For

MESHDYNAMICS SYSTEM INTEGRATORS

NETWORK LAYOUT DESIGN AND ANTENNA SELECTION

NETWORK DESIGN

The design of most networks starts with a satellite view of the deployment area. This can be gotten from Google Maps.

The satellite view can then be labeled to mark the root and relay nodes of a tree based wireless mesh network.

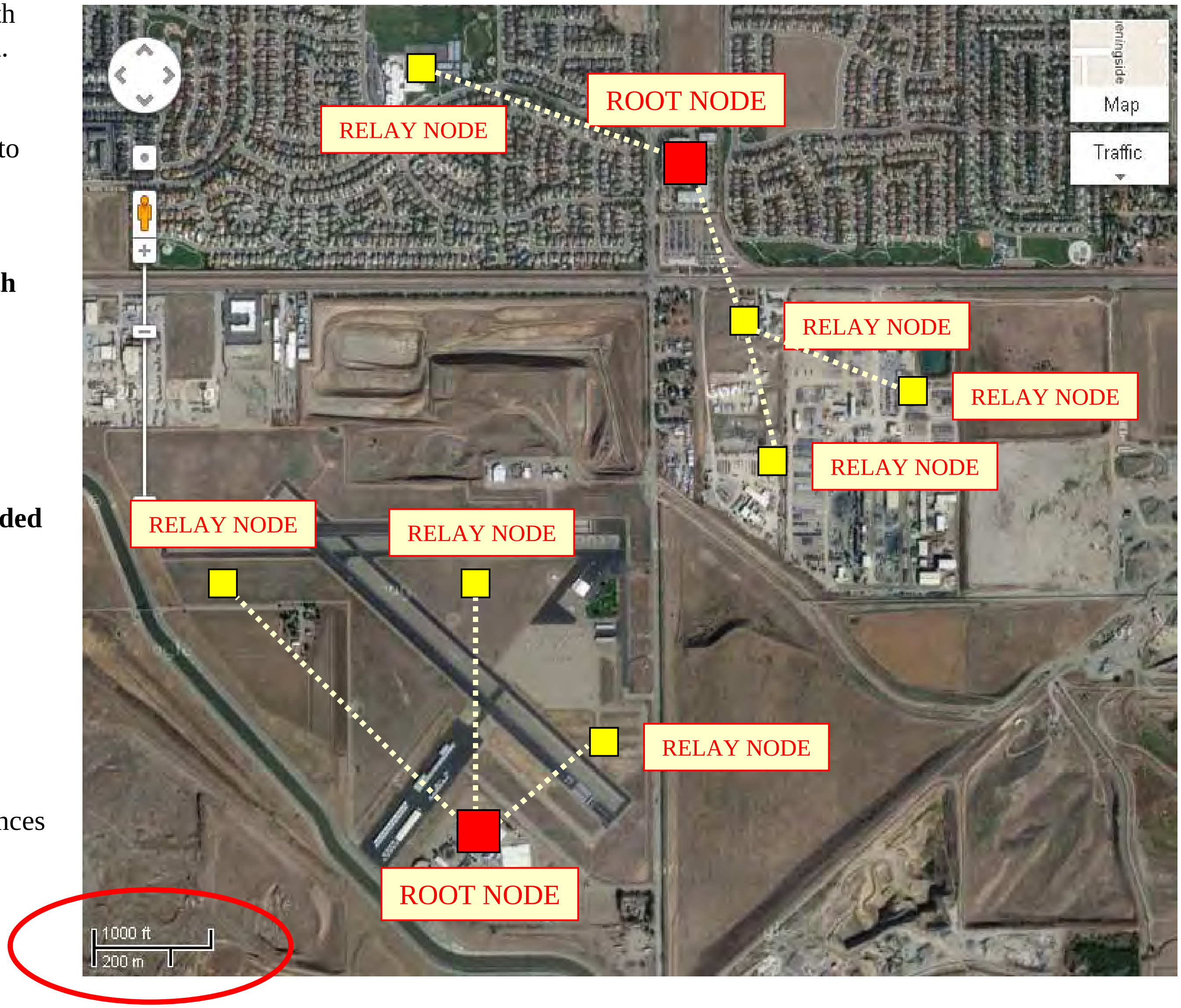
1) Where is the root of the bandwidth (root nodes):

Internet source
Security Office
Network Operations Center
etc.

2) Where are the points/areas of needed bandwidth (relay nodes):

Associated Client Devices
Surveillance Cameras
Vehicles
Customer Homes
etc.

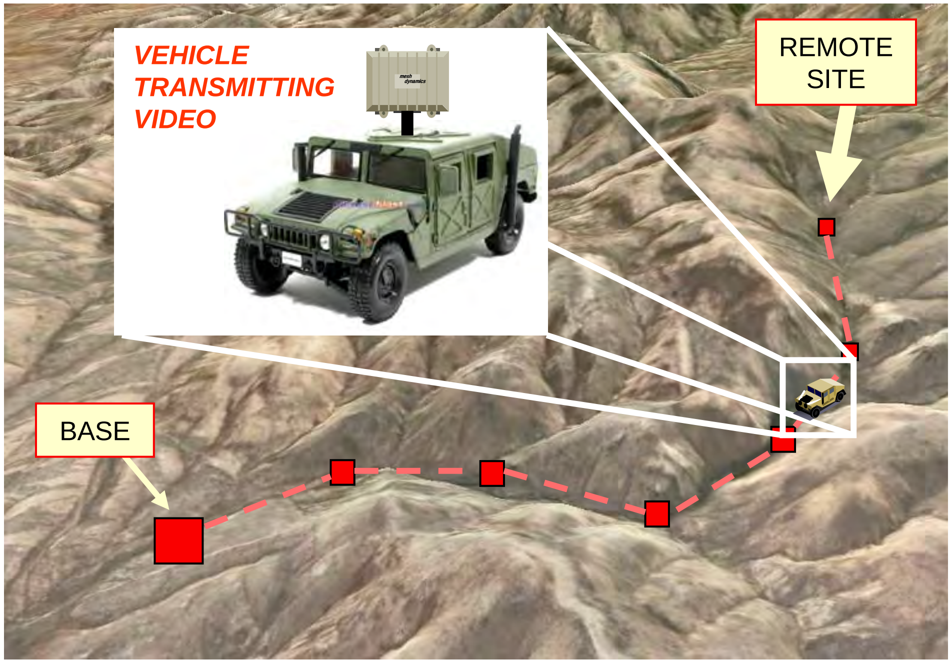
Node-to-node and node-to-client distances can be gauged using the satellite view.

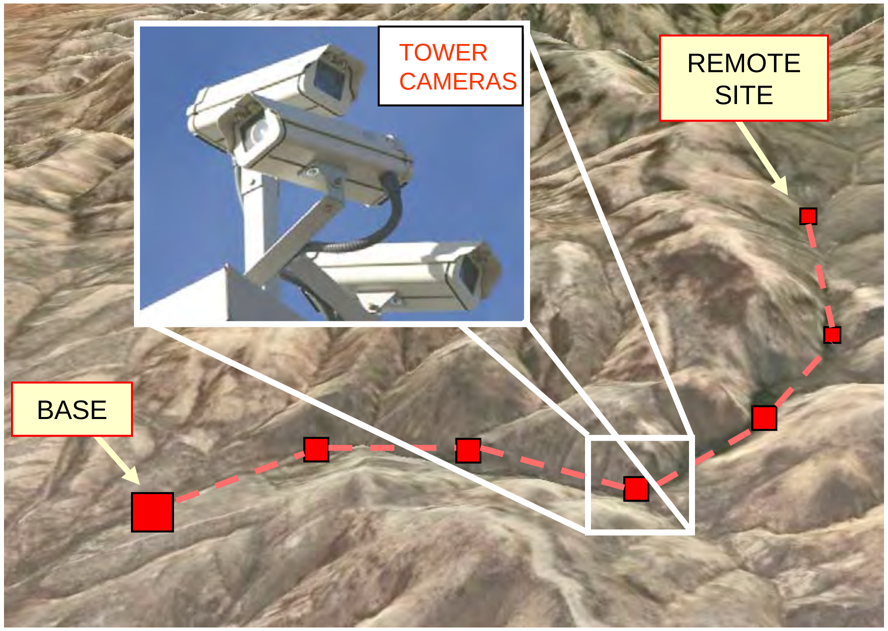


NODE LOCATIONS

<u>Node locations are influenced by:</u>

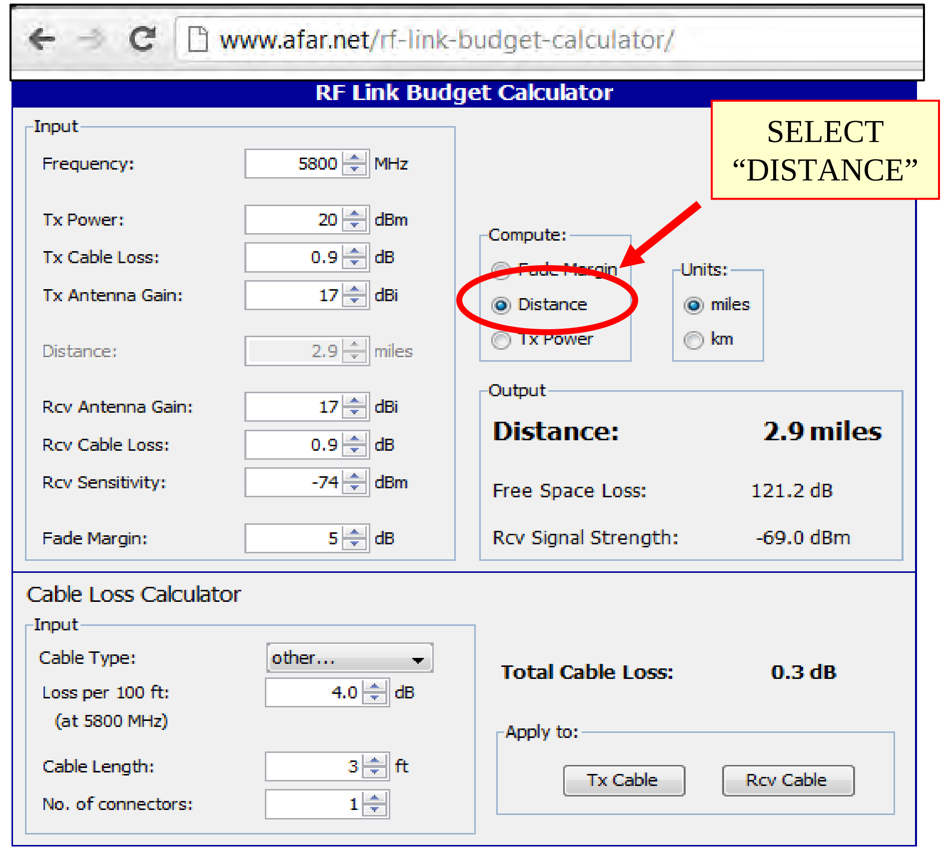
---The start (root node) and end points (edge nodes) of bandwidth
---Points in between root node and edge node (backhaul)
---Local distribution of client devices
---Camera locations
---Possible vehicle locations
---Available power sources
---Limitations of antenna ranges
---Limitations of node-mounting locations





RANGE ESTIMATION

Node-to-node, and node-to-client ranges vary tremendously. It is helpful to use a link budget calculator – such the one shown (right).



Radio Power: The Wistron radio cards used by Meshdynamics have a maximum power output of 350mW (~25dBm). As can be seen by the table below, the transmit (Tx) power changes with varying data rates. Receive sensitivity (Rx) also reduces with high data rates.

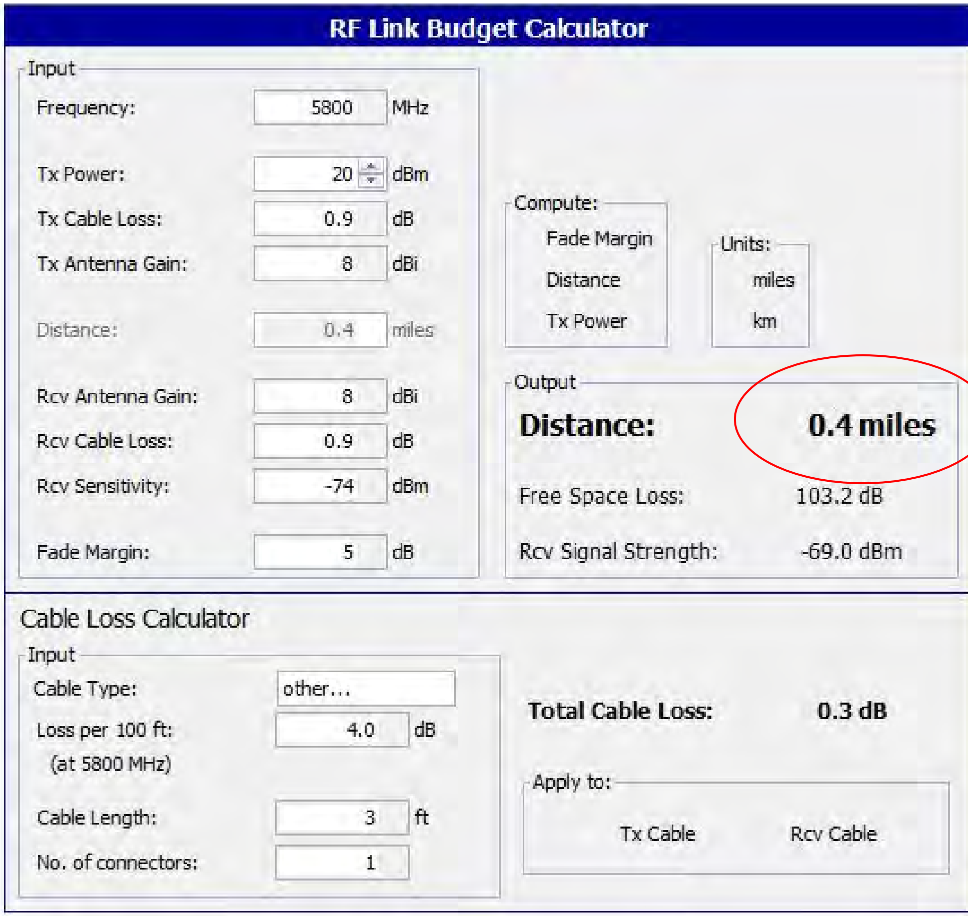
Antenna Gain: Higher gain antennas provide more range, but, as distances increase, there is more noise and effective data rate is reduced. Hence a margin of safety is suggested. The following values have been plugged in.

Frequency: **5800MHz**
Tx power: **20dBm** (for 54Mbps, as per table)
Tx cable loss: **0.9dB**
Tx Antenna Gain: **17dBi**
Receive Antenna Gain: **17dBi**
Receive Cable Loss: **0.9dB**
Receive Sensitivity: **-74dBm** (For 54 Mbps)
Fade Margin: **5dB**

RADIO OPERATING FREQUENCY 5.20-5.825GHz

	TX SPECIFICATIONS					RX SPECIFICATIONS		
	DataRate	Avg.Power	Tolerance			DataRate	Sensitivity	Tolerance
802.11a OFDM	6Mbps	25dBm	+/-1.5dB		802.11a OFDM	6Mbps	-94 dBm	+/-1.5dB
	9Mbps	25dBm	+/-1.5dB			9Mbps	-93 dBm	+/-1.5dB
	12Mbps	25dBm	+/-1.5dB			12Mbps	-91 dBm	+/-1.5dB
	18Mbps	25dBm	+/-1.5dB			18Mbps	-90 dBm	+/-1.5dB
	24Mbps	23dBm	+/-1.5dB			24Mbps	-86 dBm	+/-1.5dB
	36Mbps	22dBm	+/-1.5dB			36Mbps	-83 dBm	+/-1.5dB
	48Mbps	21dBm	+/-1.5dB			48Mbps	-77 dBm	+/-1.5dB
	54Mbps	20dBm	+/-1.5dB			54Mbps	-74 dBm	+/-1.5dB

RANGE ESTIMATION



For mobile nodes and/or more redundant paths, omni-directional antennas are preferred. However, their drawback is lower gain and thus lower range. Range calculation above for 54 Mbps, 8 Dbi Antenna

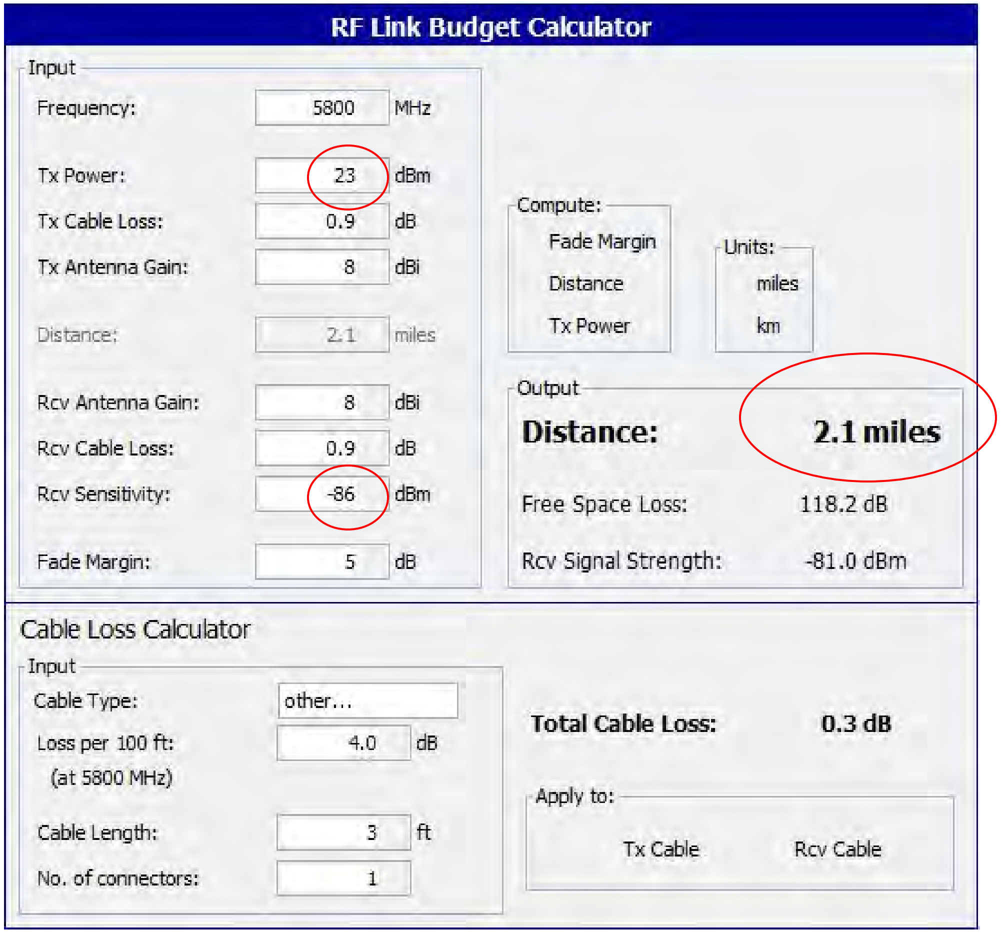
SuperPass 5.1-5.9 Antennas should be used.

www.superpass.com/5100-5900M.html

SuperPass omni SPDJ80 9 Dbi shown above

See www.meshdynamics.com/MDInstallationInstructions.html for suggested sector and panel antennas for static nodes suggestions

RANGE ESTIMATION



<u>Changing the Transmit Rate from 54 Mbps to 24 Mbps:</u>

1. Increases transmit power to 23 Dbm
2. Increases receiver sensitivity to – 86 Dbm

<u>Note</u>: the transmit rate control algorithms automatically reduce transmit rate when control system running in each node deems it necessary.

Expert users can also set Transmit rate upper limits manually, see the NMS configuration manual.

Frequency: **5800MHz**
Tx power: **23dBm** (for 24 Mbps, as per table, page 4)
Tx cable loss: **0.9dB**
Tx Antenna Gain: **8dBi**
Receive Antenna Gain: **8dBi**
Receive Cable Loss: **0.9dB**
Receive Sensitivity: **-86dBm** (For 24 Mbps)
Fade Margin: **5dB**

See www.meshdynamics.com/MDInstallationInstructions.html for suggested sector and panel antennas for static nodes suggestions

MODEL NUMBERS, ANTENNAS, AND CHANNELS

The following slides help to give an idea how to manage antennas and channels with various node model numbers.

Model number selection is the first step in the design of a network. Most nodes will need an uplink, a downlink and an AP radio. Some nodes can go without an AP radio, while others will benefit from an *additional* AP radio. Some nodes do not need a downlink radio, and some may have *multiple* downlink radios. The following deployment examples show scenarios where several different model numbers are used.

Antenna selection is the next step in network design. If a node has multiple AP radios, for example, it needs to be determined *where* the signal from these radios need to be spread.

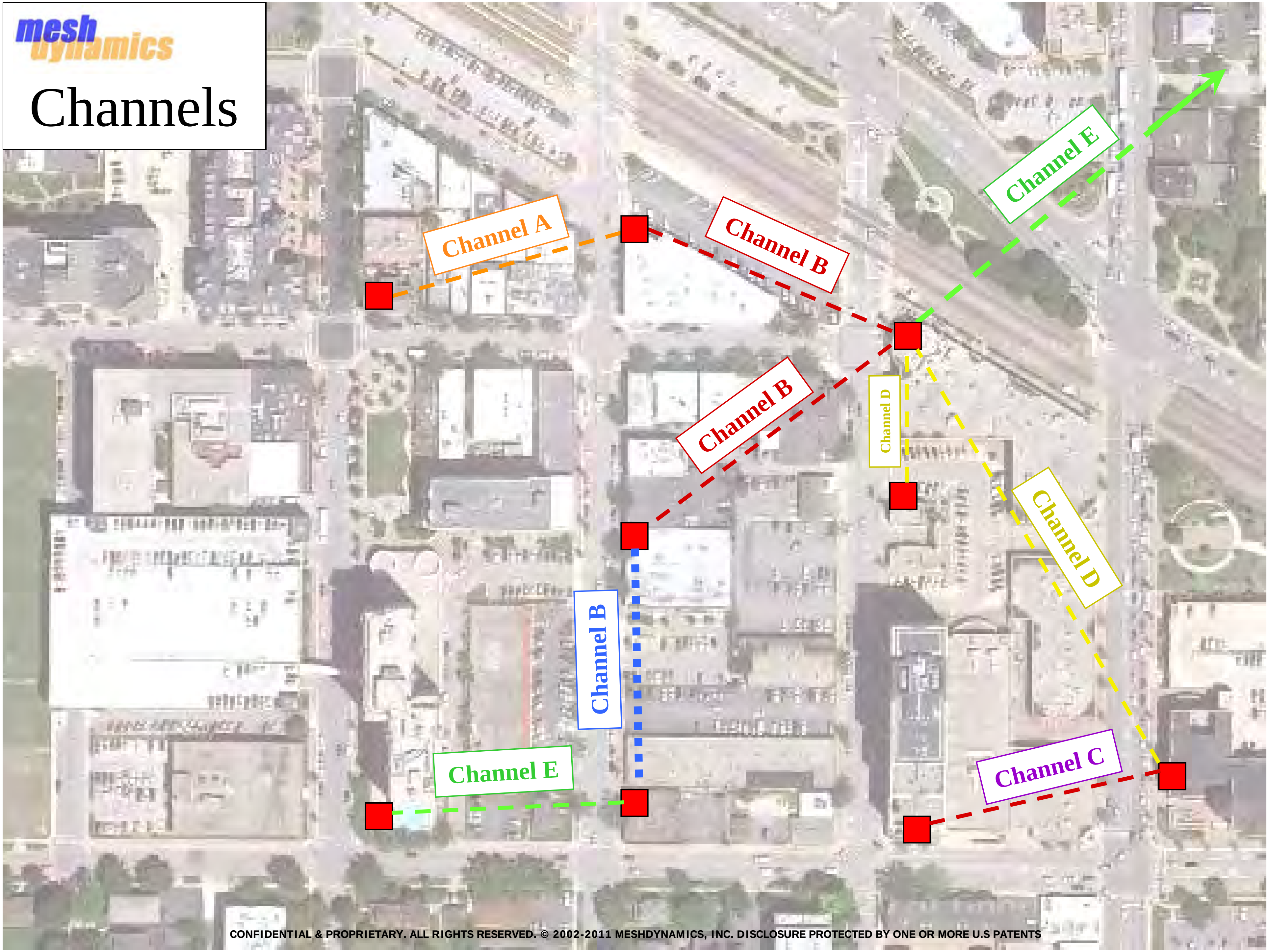
Multiple downlink radios can help the structure of a backhaul. Typically, if a node has multiple downlink radios, directional antennas are needed on each downlink to “shoot” the downlinks’ signals to their intended child nodes.

Multiple downlink radios on **root** nodes will give the mesh more bandwidth; each downlink on a root node will provide a separate channel. Again, antennas should be chosen to shoot the signal to the downlinks’ intended child nodes.

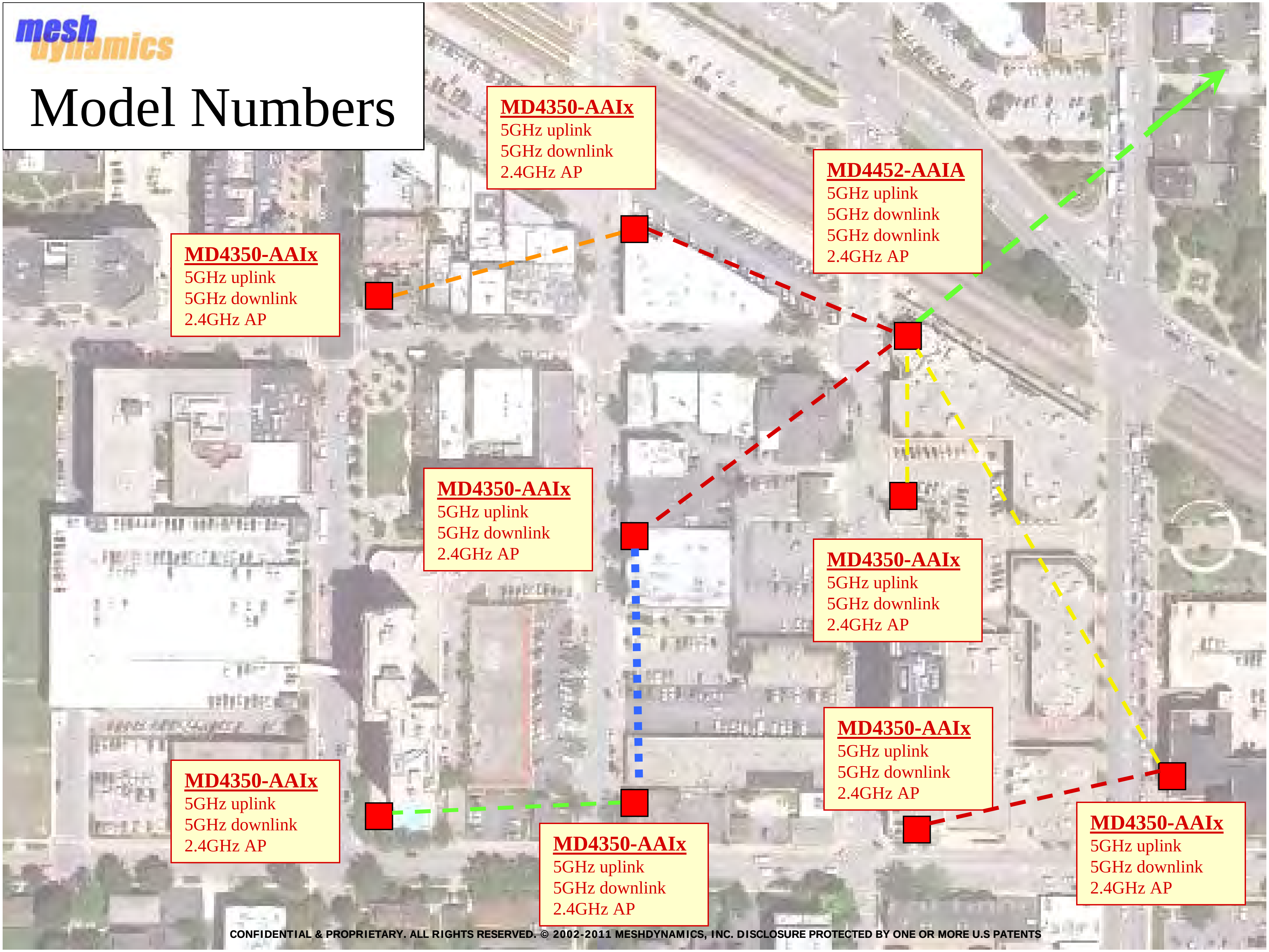
Channel usage is closely related to antenna spreads used in a deployment. It is possible to encounter signal overlap of the same channel if antenna spreads are not chosen carefully.

URBAN DEPLOYMENT

Channels

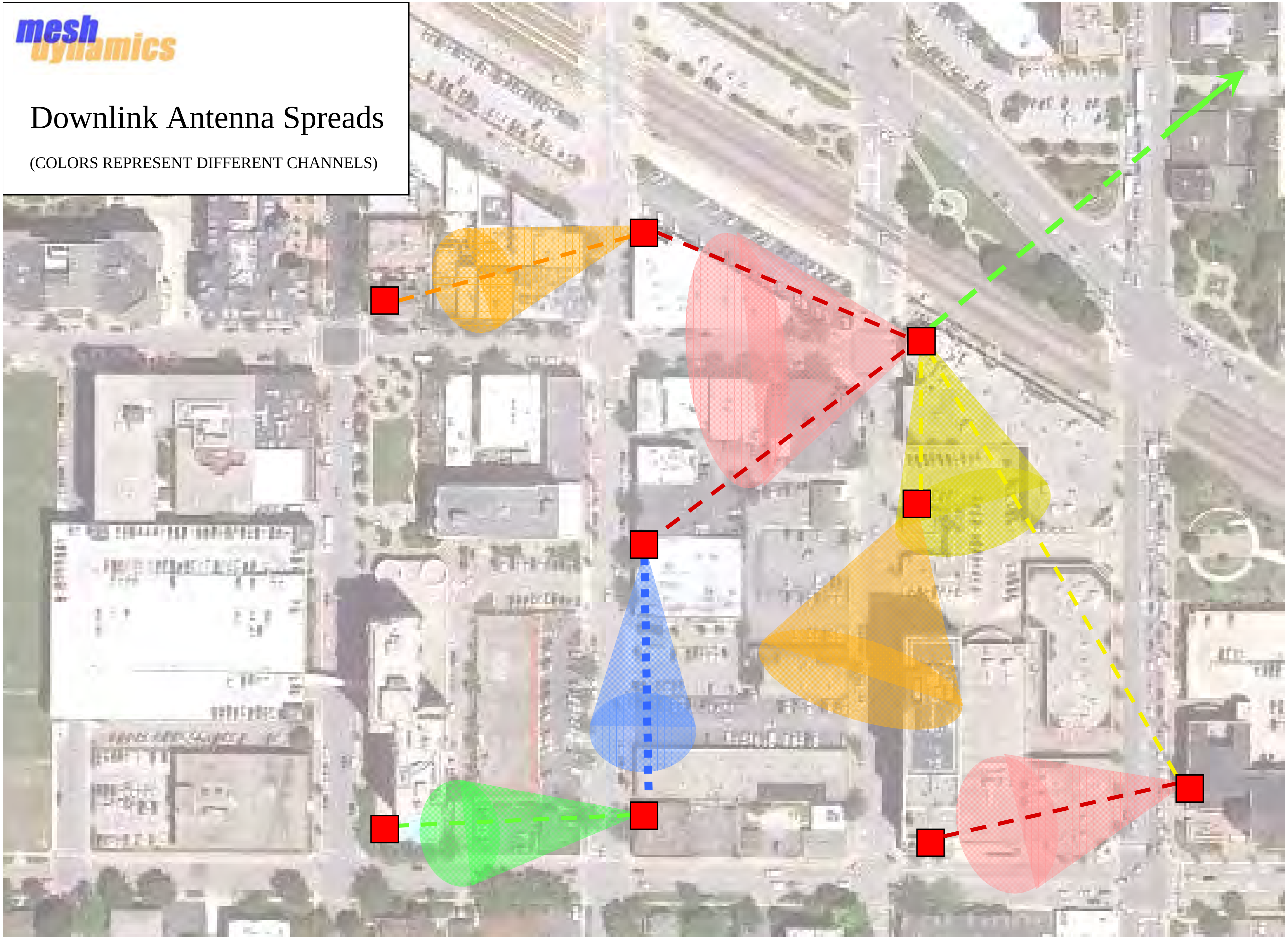

Channel A
Channel B
Channel E
Channel B
Channel D
Channel D
Channel B
Channel E
Channel C

Model Numbers



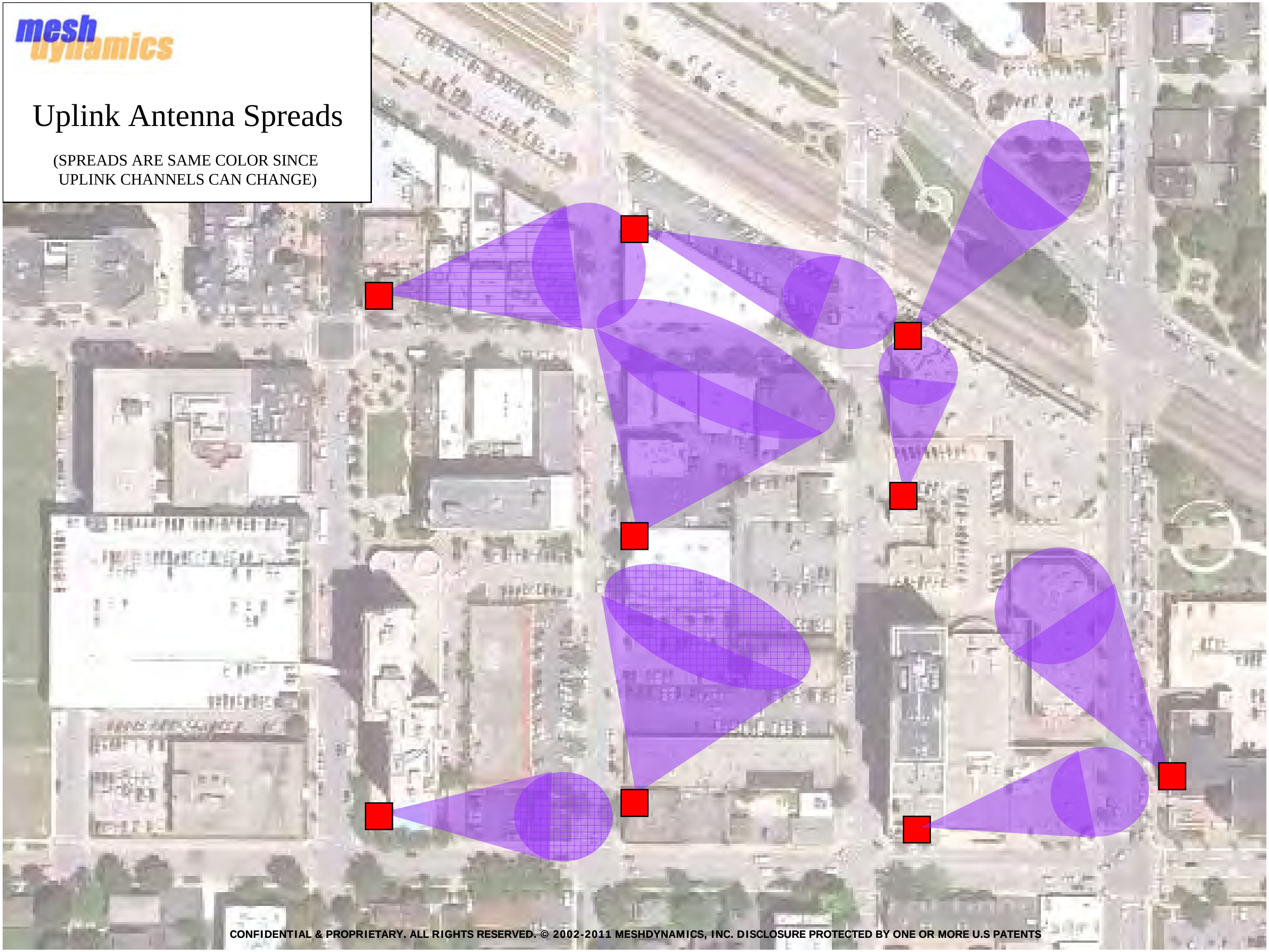
Downlink Antenna Spreads

(COLORS REPRESENT DIFFERENT CHANNELS)



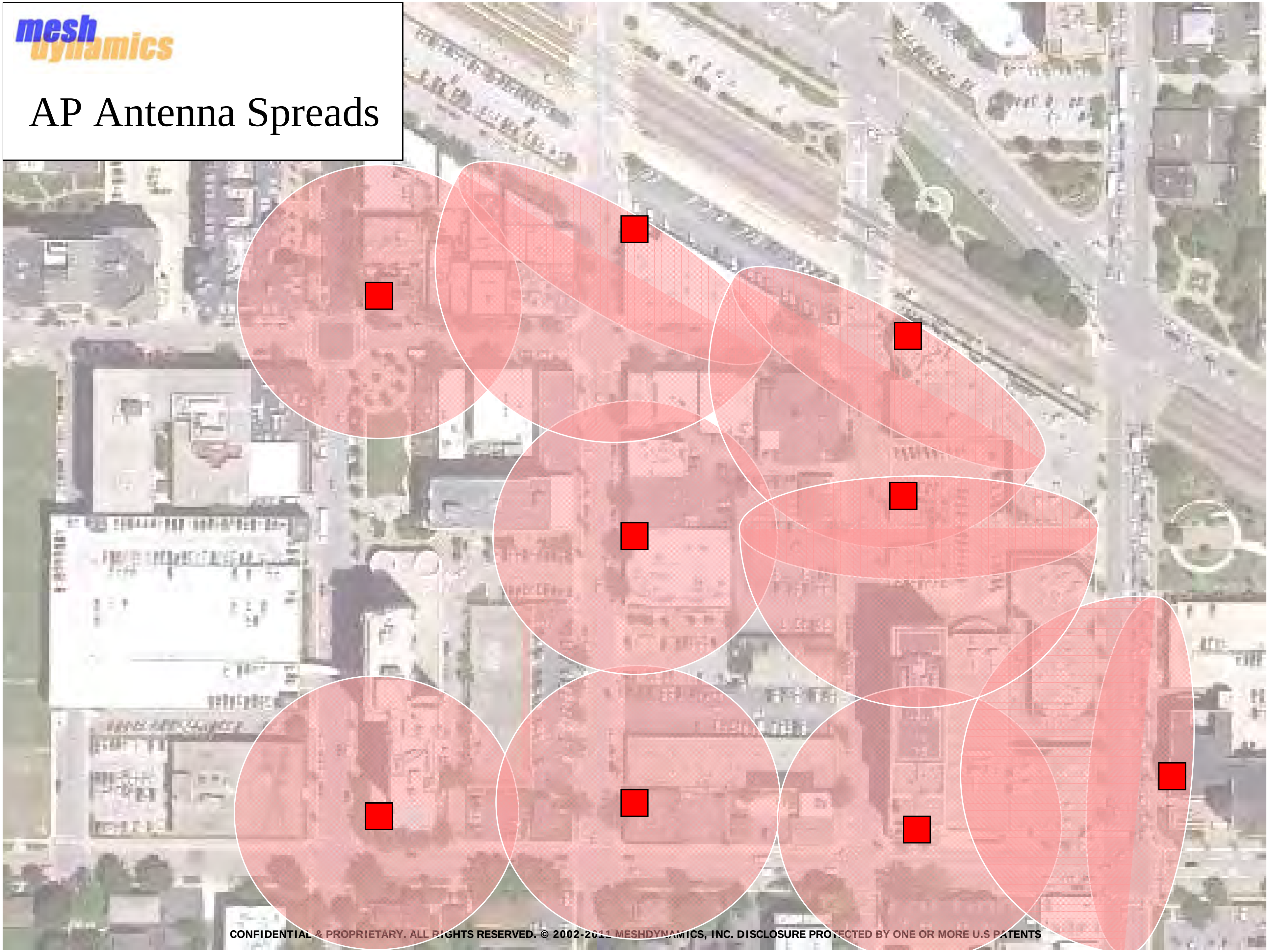
Uplink Antenna Spreads

(SPREADS ARE SAME COLOR SINCE UPLINK CHANNELS CAN CHANGE)

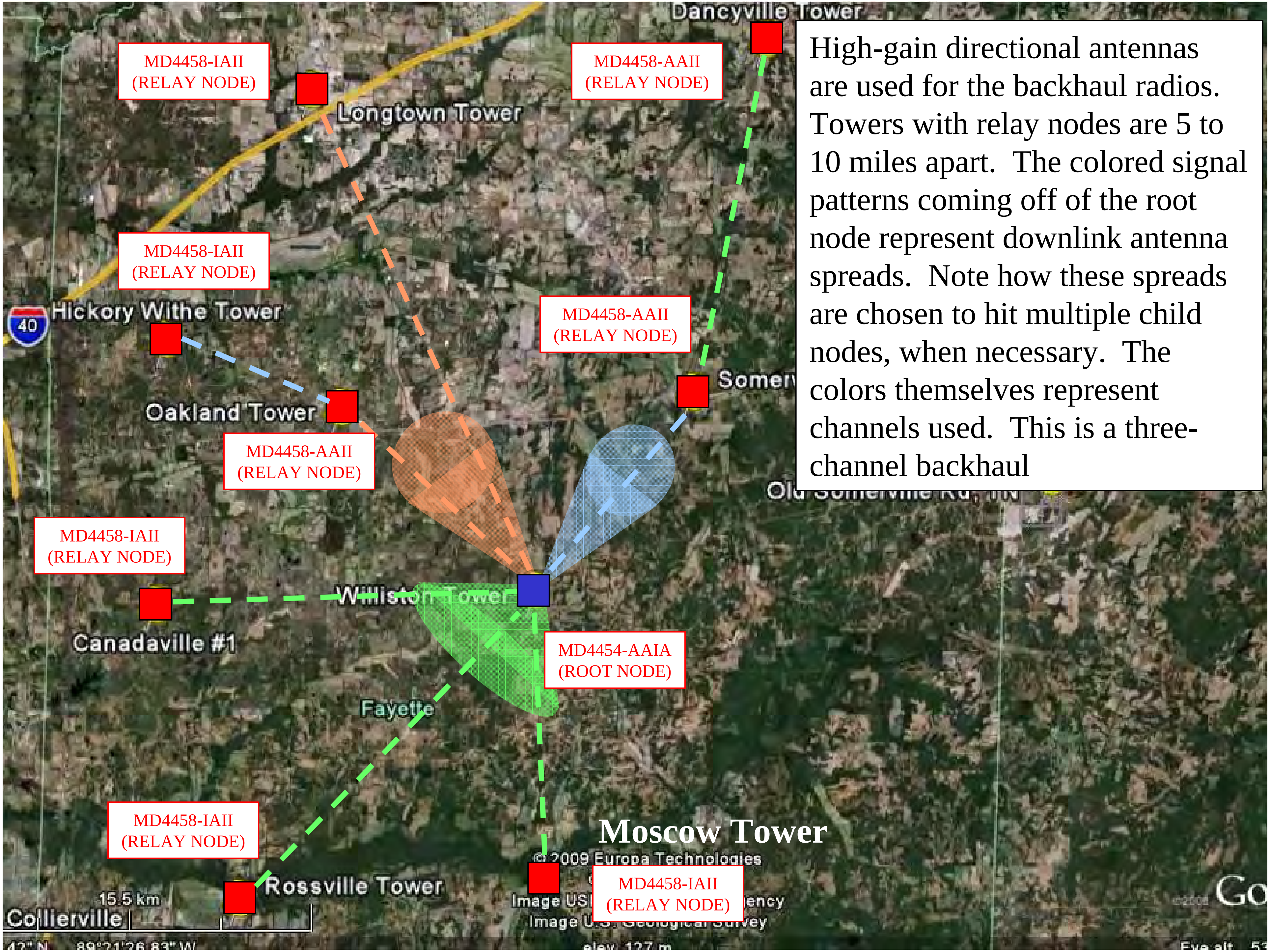


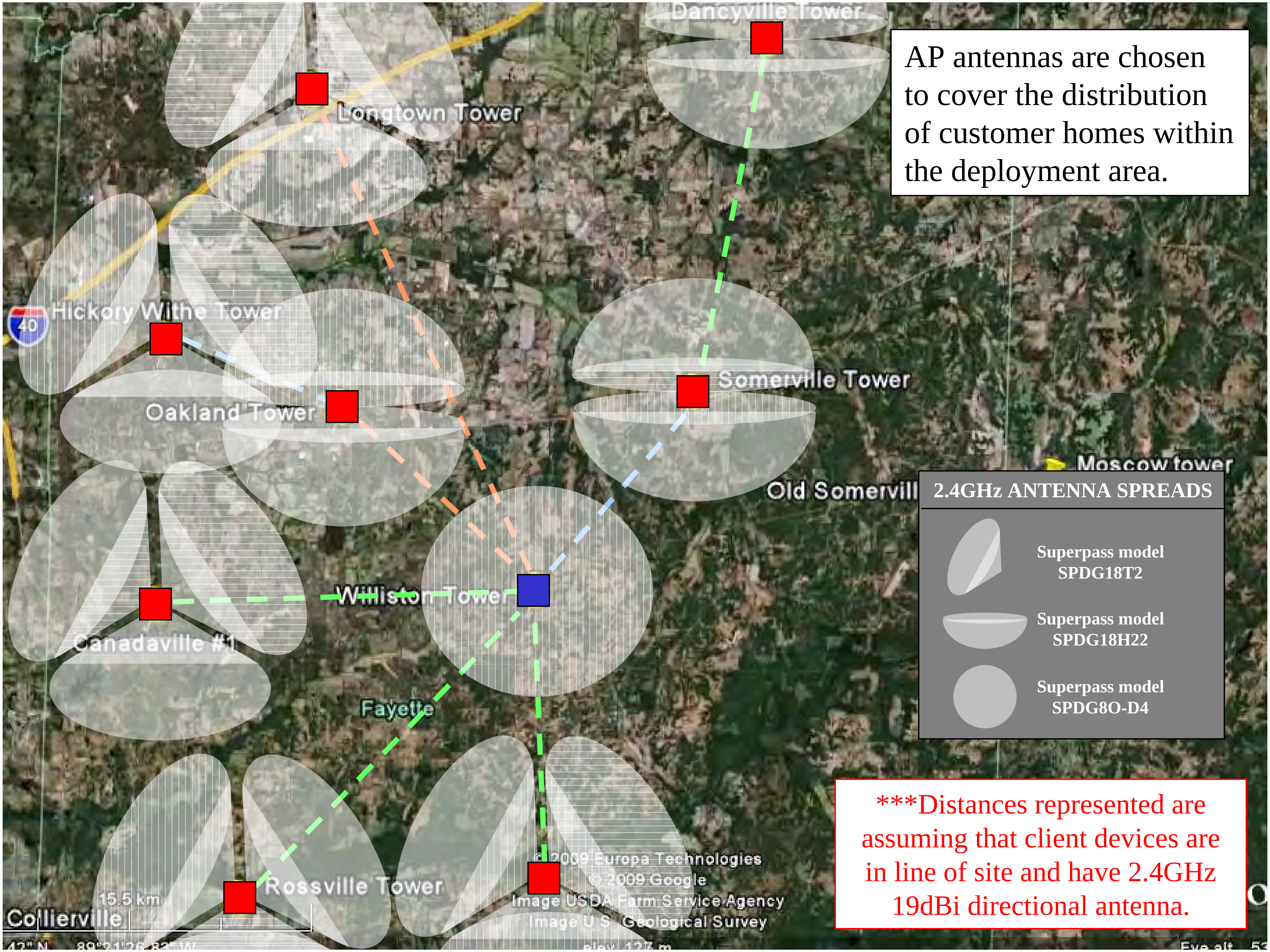
mesh dynamics

AP Antenna Spreads

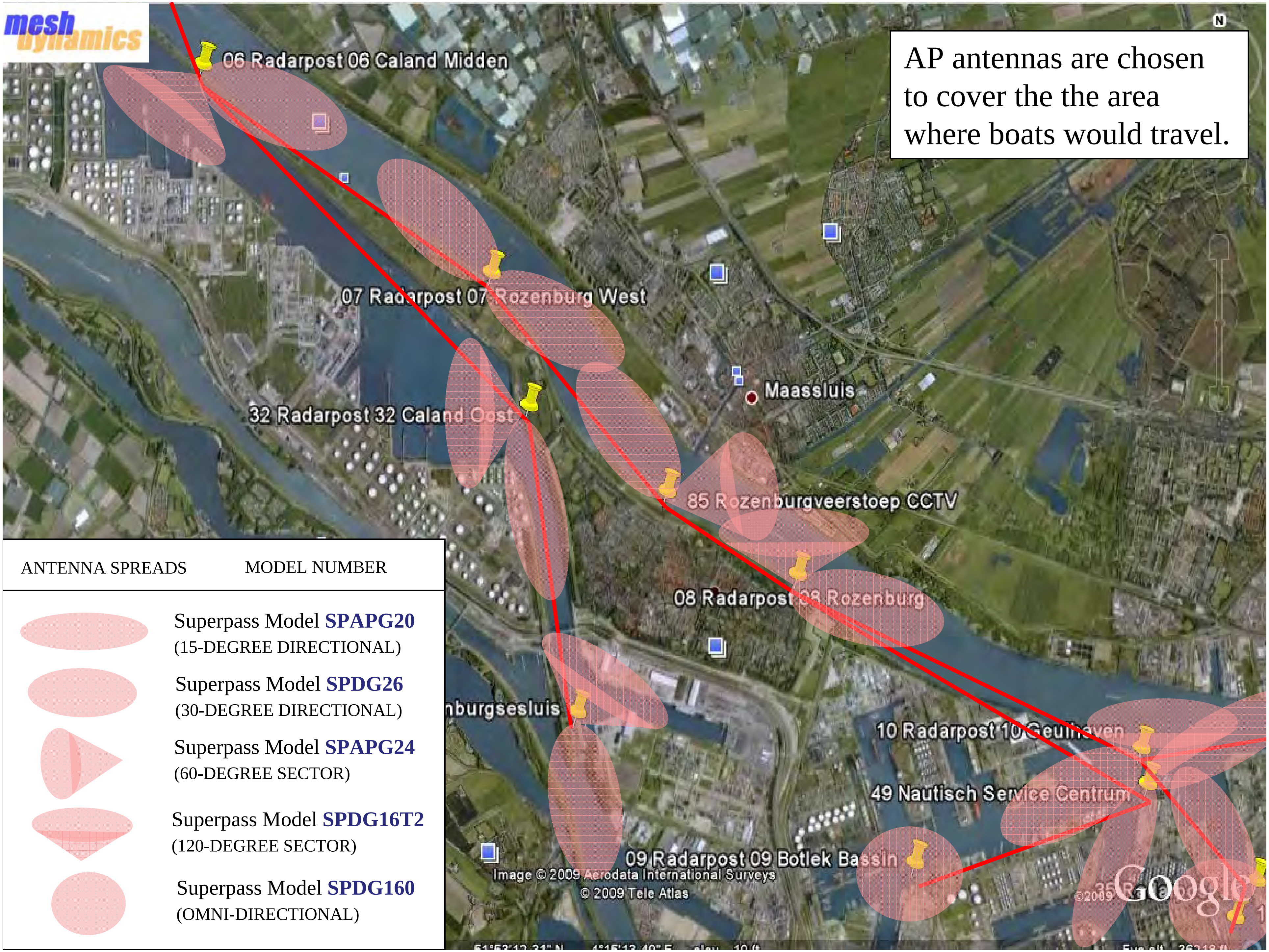


RURAL DEPLOYMENT

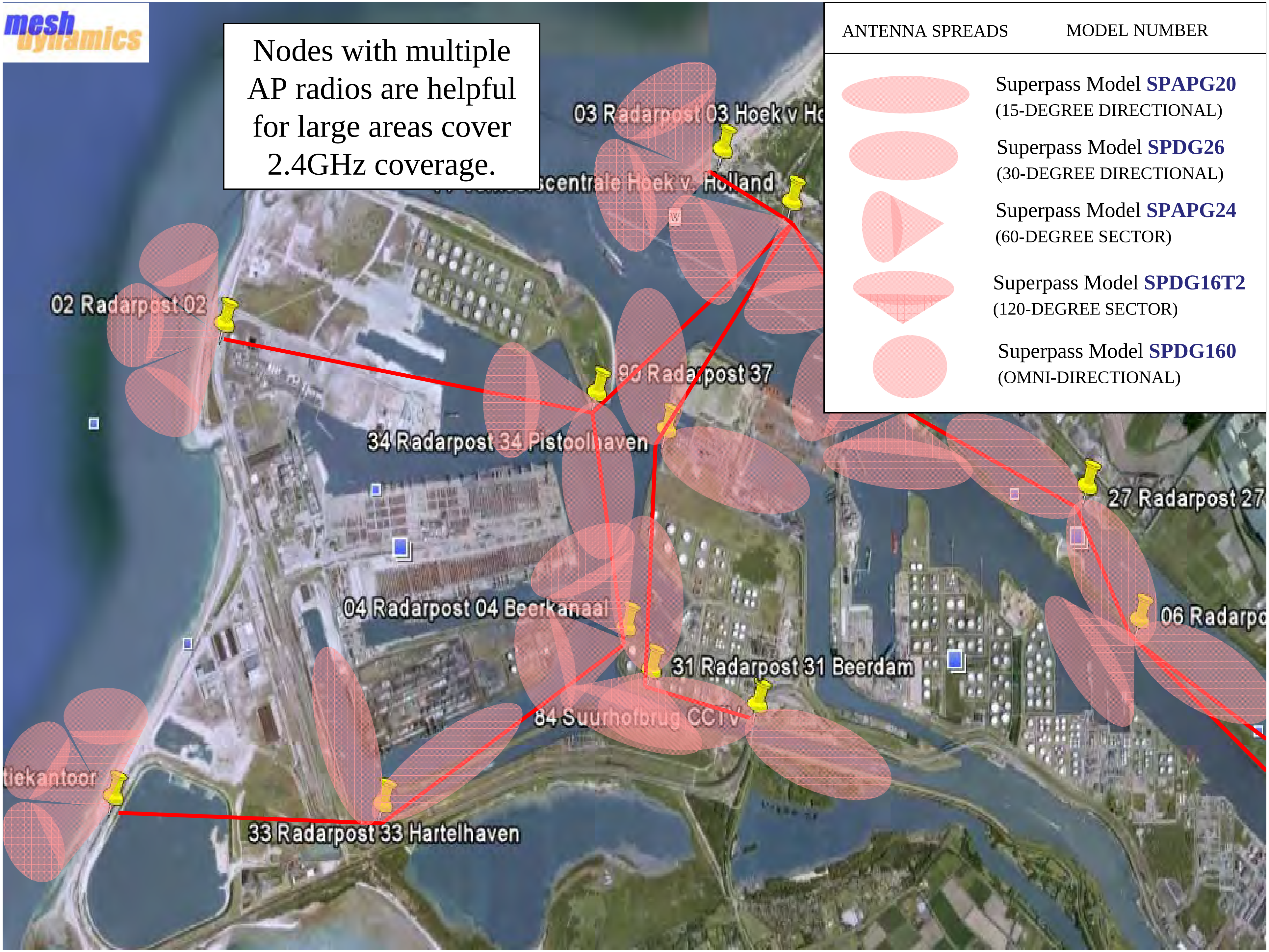

High-gain directional antennas are used for the backhaul radios. Towers with relay nodes are 5 to 10 miles apart. The colored signal patterns coming off of the root node represent downlink antenna spreads. Note how these spreads are chosen to hit multiple child nodes, when necessary. The colors themselves represent channels used. This is a three-channel backhaul
Dancyville Tower
MD4458-IAII (RELAY NODE)
Longtown Tower
MD4458-AAII (RELAY NODE)
MD4458-IAII (RELAY NODE)
Hickory Withe Tower
MD4458-AAII (RELAY NODE)
Oakland Tower
MD4458-AAII (RELAY NODE)
MD4458-IAII (RELAY NODE)
Williston Tower
Canadaville #1
MD4454-AAIA (ROOT NODE)
Fayette
MD4458-IAII (RELAY NODE)
Moscow Tower
© 2009 Europa Technologies
Rossville Tower
MD4458-IAII (RELAY NODE)
15.5 km
Collierville


AP antennas are chosen to cover the distribution of customer homes within the deployment area.
Dancyville Tower
Longtown Tower
Hickory Withe Tower
40
Oakland Tower
Somerville Tower
Moscow tower
Old Somervill
Williston Tower
Canadaville #1
Fayette
Rossville Tower
Collierville
15.5 km
© 2009 Europa Technologies
© 2009 Google
Image USDA Farm Service Agency
Image U.S. Geological Survey
2.4GHz ANTENNA SPREADS
Superpass model SPDG18T2
Superpass model SPDG18H22
Superpass model SPDG8O-D4
***Distances represented are assuming that client devices are in line of site and have 2.4GHz 19dBi directional antenna.

HARBOR DEPLOYMENT


mesh dynamics
AP antennas are chosen to cover the the area where boats would travel.
06 Radarpost 06 Caland Midden
07 Radarpost 07 Rozenburg West
32 Radarpost 32 Caland Oost
Maassluis
85 Rozenburgveerstoep CCTV
08 Radarpost 08 Rozenburg
nburgsesluis
10 Radarpost 10 Geulhaven
49 Nautisch Service Centrum
09 Radarpost 09 Botlek Bassin
Image © 2009 Aerodata International Surveys
© 2009 Tele Atlas
Google
ANTENNA SPREADS
MODEL NUMBER
Superpass Model SPAPG20
(15-DEGREE DIRECTIONAL)
Superpass Model SPDG26
(30-DEGREE DIRECTIONAL)
Superpass Model SPAPG24
(60-DEGREE SECTOR)
Superpass Model SPDG16T2
(120-DEGREE SECTOR)
Superpass Model SPDG160
(OMNI-DIRECTIONAL)

Nodes with multiple AP radios are helpful for large areas cover 2.4GHz coverage.



ANTENNA SPREADS	MODEL NUMBER
	Superpass Model **SPAPG20** (15-DEGREE DIRECTIONAL)
	Superpass Model **SPDG26** (30-DEGREE DIRECTIONAL)
	Superpass Model **SPAPG24** (60-DEGREE SECTOR)
	Superpass Model **SPDG16T2** (120-DEGREE SECTOR)
	Superpass Model **SPDG160** (OMNI-DIRECTIONAL)

RECOMMENDATIONS FOR HARBOR DEPLOYMENT

- Since most nodes will be a good distance from their parent and child nodes (2km+), directional antennas should be used on the backhaul links (Superpass model SPPJ48-BD is recommended for these links).

- In some situations, a child node may have multiple parent nodes within a small horizontal angle of its view. In these situations, it is beneficial to chose an antenna for the child node's uplink such that the antenna's spread hits these multiple parents.

  For example, 22 Radarpost has four potential parent nodes in its site:
  21 Radarpost,
  29 Radarpost Erasmus,
  28 Radarpost,
  28 Boompjes.

  In this situation, a suitable antenna for the uplink would have a horizontal spread big enough to encompass the four mentioned locations (Superpass model SPDN6W would be suitable --it has a 30-degree H-spread, and a 14-degree V-spread).

- Various model numbers are recommended for the mesh nodes…

  For the **root node**, the MD4454-AAIA. This takes advantage of multiple-downlink technology, while also providing an AP radio. Whichever location(s) is selected to be the root node, antennas can be selected appropriately to aim the bandwidth to surrounding child nodes or node clusters.

  For the **relay nodes**. The MD4458-AAII, MD4458-IAII and the MD4452-AAIA are recommended.
  The MD4458-AAII provides two AP radios in addition to the backhaul radios. Antennas can be chosen for the AP radios in order to optimize the coverage distribution in areas where this might be needed.

  The MD4458-IAII is used in situations where a node is on the edge of a deployment, and the only backhaul radio needed on the node is the uplink. The other three radios can be APs.

  The MD4452-AAIA provides a second downlink radio to "shoot" the backhaul to child nodes in different locations/directions relative to the parent node. This might be useful in the location of 10 Radarpost, for example.

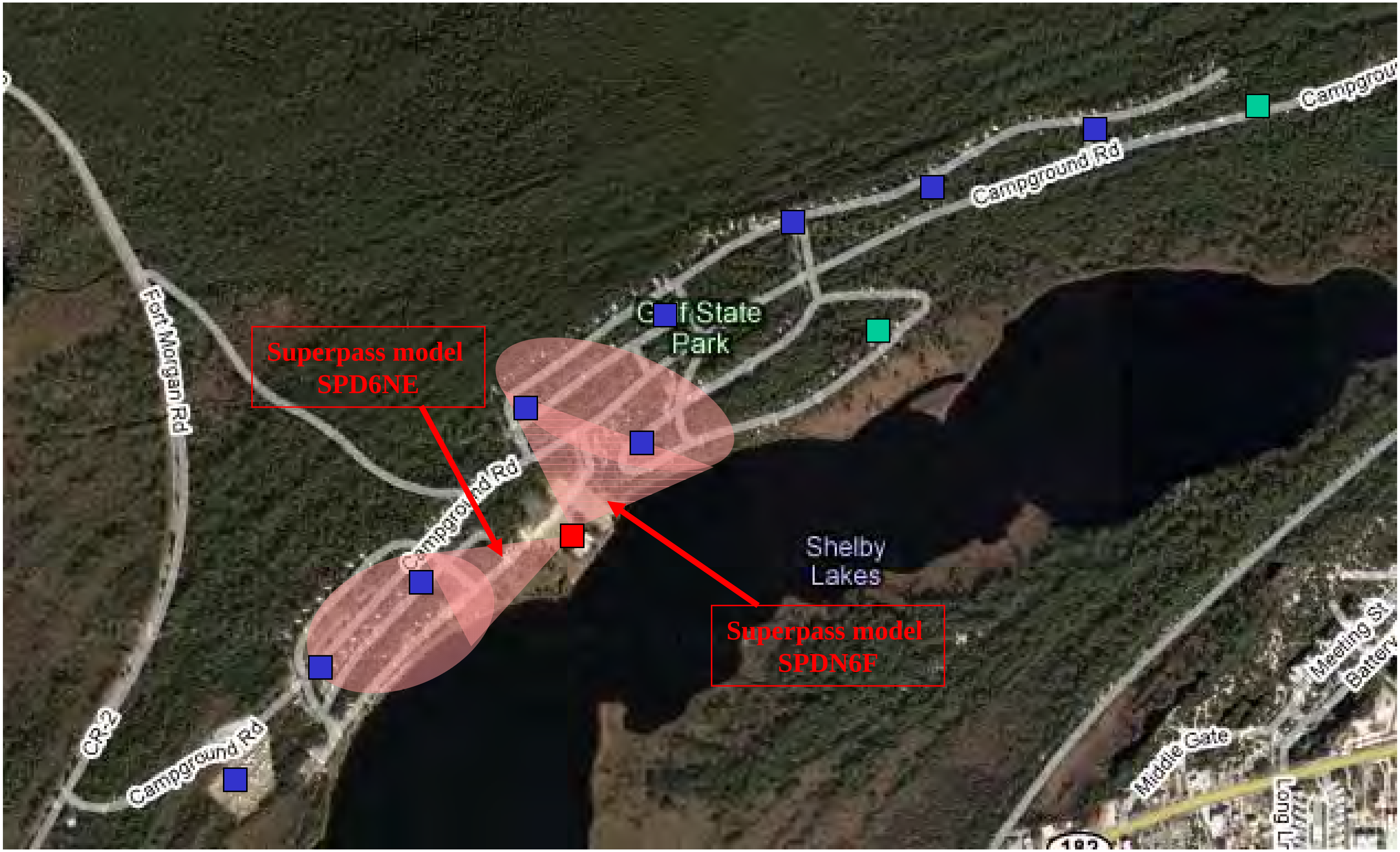
CAMPGROUNDS

MD4452-AAIA ROOT NODE (ONE UPLINK, TWO DOWNLINKS, ONE AP RADIO)

MD4350-AAIA RELAY NODE (ONE UPLINK, ONE DOWNLINK, ONE AP RADIO)

RADIATION SPREAD OF ROOT NODE'S DOWNLINKS (SECTOR ANTENNAS)

The root node will have two downlinks each with sector antennas. This will give each "section" of the mesh 22 Mbps of bandwidth (44 Mbps total) as opposed to the whole mesh sharing only one downlink from the root node).

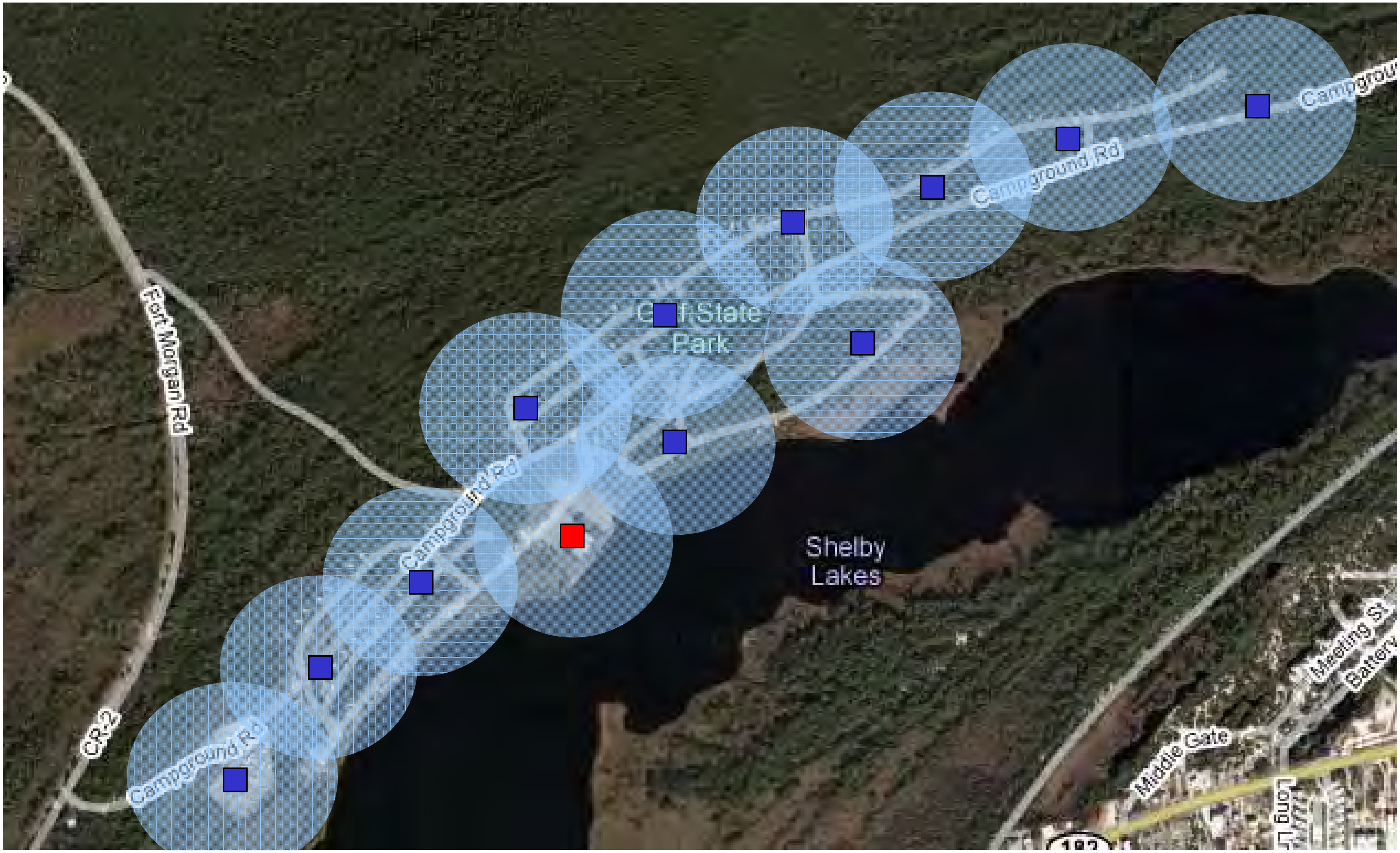


■ **MD4452-AAIA** ROOT NODE (ONE UPLINK, TWO DOWNLINKS, ONE AP RADIO)

■ **MD4350-AAIA** RELAY NODE (ONE UPLINK, ONE DOWNLINK, ONE AP RADIO)

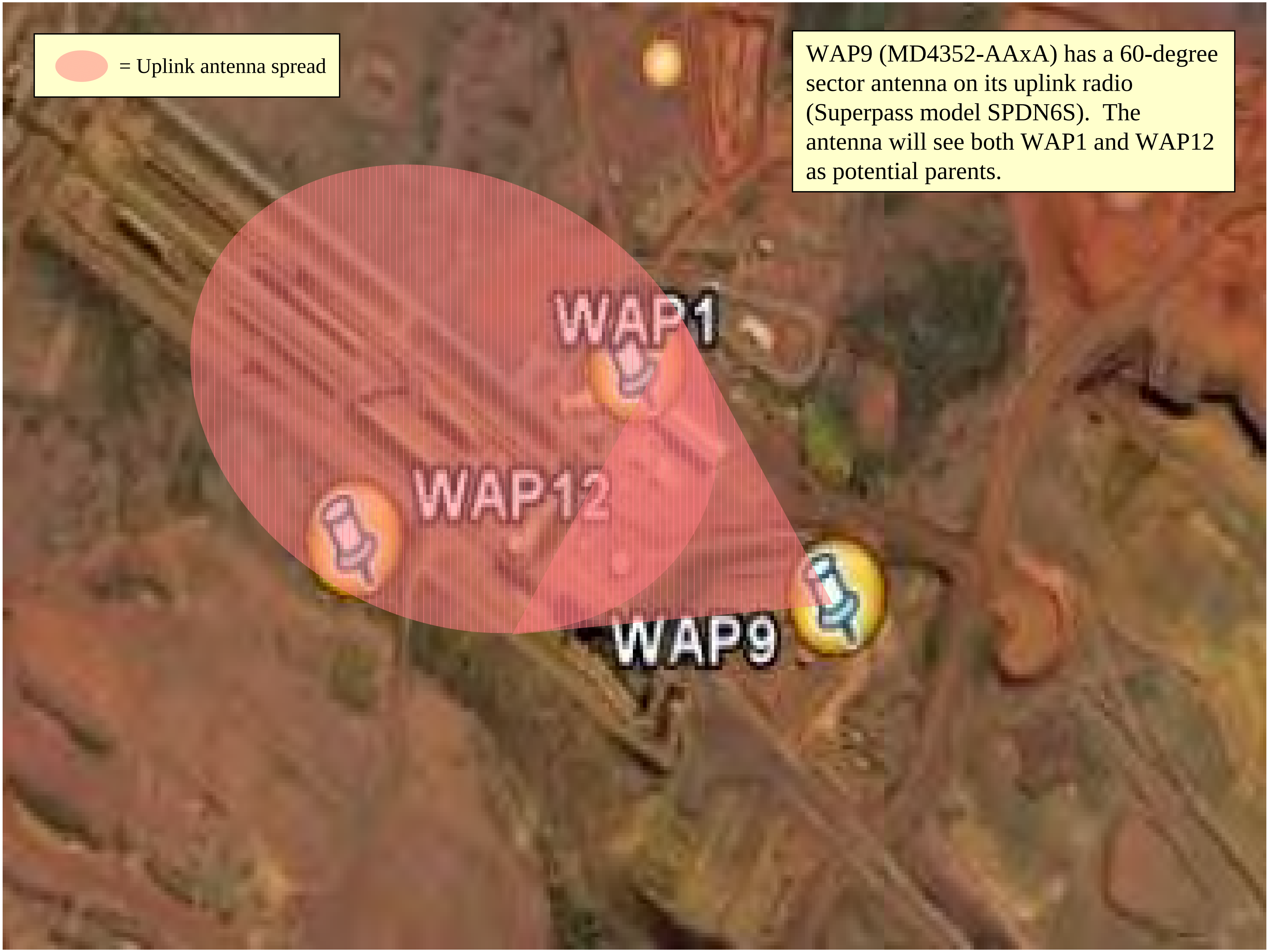
RADIATION SPREAD OF AP OMNI-DIRECTIOAL ANTENNAS

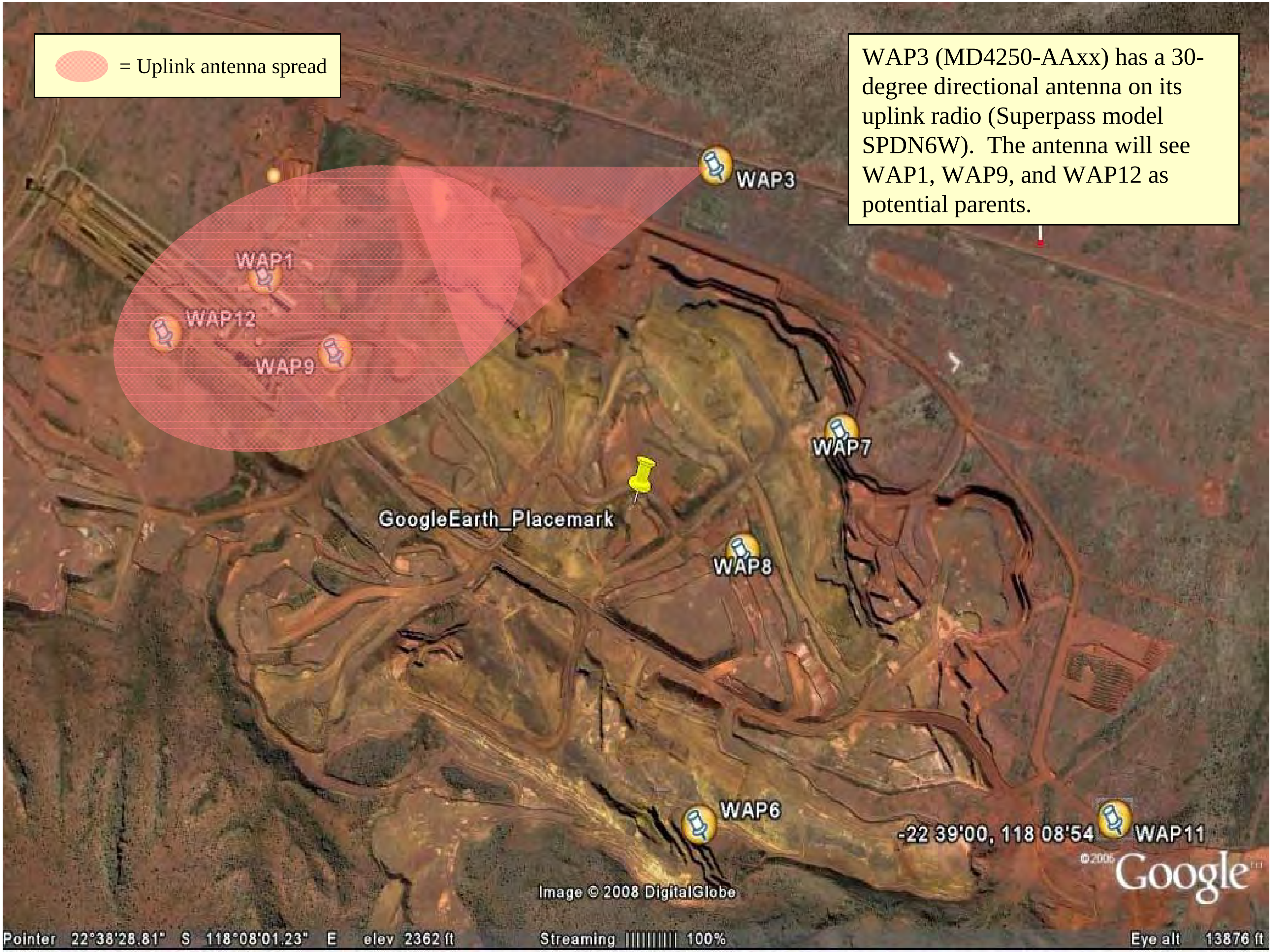
Each of the nodes will have a Superpass model SPDG160 omni-directional antenna on its AP radio.
All backhaul antennas of the MD4350-AAIx's will have Superpass model SPDJ160 omni-directional antennas.

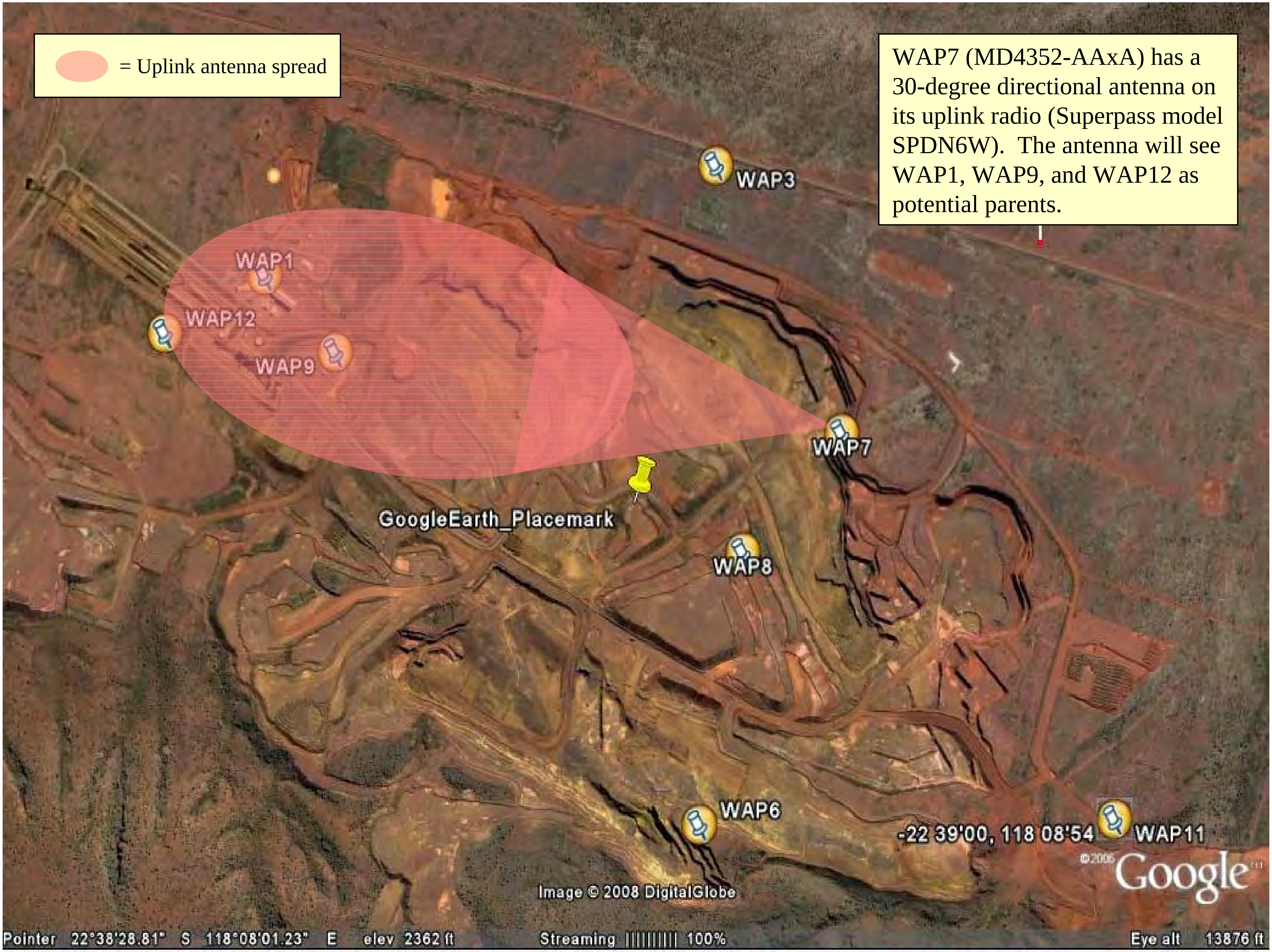


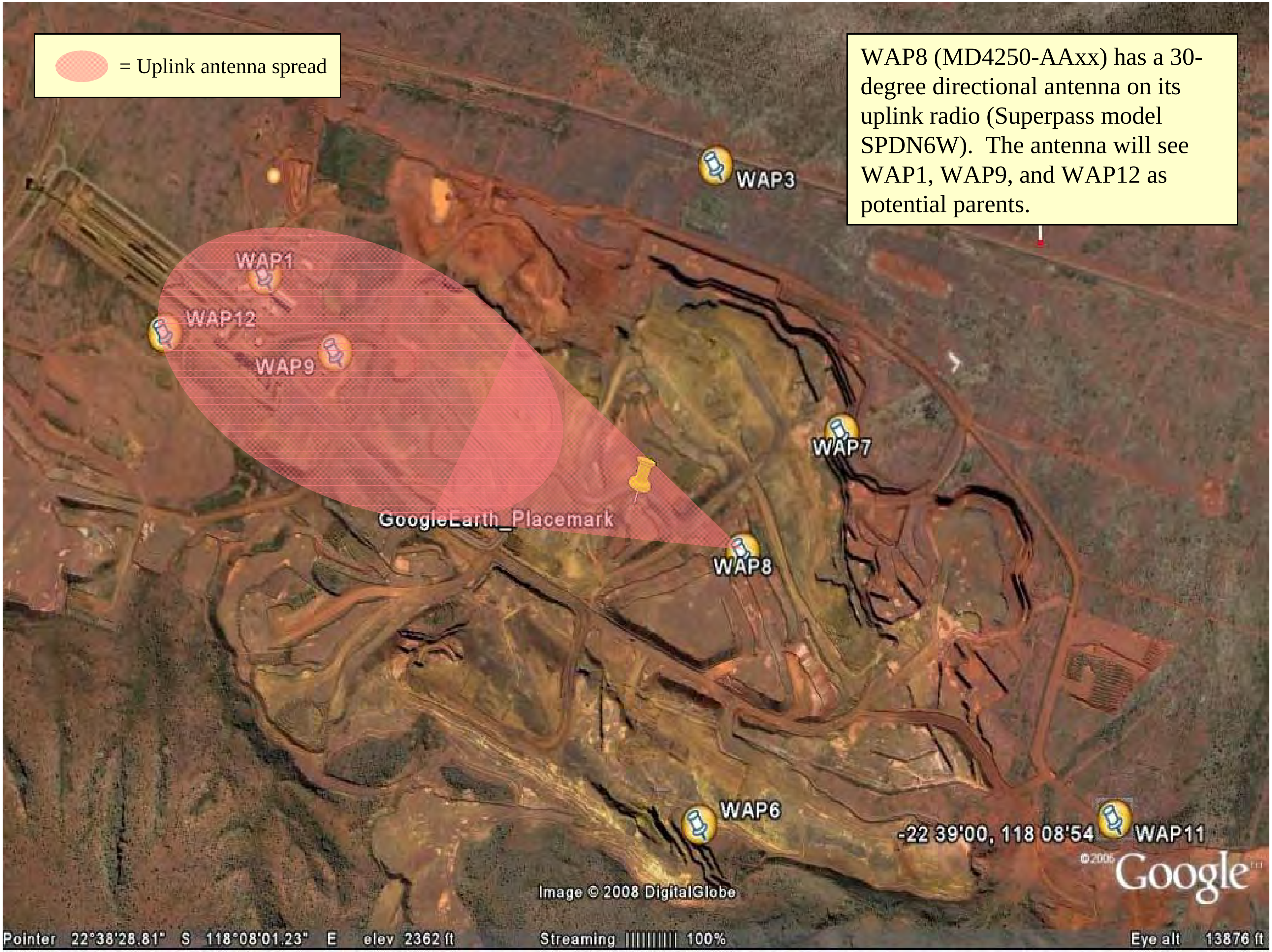
SURFACE MINING DEPLOYMENT


= Uplink antenna spread
WAP12 (MD4250-AAxx) has 60-degree sector antenna on its uplink radio (Superpass model SPDN6S). The antenna will see both WAP1 and WAP9 as potential parents.
WAP1
WAP12
WAP9

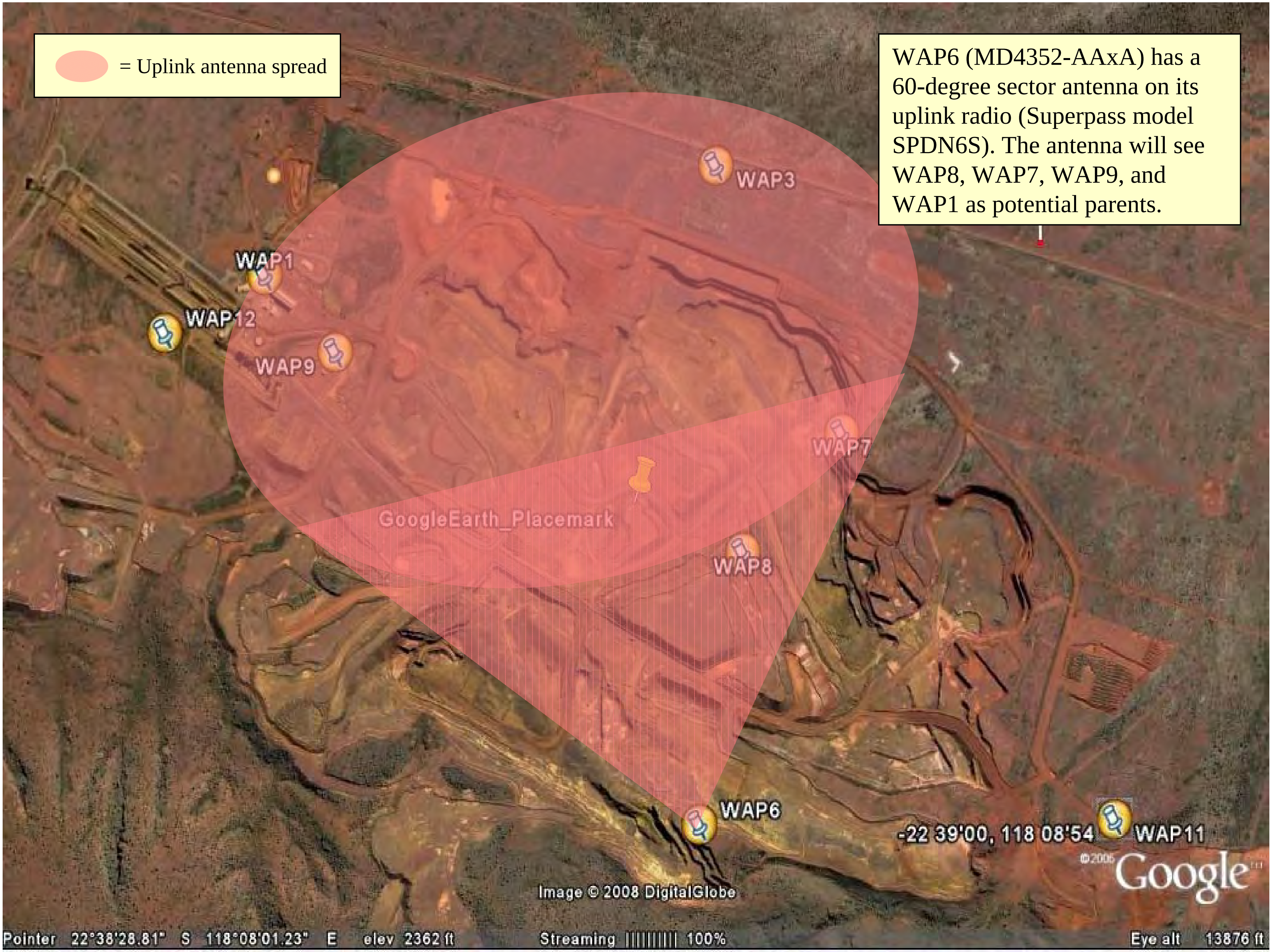

= Uplink antenna spread
WAP9 (MD4352-AAxA) has a 60-degree sector antenna on its uplink radio (Superpass model SPDN6S). The antenna will see both WAP1 and WAP12 as potential parents.
WAP1
WAP12
WAP9


= Uplink antenna spread
WAP3 (MD4250-AAxx) has a 30-degree directional antenna on its uplink radio (Superpass model SPDN6W). The antenna will see WAP1, WAP9, and WAP12 as potential parents.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Google
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

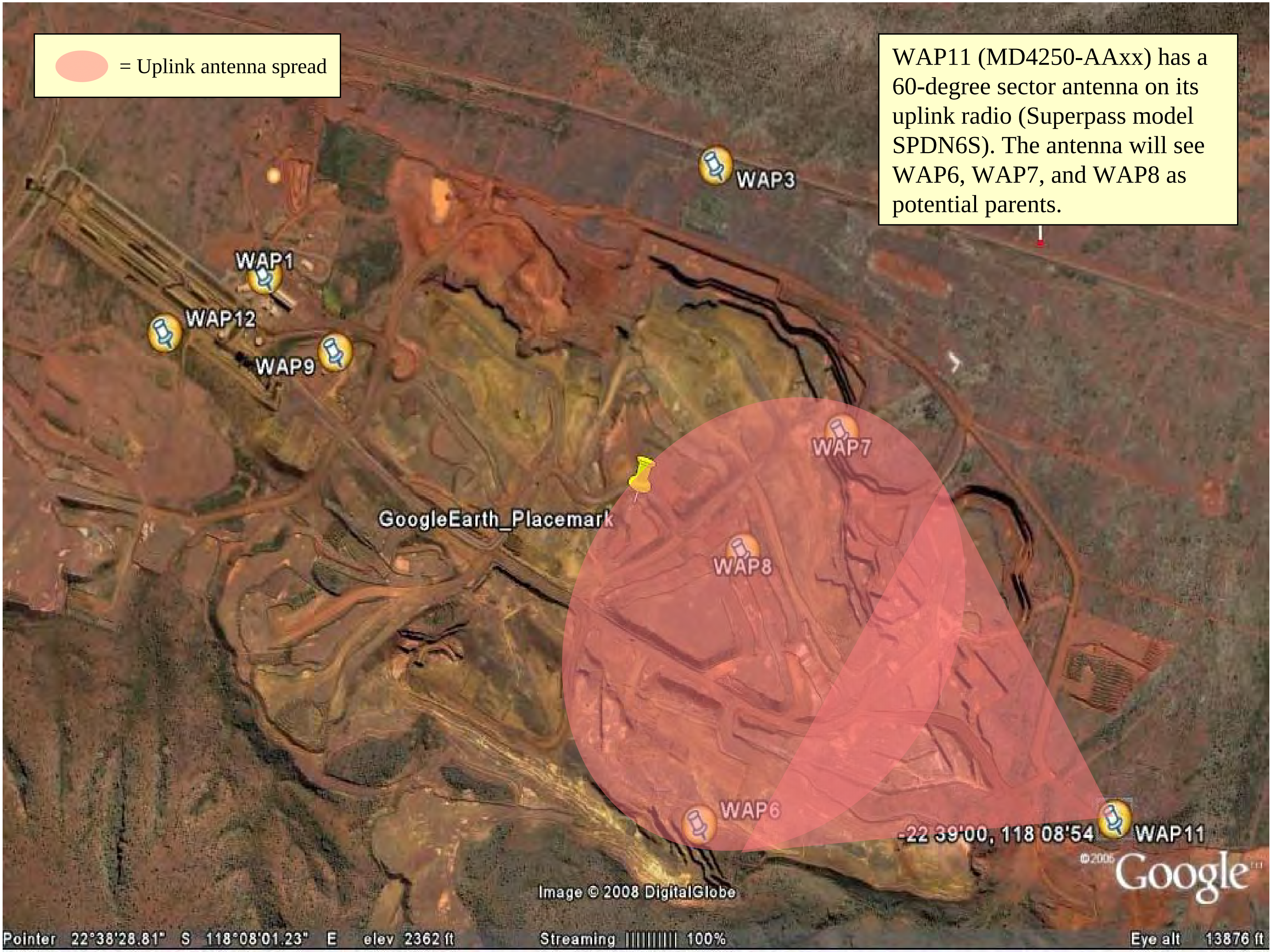

= Uplink antenna spread
WAP7 (MD4352-AAxA) has a 30-degree directional antenna on its uplink radio (Superpass model SPDN6W). The antenna will see WAP1, WAP9, and WAP12 as potential parents.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft



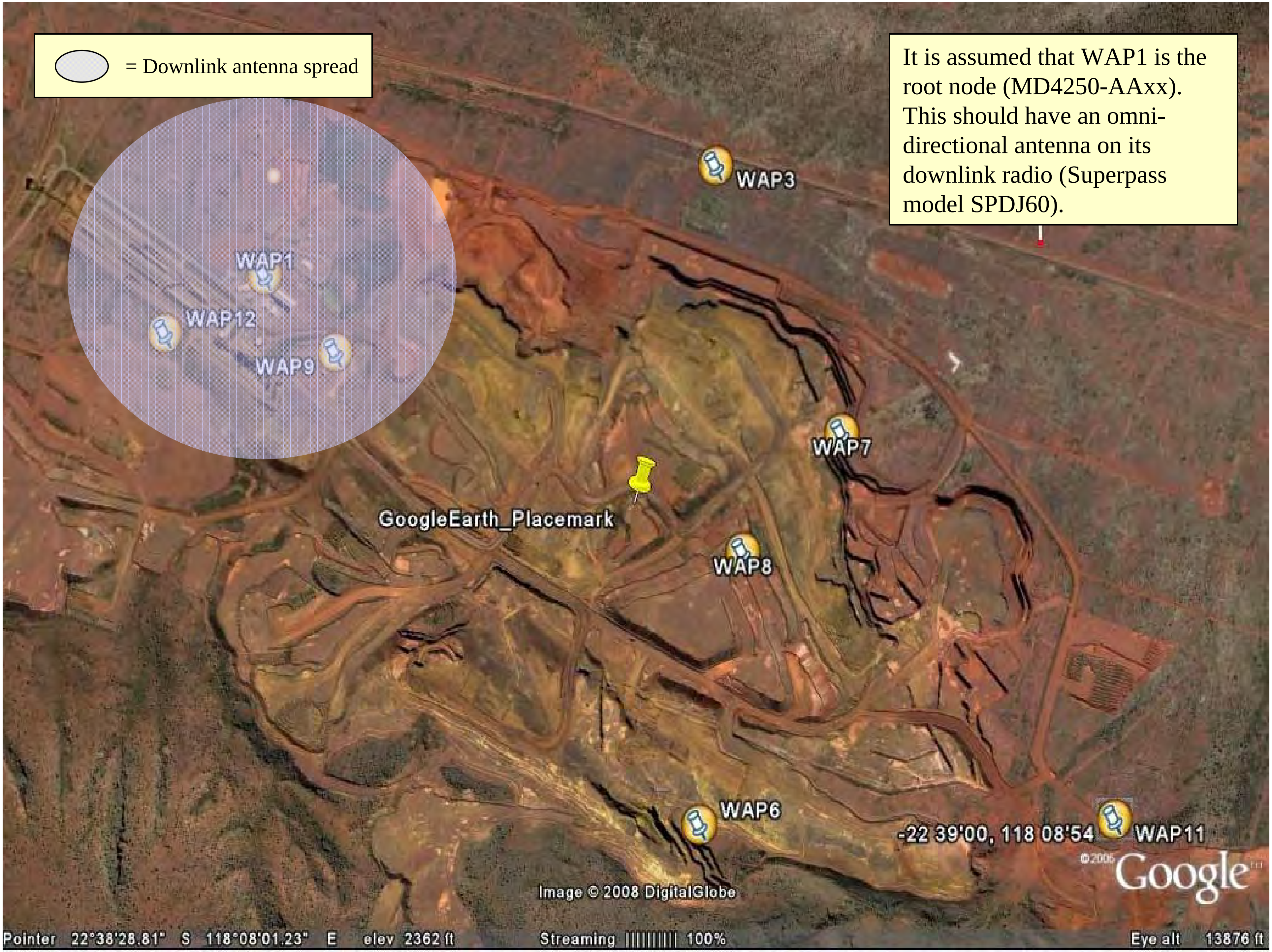
= Uplink antenna spread
WAP8 (MD4250-AAxx) has a 30-degree directional antenna on its uplink radio (Superpass model SPDN6W). The antenna will see WAP1, WAP9, and WAP12 as potential parents.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Google
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

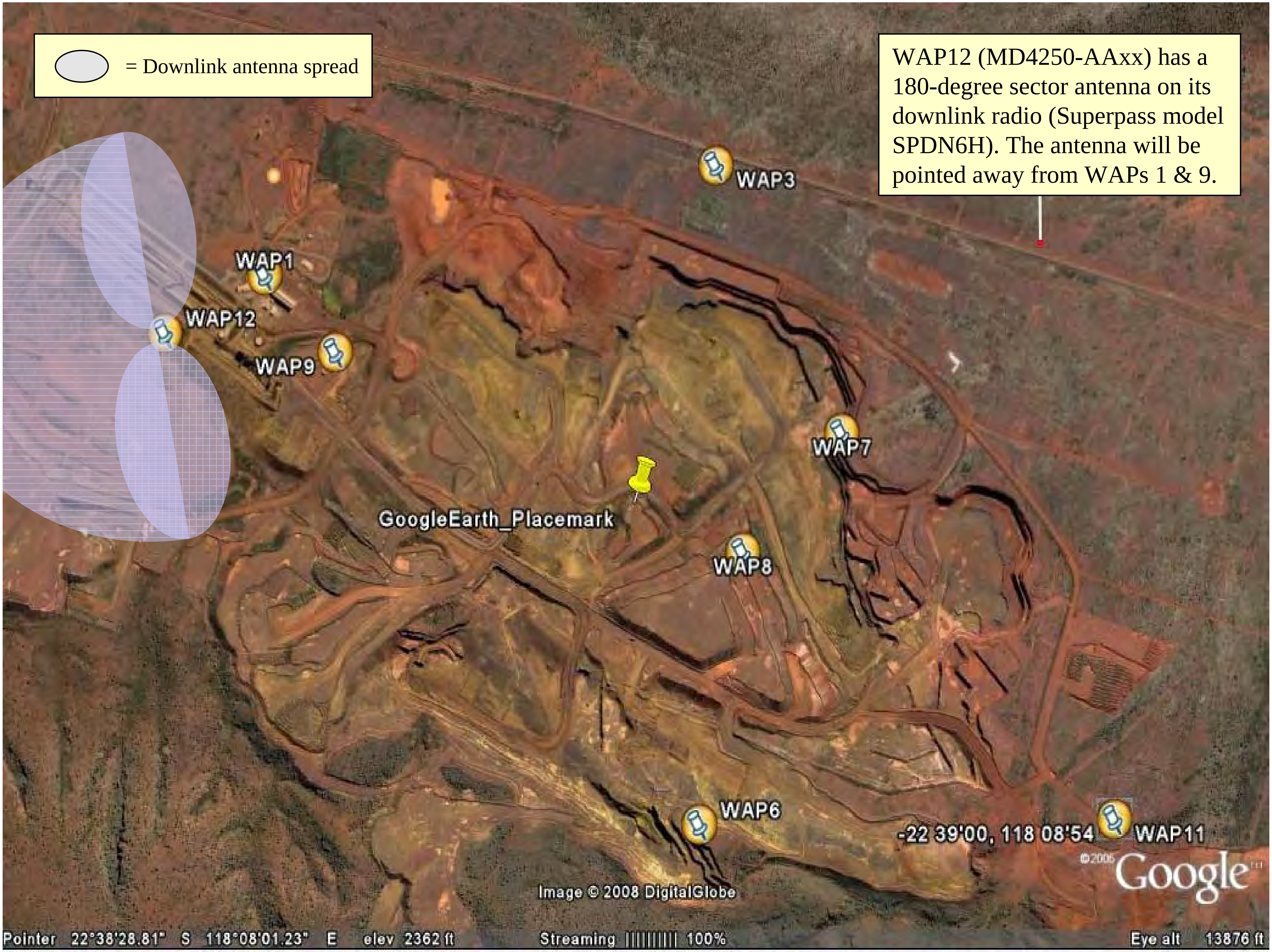


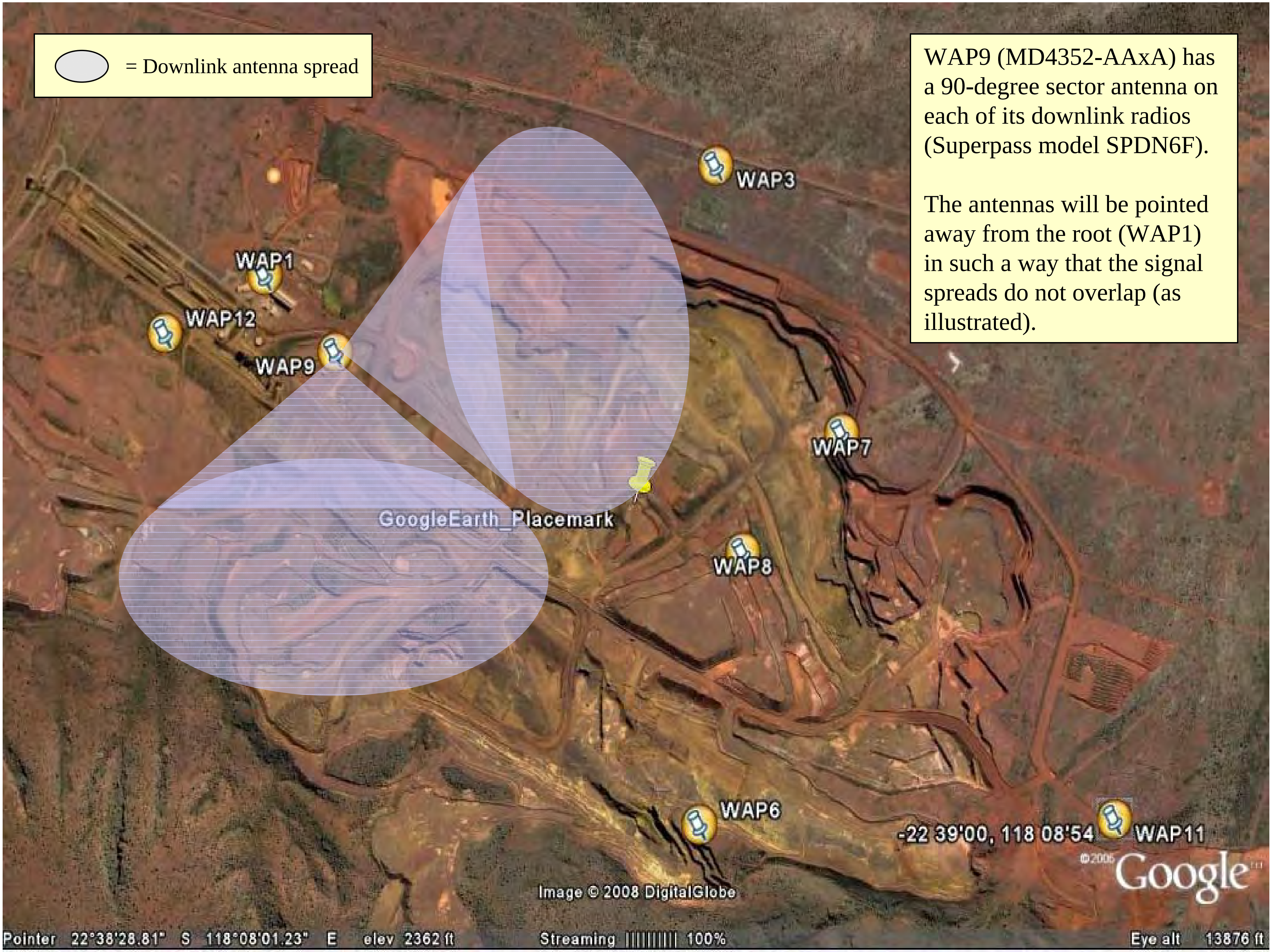
= Uplink antenna spread
WAP6 (MD4352-AAxA) has a 60-degree sector antenna on its uplink radio (Superpass model SPDN6S). The antenna will see WAP8, WAP7, WAP9, and WAP1 as potential parents.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
© 2006 Google
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

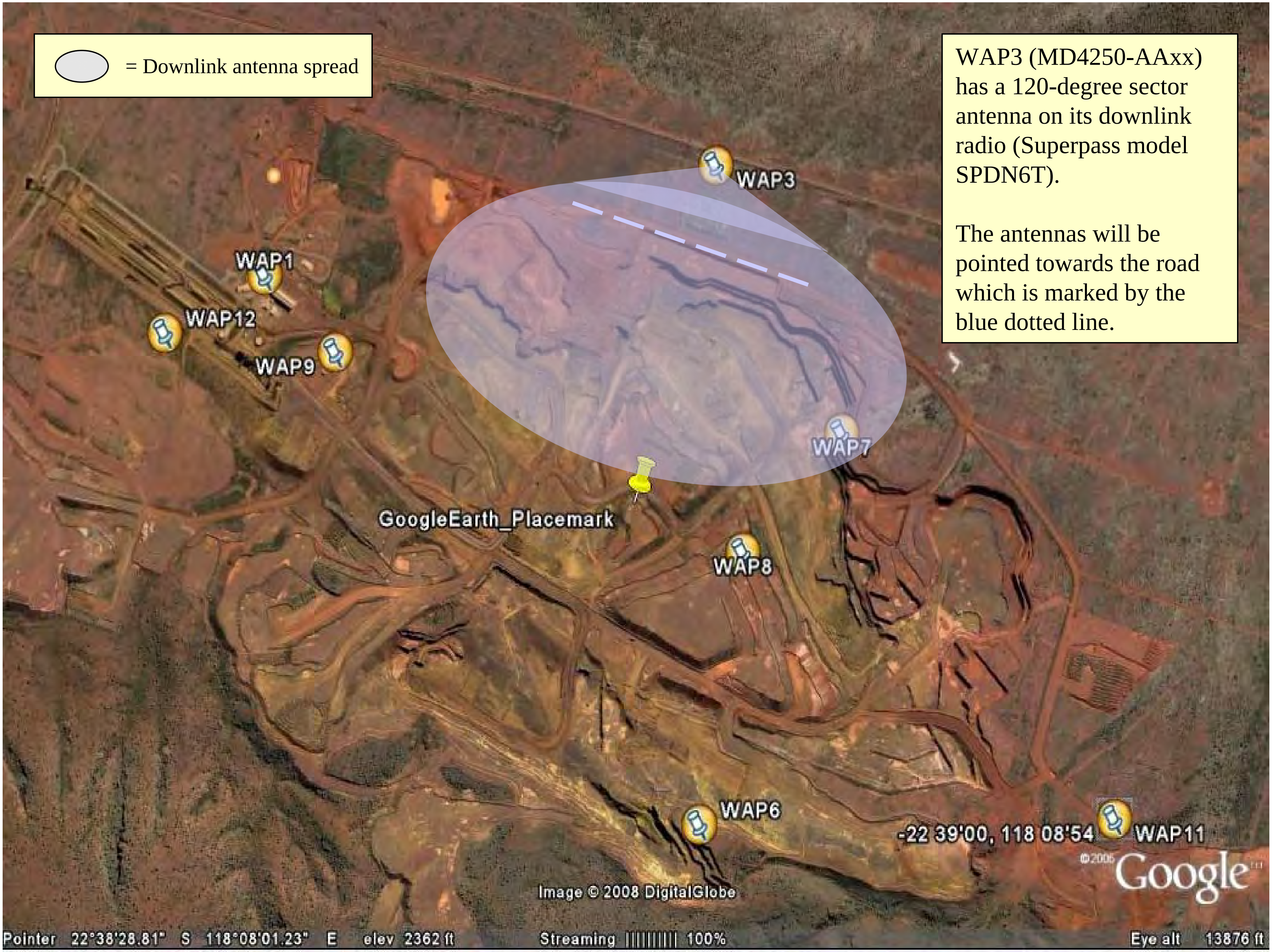


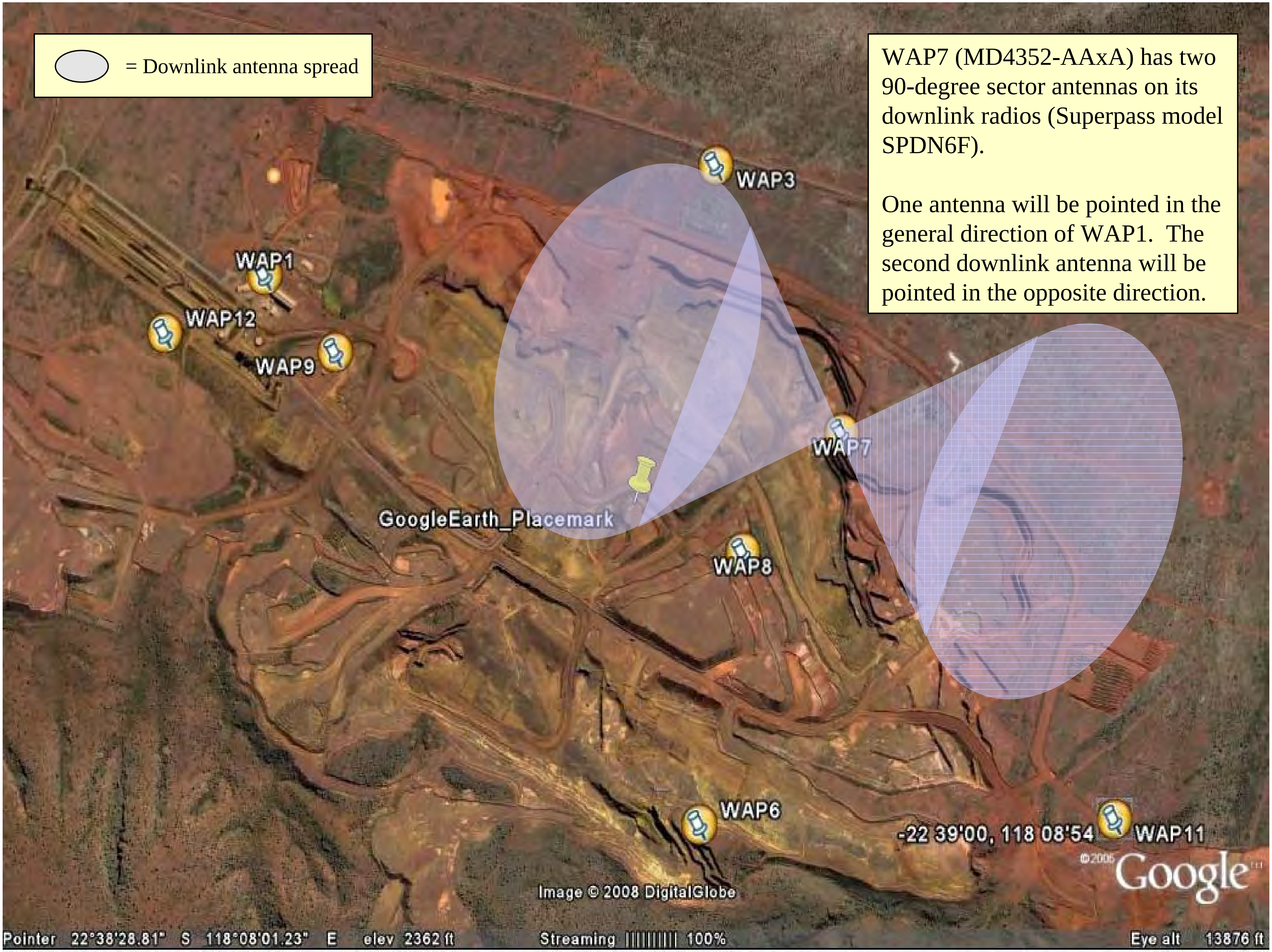
= Uplink antenna spread
WAP11 (MD4250-AAxx) has a 60-degree sector antenna on its uplink radio (Superpass model SPDN6S). The antenna will see WAP6, WAP7, and WAP8 as potential parents.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Google
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

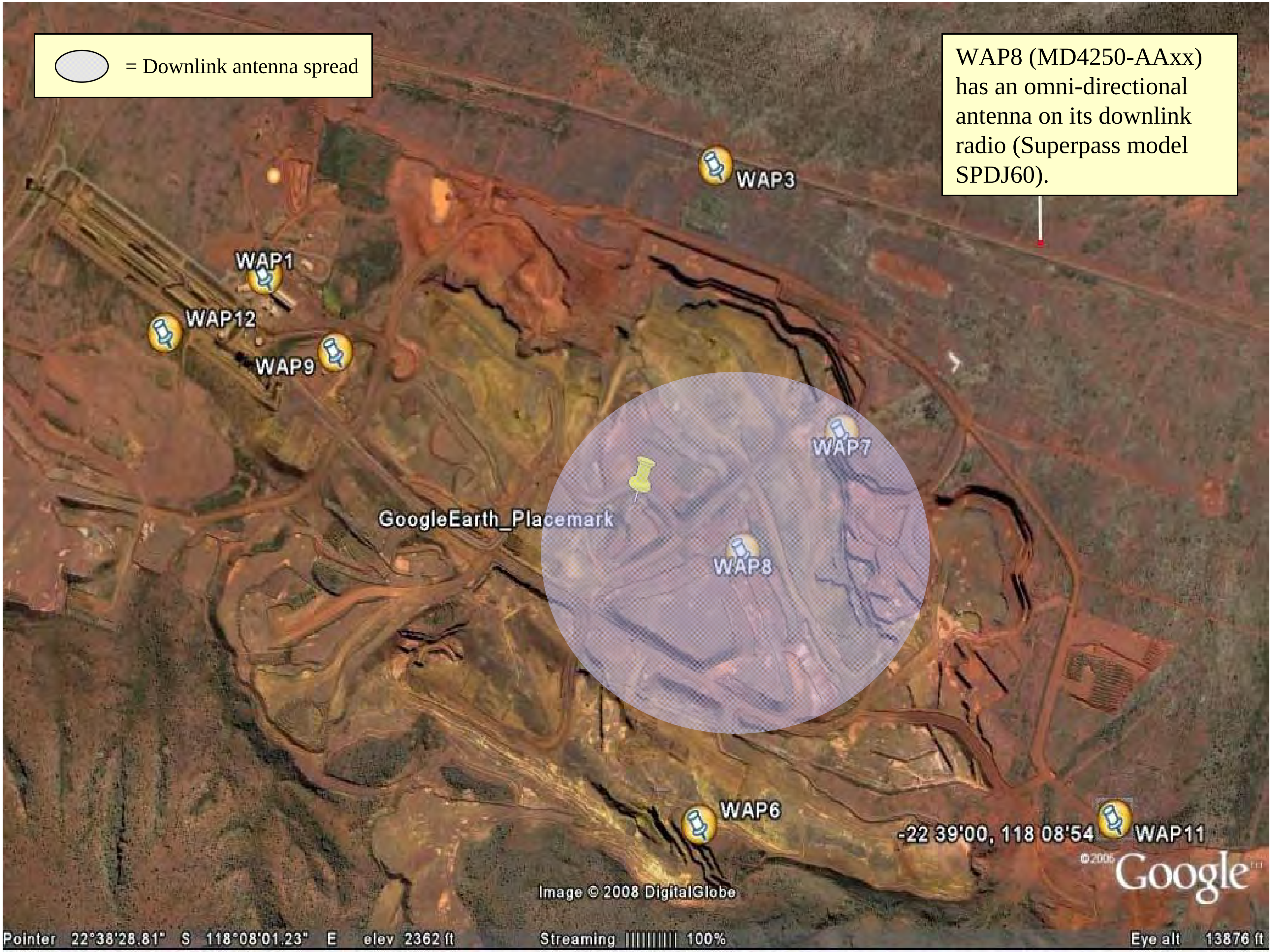

= Downlink antenna spread
It is assumed that WAP1 is the root node (MD4250-AAxx). This should have an omni-directional antenna on its downlink radio (Superpass model SPDJ60).
WAP1
WAP12
WAP9
WAP3
WAP7
WAP8
GoogleEarth_Placemark
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
© 2006 Google
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

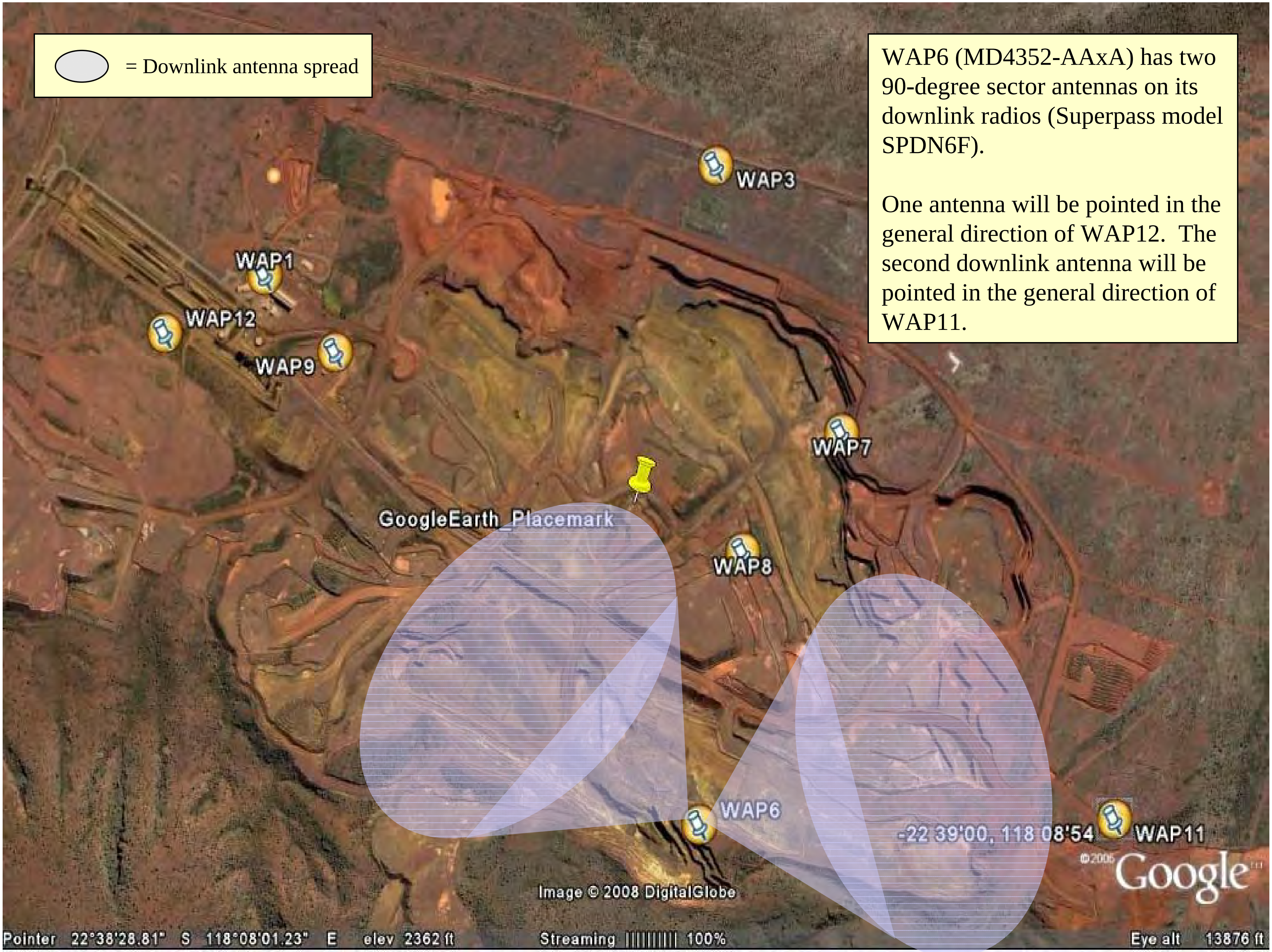

= Downlink antenna spread
WAP12 (MD4250-AAxx) has a 180-degree sector antenna on its downlink radio (Superpass model SPDN6H). The antenna will be pointed away from WAPs 1 & 9.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
©2006
Google
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

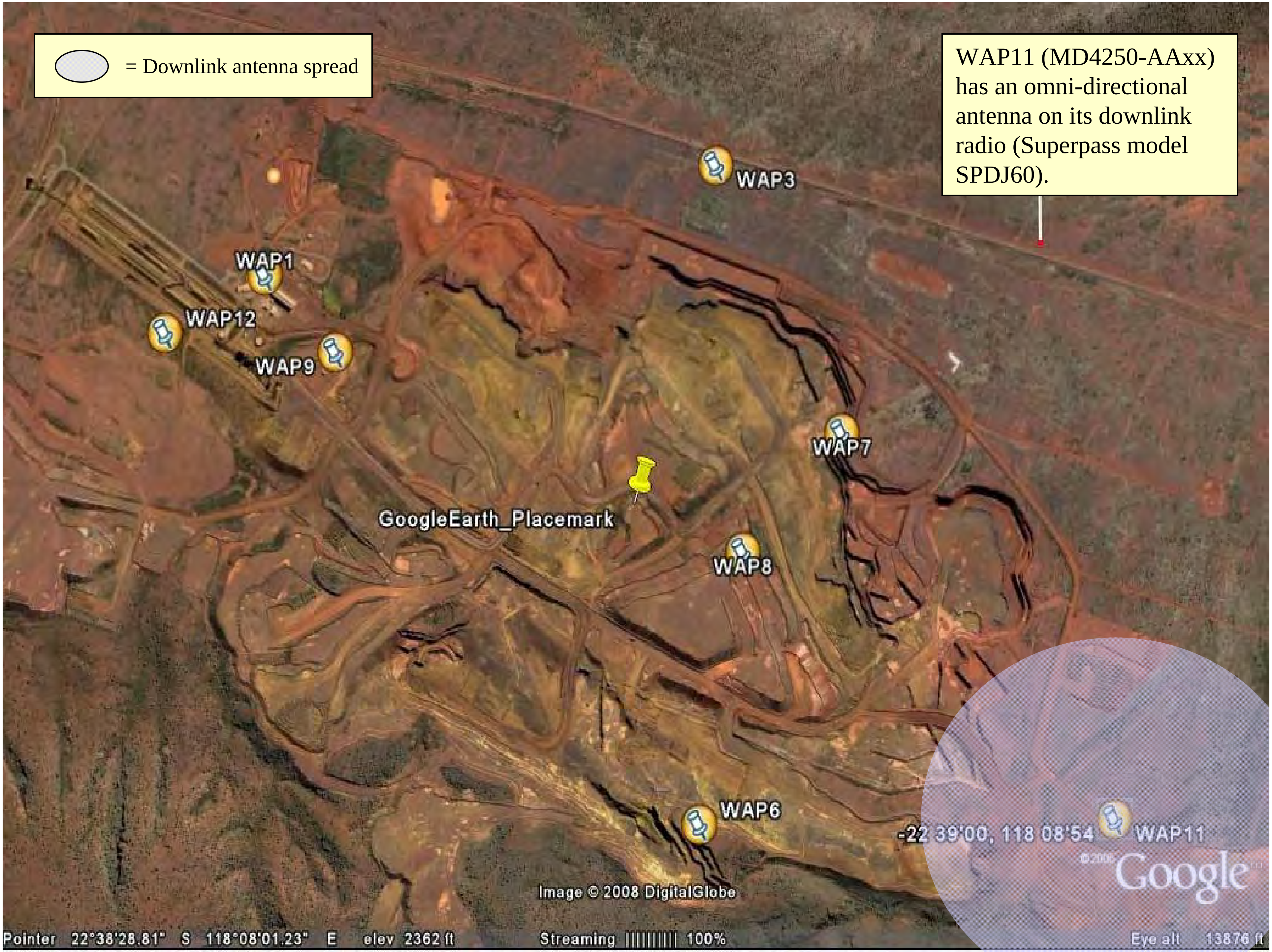

= Downlink antenna spread
WAP9 (MD4352-AAxA) has a 90-degree sector antenna on each of its downlink radios (Superpass model SPDN6F).
The antennas will be pointed away from the root (WAP1) in such a way that the signal spreads do not overlap (as illustrated).
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Google
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft


= Downlink antenna spread
WAP3 (MD4250-AAxx) has a 120-degree sector antenna on its downlink radio (Superpass model SPDN6T).
The antennas will be pointed towards the road which is marked by the blue dotted line.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
©2006
Google
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft


= Downlink antenna spread
WAP7 (MD4352-AAxA) has two 90-degree sector antennas on its downlink radios (Superpass model SPDN6F).
One antenna will be pointed in the general direction of WAP1. The second downlink antenna will be pointed in the opposite direction.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Google
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

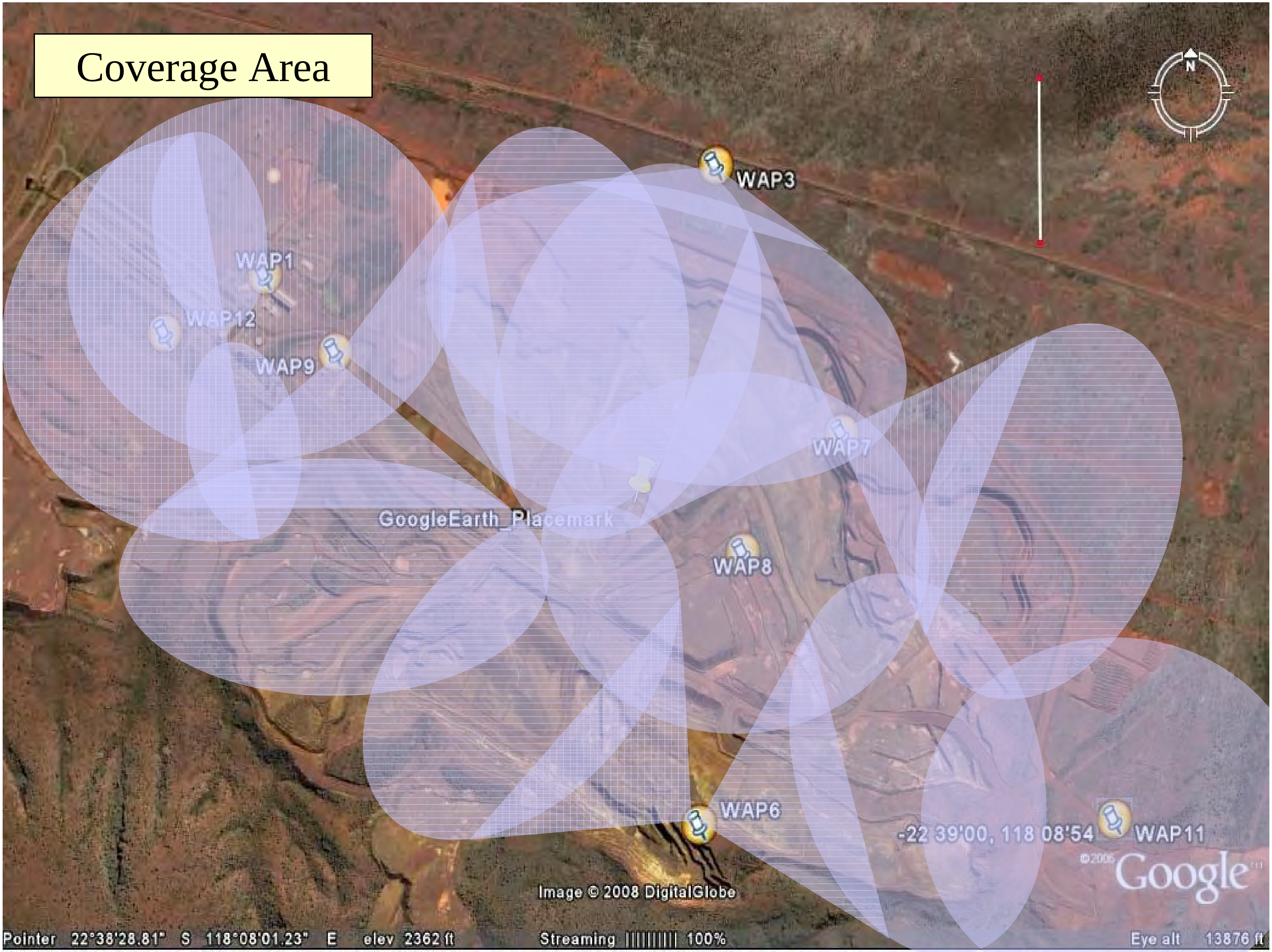

= Downlink antenna spread
WAP8 (MD4250-AAxx) has an omni-directional antenna on its downlink radio (Superpass model SPDJ60).
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft


= Downlink antenna spread
WAP6 (MD4352-AAxA) has two 90-degree sector antennas on its downlink radios (Superpass model SPDN6F).
One antenna will be pointed in the general direction of WAP12. The second downlink antenna will be pointed in the general direction of WAP11.
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Google
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming ||||||||| 100%
Eye alt 13876 ft



= Downlink antenna spread
WAP11 (MD4250-AAxx) has an omni-directional antenna on its downlink radio (Superpass model SPDJ60).
WAP3
WAP1
WAP12
WAP9
WAP7
GoogleEarth_Placemark
WAP8
WAP6
-22 39'00, 118 08'54
WAP11
Image © 2008 DigitalGlobe
Pointer 22°38'28.81" S 118°08'01.23" E elev 2362 ft
Streaming |||||||||| 100%
Eye alt 13876 ft

Coverage Area



For more information on the MD4000 Modular Mesh Nodes,

Please visit:

www.meshdynamics.com/tech-presentations.html

Or send us an email at

techsupport@MeshDynamics.com

Thank you.