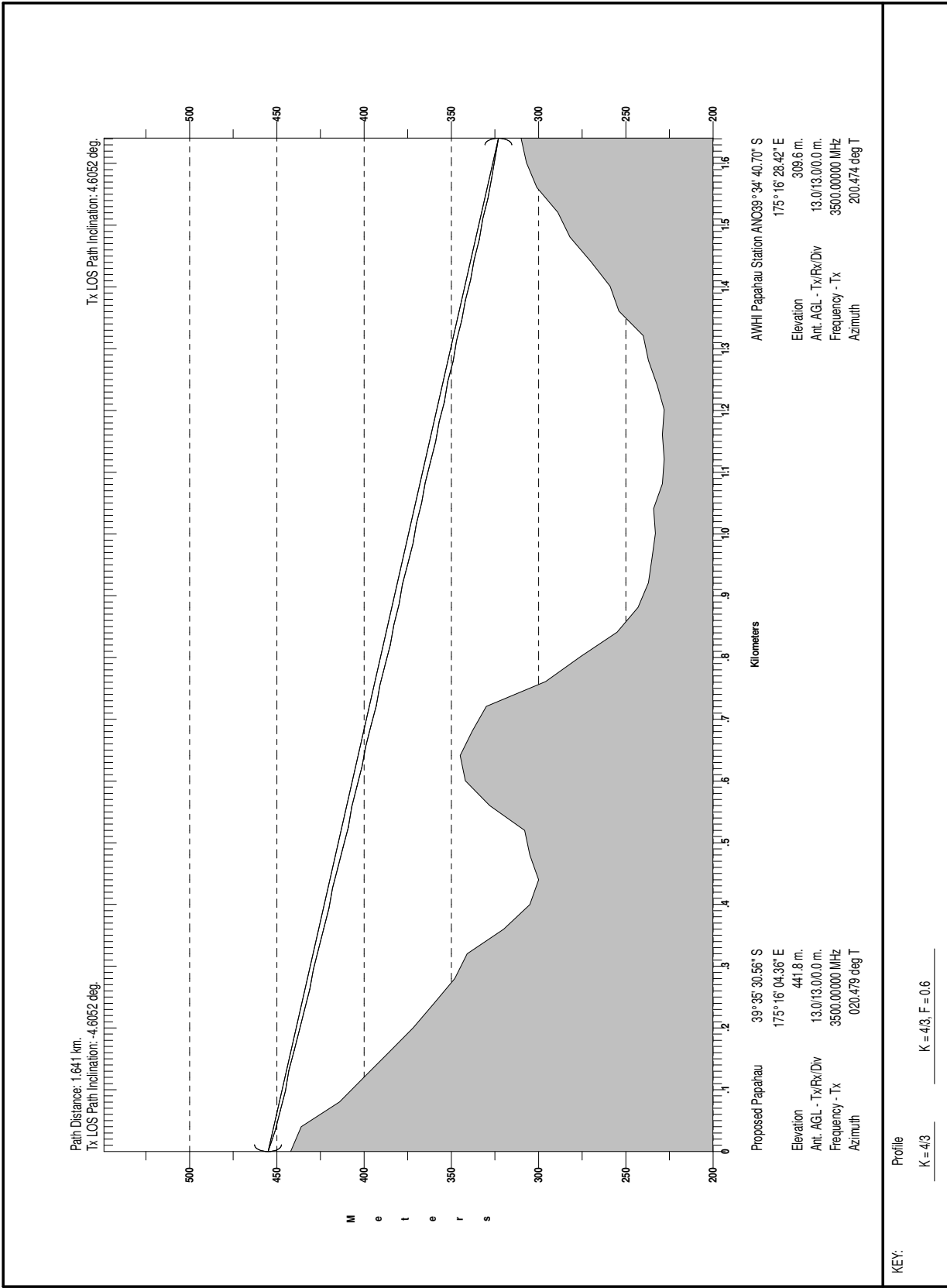
KEY:
 Profile
 K = 4/3 K = 4/3, F = 0.6

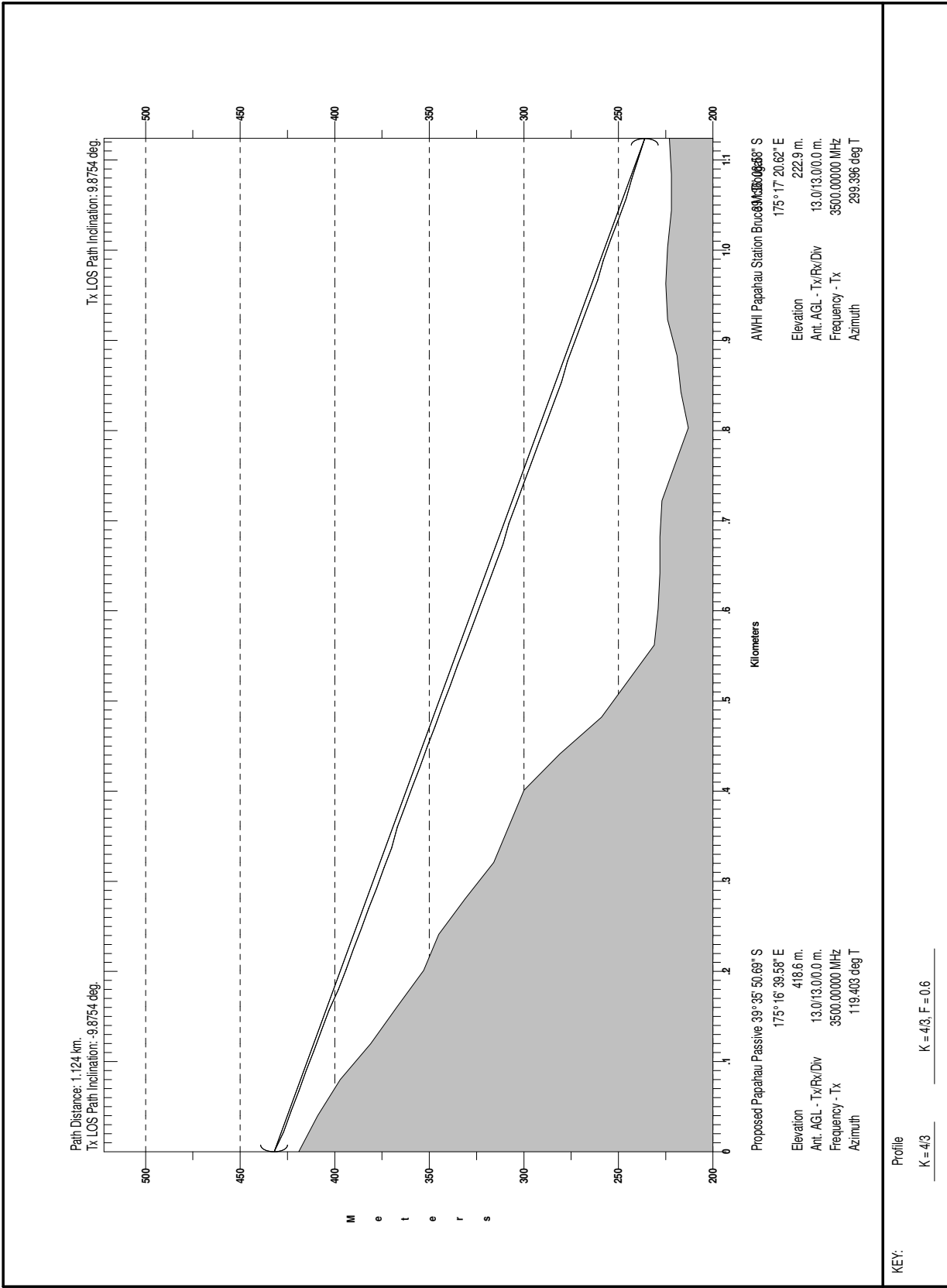


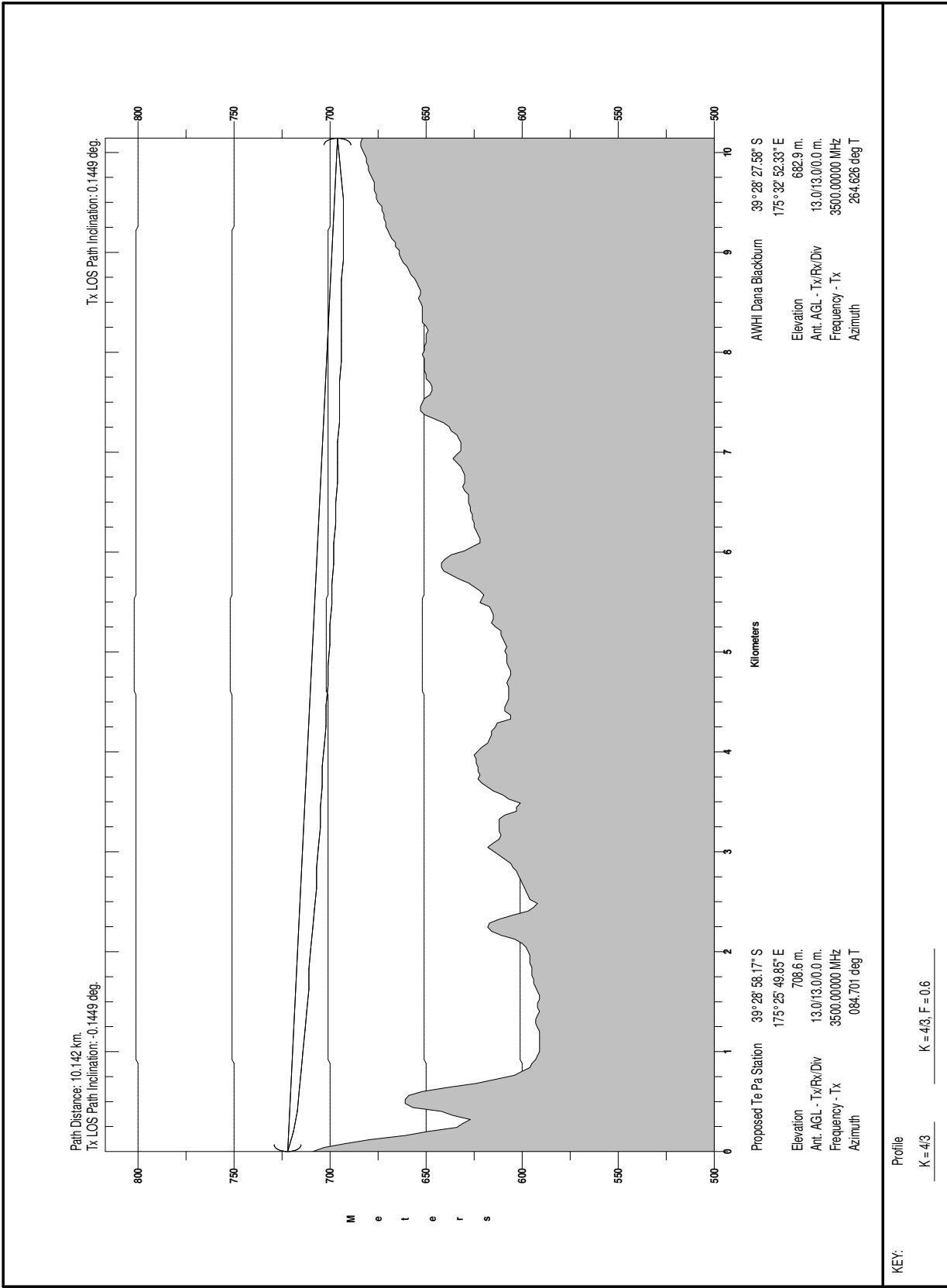


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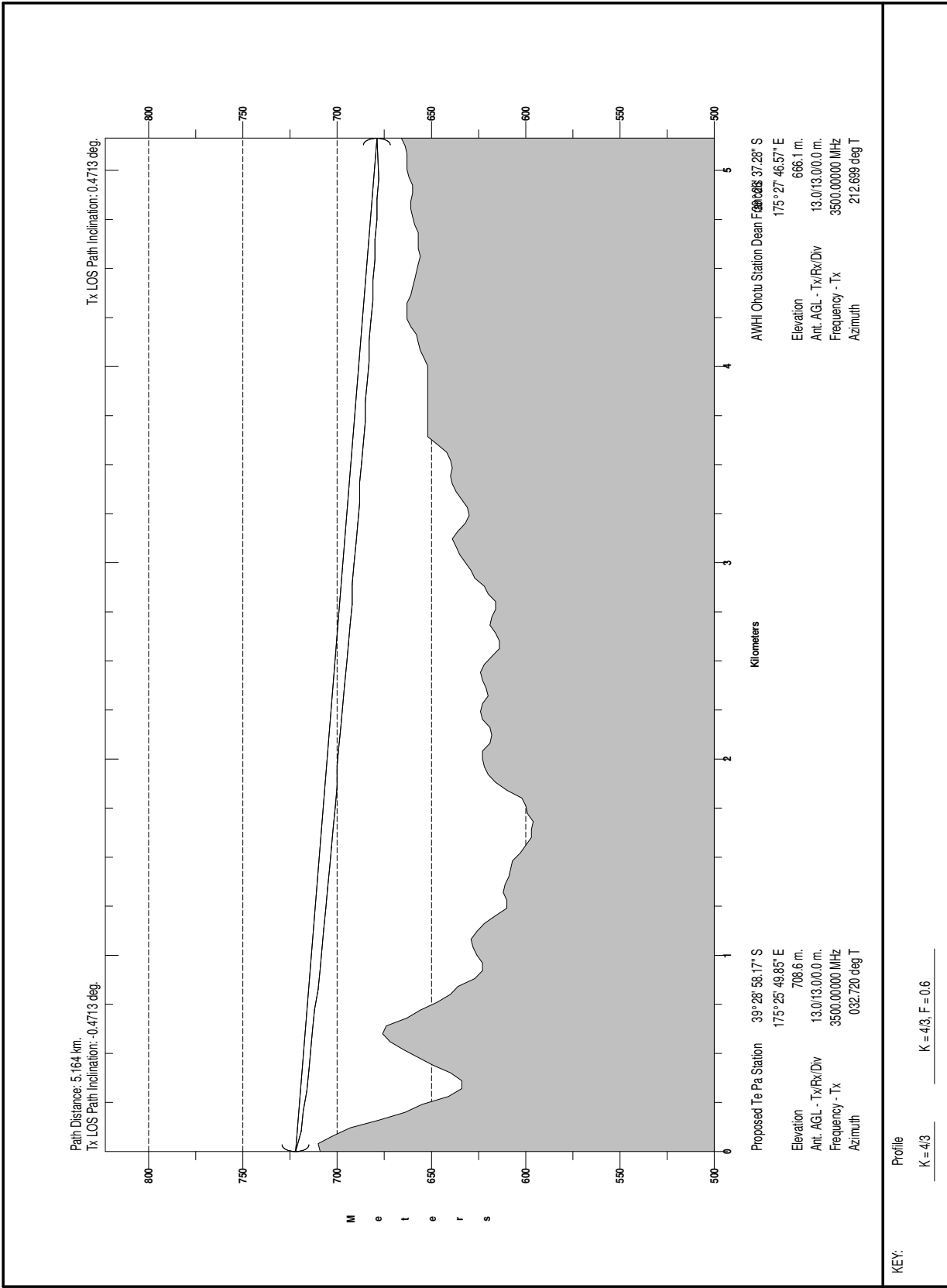






KEY:

Profile
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Path Distance: 5.164 km.
Tx LOS Path Inclination: -0.4713 deg.

Path Distance: 5.164 km.
Tx LOS Path Inclination: 0.4713 deg.

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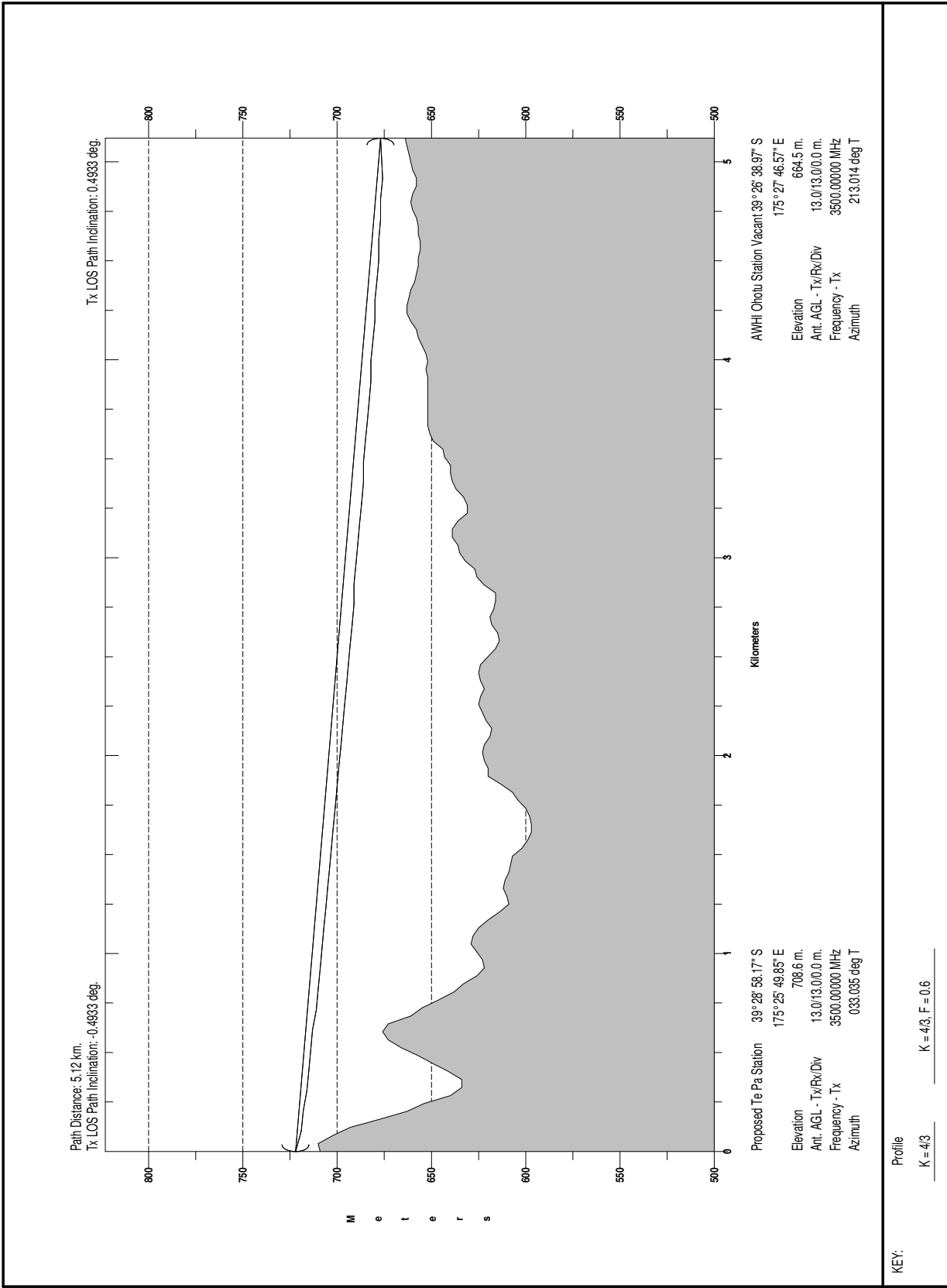
Proposed Te Pa Station 39° 28' 58.17" S
175° 25' 49.85" E
Elevation 708.6 m.
Ant. AGL - Tx/Rx/Div 13.0/13.0/0.0 m.
Frequency - Tx 3500.00000 MHz
Azimuth 032.720 deg T

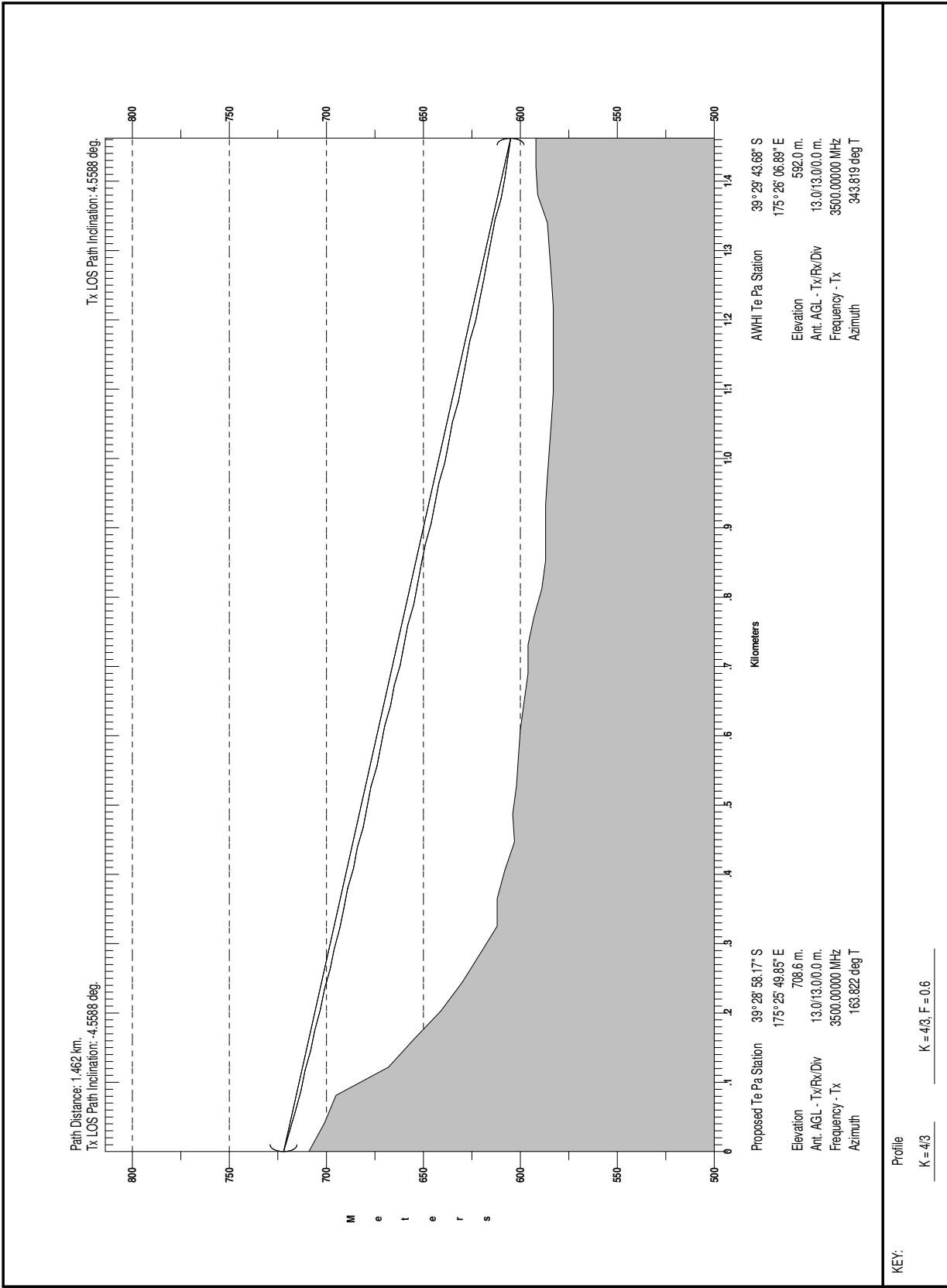
AVHI Chotu Station Dean F680028 37.28" S
175° 27' 46.57" E
Elevation 666.1 m.
Ant. AGL - Tx/Rx/Div 13.0/13.0/0.0 m.
Frequency - Tx 3500.00000 MHz
Azimuth 212.689 deg T

Kilometers

KEY: Profile

K = 4/3 F = 0.6





KEY:

Profile
K = 4/3 K = 4/3, F = 0.6

