# D20 FIU Site Characterization: Summary

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See configuration management system for approval history.




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# Change Record

| REVISION | DATE | ECO # | DESCRIPTION OF CHANGE |
|---|---|---|---|
| A | 4/18/2012 | ECO-00259 | INITIAL RELEASE |
| B | 06/28/2016 | ECO-03924 | Updated document to reflect new core site; Delete relocatable site info |
| | | | |
| | | | |

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# 1 DESCRIPTION

## 1.1 Purpose

The data summarized here is used to inform the site design activities for NEON project Teams, EHS (permitting), FCC, ENG and FSU. This document summarizes the FIU site characterization data collected, analyzed, and described in the FIU D20 Site Characterization: Supporting Data (AD[01]).

## 1.2 Scope

This document summarizes the FIU site characterization data for the D20 tower locations: Pu'u Maka'ala (Core). Issues and concerns for each site that need attention are also addressed in this document according to our best knowledge.

Disclaimer: all latitude and longitude points are subject to the tolerances of our measurement system, i.e., GPS, typically approximately ±3 m.

# 2 RELATED DOCUMENTS AND ACRONYMS

## 2.1 Applicable Documents

Applicable documents contain information that shall be applied in the current document. Examples are higher level requirements documents, standards, rules and regulations.

| | |
|---|---|
| AD [01] | NEON.DOC.011084 D20 Site Characterization Supporting Data.docx |
| AD [02] | NEON.DOC.011018 WID between FIU and FCC |
| AD [03] | NEON.DOC.011008 FIU Tower Science Requirements |
| AD [04] | NEON.DOC.011072 FIU Precipitation Collector Site Design |

## 2.2 Reference Documents

Reference documents contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

| | |
|---|---|
| RD [01] | NEON.DOC.000008 NEON Glossary of Abbreviations |
| RD [02] | NEON.DOC.000243 NEON Acronym List |
| RD [03] | |
| RD [04] | |

## 2.3 External References

External references contain information pertinent to this document, but are not NEON configuration-controlled. Examples include manuals, brochures, technical notes, and external websites.

| | |
|---|---|
| ER [01] | |
| ER [02] | |
| ER [03] | |

# 3 PU'U MAKA'ALA, CORE TOWER SITE

## 3.1 Desired ecosystem

**Table 1**. Ecosystem at the Pu'u Maka'ala core tower site.

| Ecosystem Type | Management activity |
|---|---|
| Ohia (*Metrosideros polymorpha)*-dominated montane rainforest | Managed as wild land |

The ecosystem at NEON Pu'u Maka'ala core site is Hawai'i Montane Rainforest, which is *ōhi'a* (*Metrosideros polymorpha*) dominated middle structure young forest with dense understory (mainly tree ferns and false staghorn fern (also call Uluhe fern)). The mean canopy height varies from 6 m to 22 m for Ohia trees inside major and secondary airshed. Pockets of well-grown stands have much taller canopy (20-25 m). The tree height surrounding the tower location is ~ 20 m. The height for tree ferns are ~4-5 m and ~ 2-3 m for false staghorn fern. Tree ferns are present in the denser part of the forest, while false staghorn ferns fill the open area. Ohia tree density is ~200-300 stems/ha with DBH >5 cm in the denser part of the forest, and ~50-100 stems/ha with DBH >5 cm at open part of the forest. Ground cover (all vegetation) is ~80-90%. The landscape at site is rolling hills. Soil depth is very shallow (generally < 2") but with deeper soil pockets of >30 cm

**Table 2**. Ecosystem and site attributes for Pu'u Maka'ala core tower site.

| Ecosystem attributes | Measure and units |
|---|---|
| Mean canopy height | 20 m |
| Surface roughness[a] | 3 m |
| Zero place displacement height[a] | 16.5 m |
| Structural elements | Open forest with denseunderstory |
| Time zone | Hawaii Standard Time |
| Magnetic declination | 9° 51' E changing by 0° 03' W/year |

Note, [a] From field observation.

## 3.2 Site Design and Tower Attributes

The site layout is summarized in the table below. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

**Table 3**. Site design and tower attributes for Pu'u Maka'ala core site.

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan or best match the surrounding environment.

| | | | | | |
|---|---|---|---|---|---|
| Airshed area | | | 80° to 150° and 230° to 290° | | Clockwise from first angle |
| Tower location | 19.553089° | -155.317310° | -- | -- | |
| Instrument hut | 19.553265° | -155.317279° | | | |
| Instrument hut orientation vector | -- | -- | 90°-270° | | Longwise |
| Instrument hut distance z | -- | -- | -- | 20 | meter |
| Anemometer/Temperature boom orientation | -- | -- | 205° | -- | |
| DFIR | 19.556761° | -155.310330° | | | |
| **Height of the measurement levels** | | | | | |
| Level 1 | | | | 0.3 | m.a.g.l. |
| Level 2 | | | | 4 | m.a.g.l. |
| Level 3 | | | | 12 | m.a.g.l. |
| Level 4 | | | | 19 | m.a.g.l. |
| Level 5 | | | | 24 | m.a.g.l. |
| Level 6 | | | | 30.5 | m.a.g.l. |
| Tower Height | | | | 30.5 | m.a.g.l. |

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

According to the wind roses, wind can blow up hill to the tower location from ocean on the southeast (80° to 150°, clockwise from 80°), and nighttime drainage flow blows from higher mountain area on the west toward the tower location (230° to 290°, clockwise from 230°). **Tower** should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is Ohia forest at this site. After FIU site characterization visit, we determined that the tower location should be at 19.55309°, -155.31731°. An **instrument hut** should be 19.553265°, -155.317279°. The instrument hut should be positioned to have the longer side parallel to E-W direction.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the southwset will be best to capture signals from all wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure.

**DFIR** location is at 19.556761°, -155.310330°, which is ~800 m northeast of tower location into an open pasture area. A secondary precipitation gauge on tower top may be needed based on the 600 m distance requirement. Wet deposition collector will collocate at the top of the tower. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

**Boardwalks**. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack or heavy rains causes paths to become uneven and further causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond 36" (0.914 m). The boardwalk to access the tower is not on any side that has a boom.

Specific Boardwalks at this site:

- No boardwalk/path is needed to instrument hut since the instrument hut is on the roadside.
- No boardwalk is needed between tower and instrument hut since the dirt road run between them. Even this road is rarely used, we should not block it.
- On-grade boardwalk to the soil array.
- On-grade boardwalk from the soil array boardwalk to the individual soil plots.
- No boardwalk or path needed to DFIR site.

The relative locations between tower, instrument hut and boardwalk can be found in the Figure below:

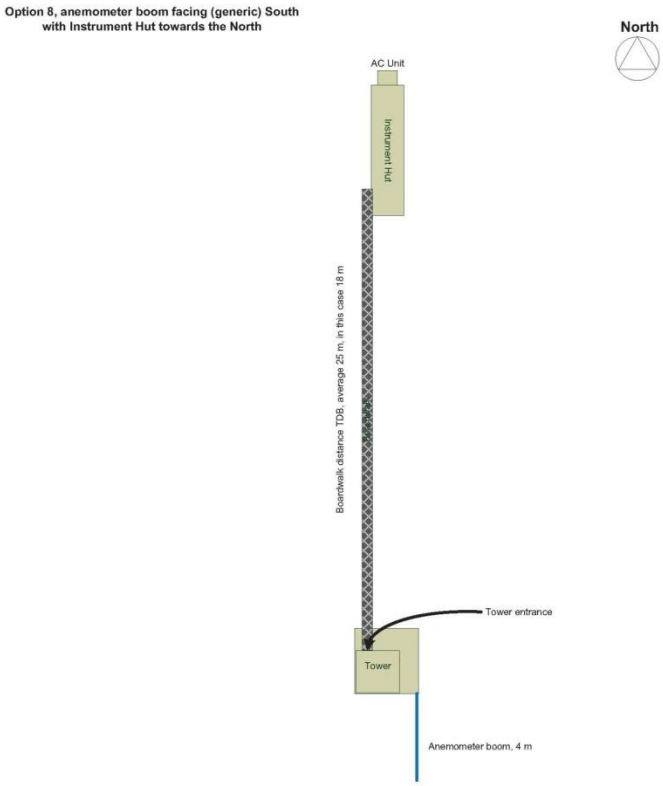



**Figure 1.** Generic diagram to demonstrate the relationship between tower and instrument hut when boom is facing south and instrument hut is on the north towards the tower.
This is just a generic diagram. The actual layout of boardwalk (or path if no boardwalk required) and instrument hut position will be the joint responsibility of FCC and FIU. At this site, the boom angle will be 205 degrees. The instrument hut location is on the northwest toward tower; the distance between instrument hut and tower is 20 m. The instrument hut vector will be E-W ($90^{o}$-$270^{o}$, longwise).


**Figure 2.** Site layout for Pu'u Maka'ala core tower site.
i) Tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 80º to 150º (clockwise from 160º) and 230º to 290º (clockwise from 230º) would have quality wind data without causing flow distortions, respectively, iii) Yellow line is the suggested access road to instrument hut, and iv) Purple pin is DFIR location

## 3.3 Soil Attributes

The soil array vector is ***from*** the soil plot closest to the tower ***toward*** the farthest soil plot. The exact location of each soil plot may be microsited to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc).

Dominant soil series at the site: Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes. The taxonomy of this soil is shown below:

**Order**: Histosols

**Suborder**: Folists

**Great group**: Udifolists

**Subgroup**: Typic Udifolists

**Family**: Euic, isomesic Typic Udifolists

**Series**: Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes

**Table 4**. Summary of soil array and soil pit information at Pu'u Maka'ala. 0° represents true north and accounts for declination.

| | |
|---|---|
| Soil plot dimensions | 5 m x 5 m |
| Soil array pattern | Non-standard |
| Distance between soil plots: x | Varies (~ 40 m) |
| Distance from tower to closest soil plot: y | 25 m |
| Latitude and longitude of 1st soil plot OR direction from tower | 19.55301, -155.31708 |
| Latitude and longitude of 2nd soil plot OR direction from tower | 19.55284, -155.31668 |
| Latitude and longitude of 3rd soil plot OR direction from tower | 19.55264, -155.31638 |
| Latitude and longitude of 4th soil plot OR direction from tower | 19.55247, -155.31592 |
| Latitude and longitude of 5th soil plot OR direction from tower | 19.55231, -155.31558 |
| Direction of soil array | ~115 degrees |
| Latitude and longitude of FIU soil pit 1 | 19.553320°, -155.317470° (primary location) |
| Latitude and longitude of FIU soil pit 2 | 19.55354, -155.31532 (alternate 1) |
| Latitude and longitude of FIU soil pit 3 | 19.55331, -155.31654 (alternate 2) |
| Dominant soil type | Lalaau very cobbly highly decomposed plant material, 2 to 10 percent slopes |

| | |
|---|---|
| Expected soil depth | 1.02-1.52 m |
| Depth to water table | >2 m |

| Expected depth of soil horizons | Expected measurement depths* |
|---|---|
| 0-0.08 m (Oa/2C1 - 0 to 3 inches: very cobbly highly decomposed plant material) | 0.04 m |
| 0.08-1.35 m (2C2 - 3 to 53 inches: cobbles) | 0.72 m |
| 1.35-1.60 (2R - 53 to 63 inches: bedrock) | |

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.

## 3.4 Information for ecosystem productivity plots

The tower at this site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (Ohia Forest). Wind blows from the airshed of 80$^o$ to 150$^o$ (clockwise from 80$^o$), and 230$^o$ to 290$^o$ (clockwise from 230$^o$). 90% signals for flux measurements are within 1000 m from tower, and 80% within 500 m. We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 80$^o$ to 150$^o$ (clockwise from 80°) and 230$^o$ to 290$^o$ (clockwise from 230$^o$) from tower.

## 3.5 Issues and attentions

DFIR location is >800 m away from tower location. A secondary precipitation gauge is needed at tower top based on the 600 m distance requirement.

Soil is rocky, new and very shallow. Typical design of soil array doesn't work here. Special design is needed for this site. The location of soil plots was handpicked at field. Each picked location is indicated by two orange ribbons tied on nearby trees.

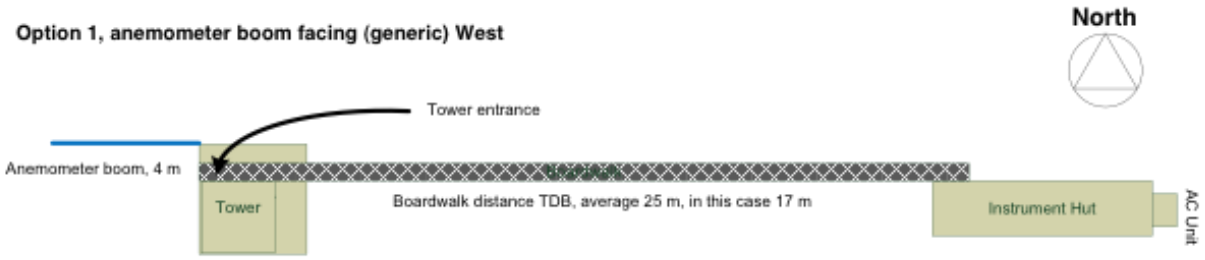
Field design above for this site was made by following the standard FIU site design procedures and assuming that we will have ability to deploy the full set of the standard FIU measurements above and below ground. However, due to the ususual shallow soil depth, the deployment of the standard soil array is not possible at this site. Variance in FIU design is needed.

Understory is super dense and fast-growing. It may be a challenge for NEON construction, deployment and maintanence.

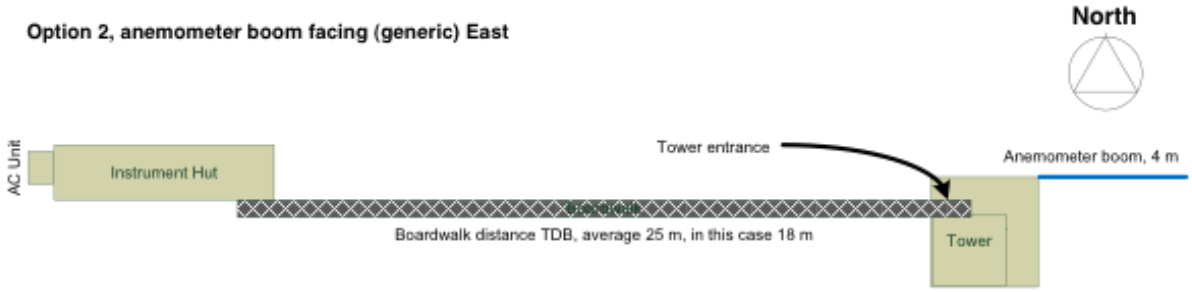
There are endanged plant species at site. NEON personnel should work with site host to identify the plants, and microsite soil pit, soil plot locations accordingly as needed prior to construccction.

This site location is next to Correction Facility. No public activities. Security is high.

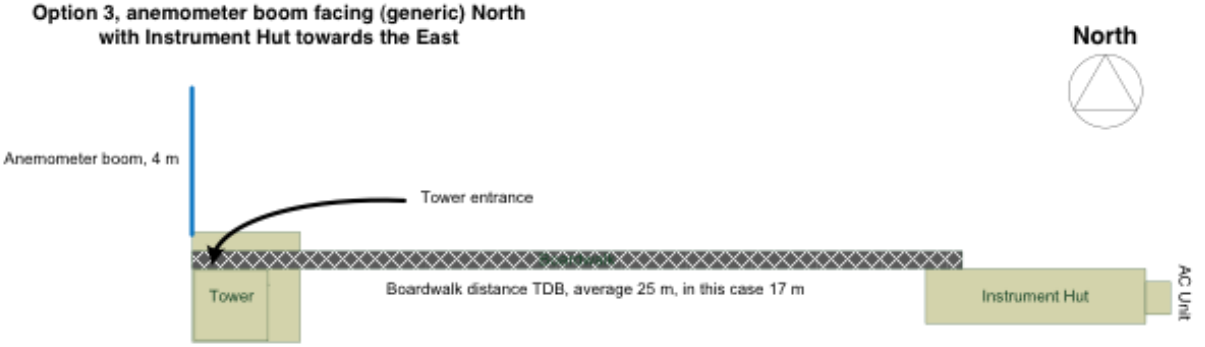
**Option 1, anemometer boom facing (generic) West**



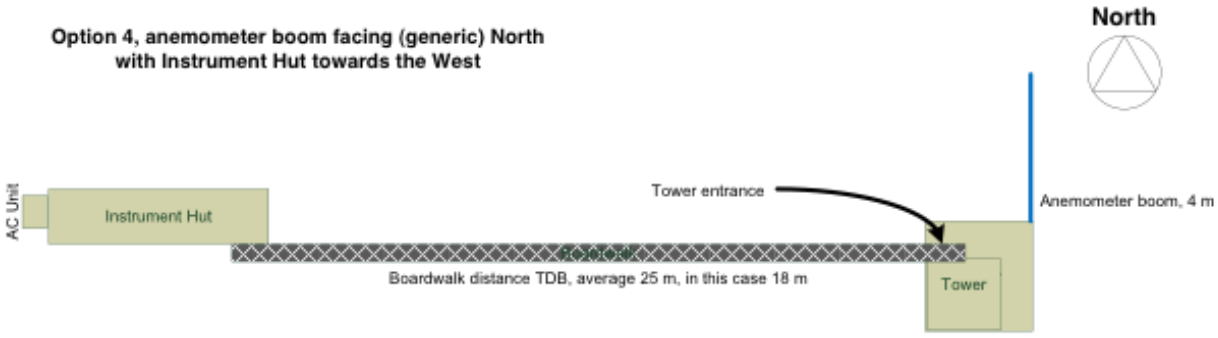

**Option 2, anemometer boom facing (generic) East**




**Option 3, anemometer boom facing (generic) North with Instrument Hut towards the East**




**Option 4, anemometer boom facing (generic) North with Instrument Hut towards the West**



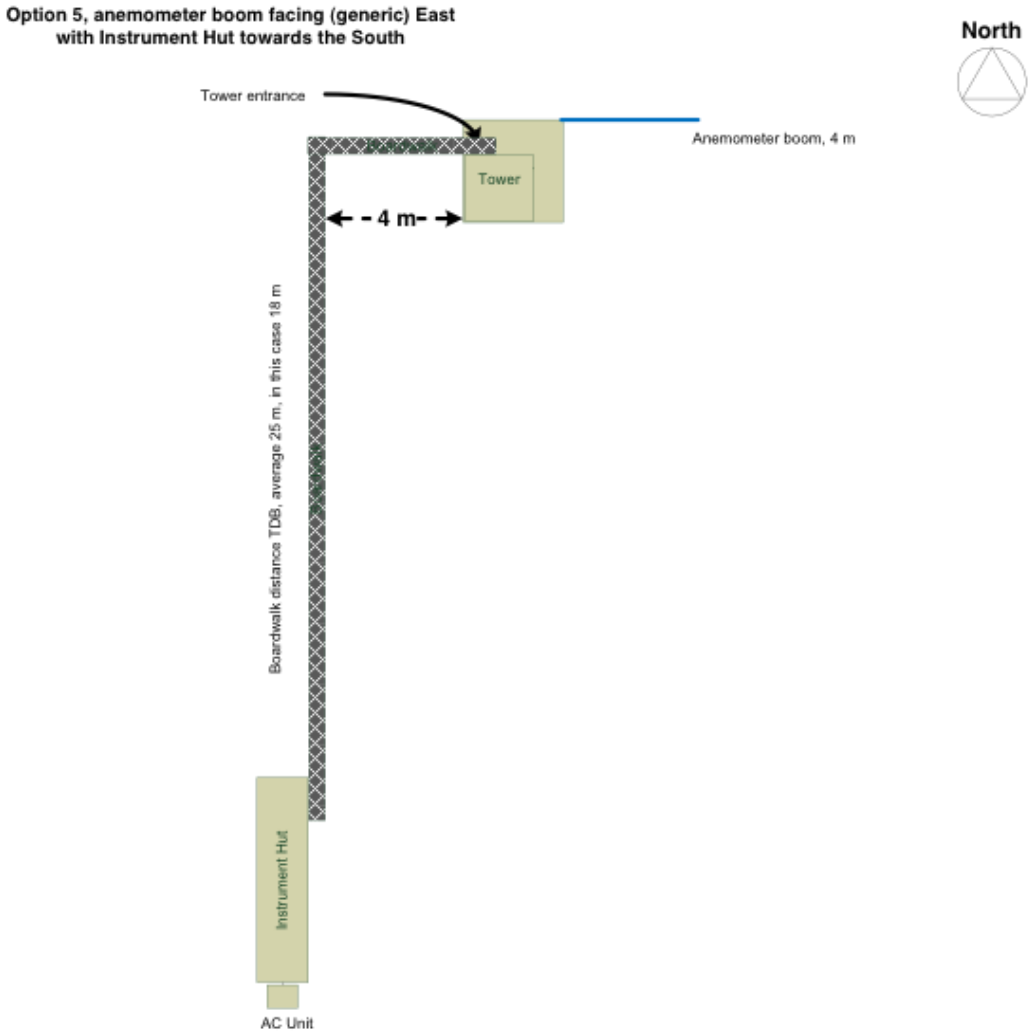
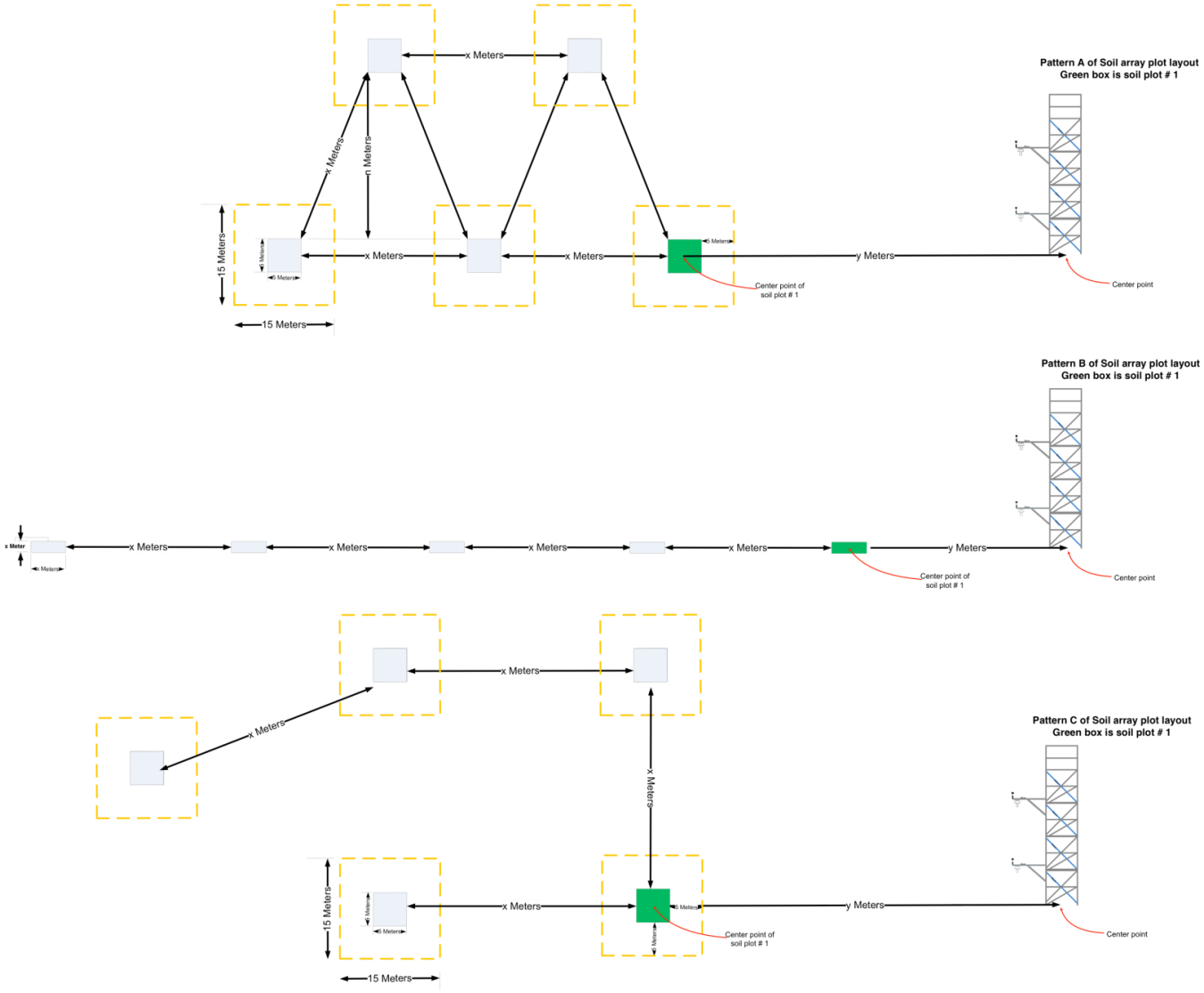



**Figure 3.** Generic patterns for the boardwalk configuration

These generic configurations are from the instrument hut to the tower based on 5 generic scenarios. The five options are based on anemometer boom orientation and the leeward side of the tower where the instrument hut is located. The tower entrance is always on the North side of the tower. Exact tower and instrument hut location and orientation will be specified at each location and presented in the site characterization document.


Pattern A of Soil array plot layout
Green box is soil plot # 1
x Meters
x Meters
n Meters
15 Meters
x Meters
x Meters
y Meters
15 Meters
Center point of soil plot # 1
Center point
Pattern B of Soil array plot layout
Green box is soil plot # 1
x Meter
x Meters
x Meters
x Meters
x Meters
y Meters
Center point of soil plot # 1
Center point
Pattern C of Soil array plot layout
Green box is soil plot # 1
x Meters
x Meters
x Meters
15 Meters
x Meters
y Meters
15 Meters
Center point of soil plot # 1
Center point

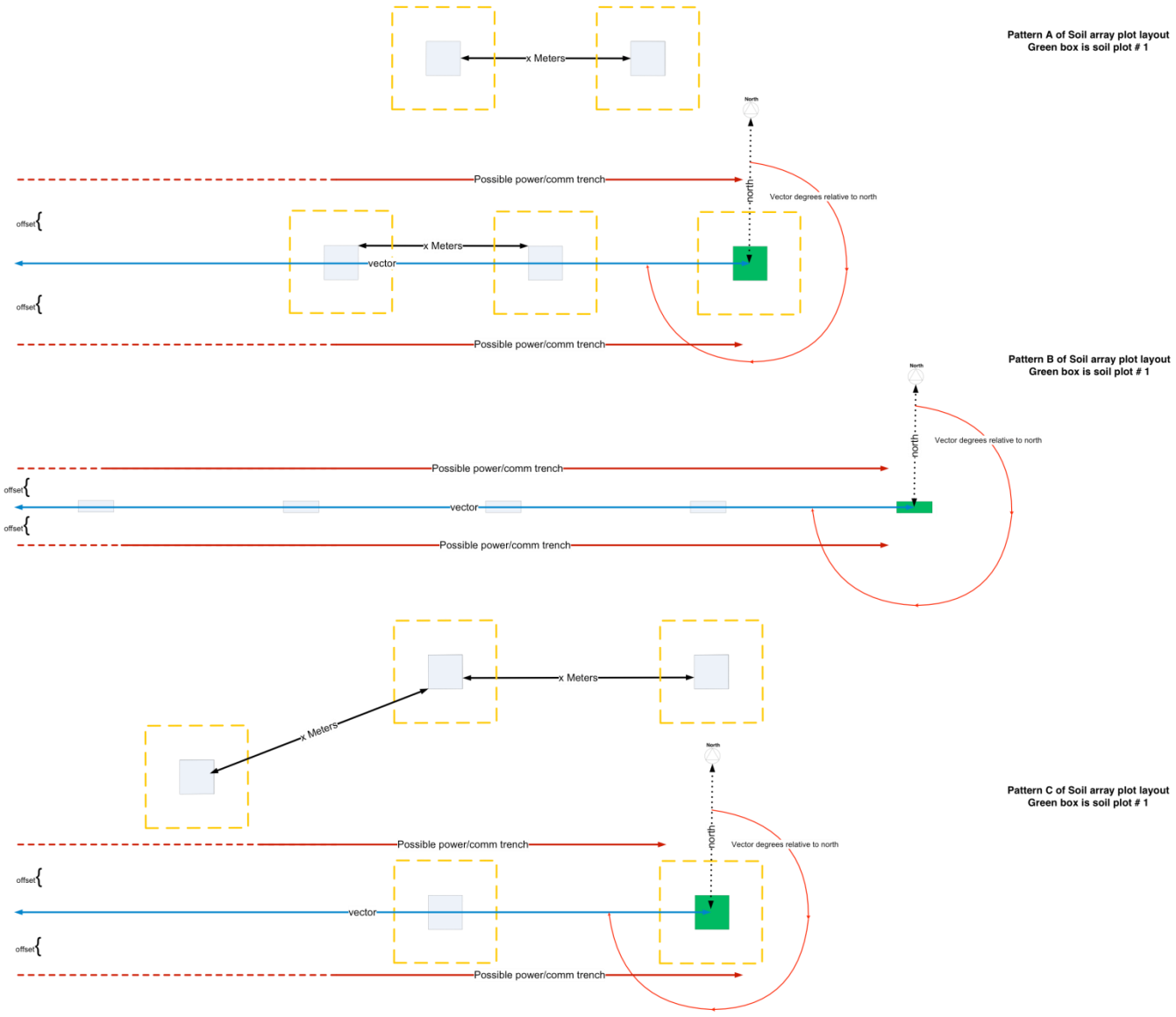



**Figure 4.** Conceptual diagram of Soil Array Patterns

Outlines the orientation for the soil array and instrument hut from the center point of the tower. The x, y, z distances are i) the distance between soil plots, ii) distance between the tower centerpoint and the closest edge of soil plot, and iii) the distance between the tower centerpoint and the closest edge of the instrument hut, respectively. The yellow outline around each soil plot is the 5 m perimeter keep out zone.

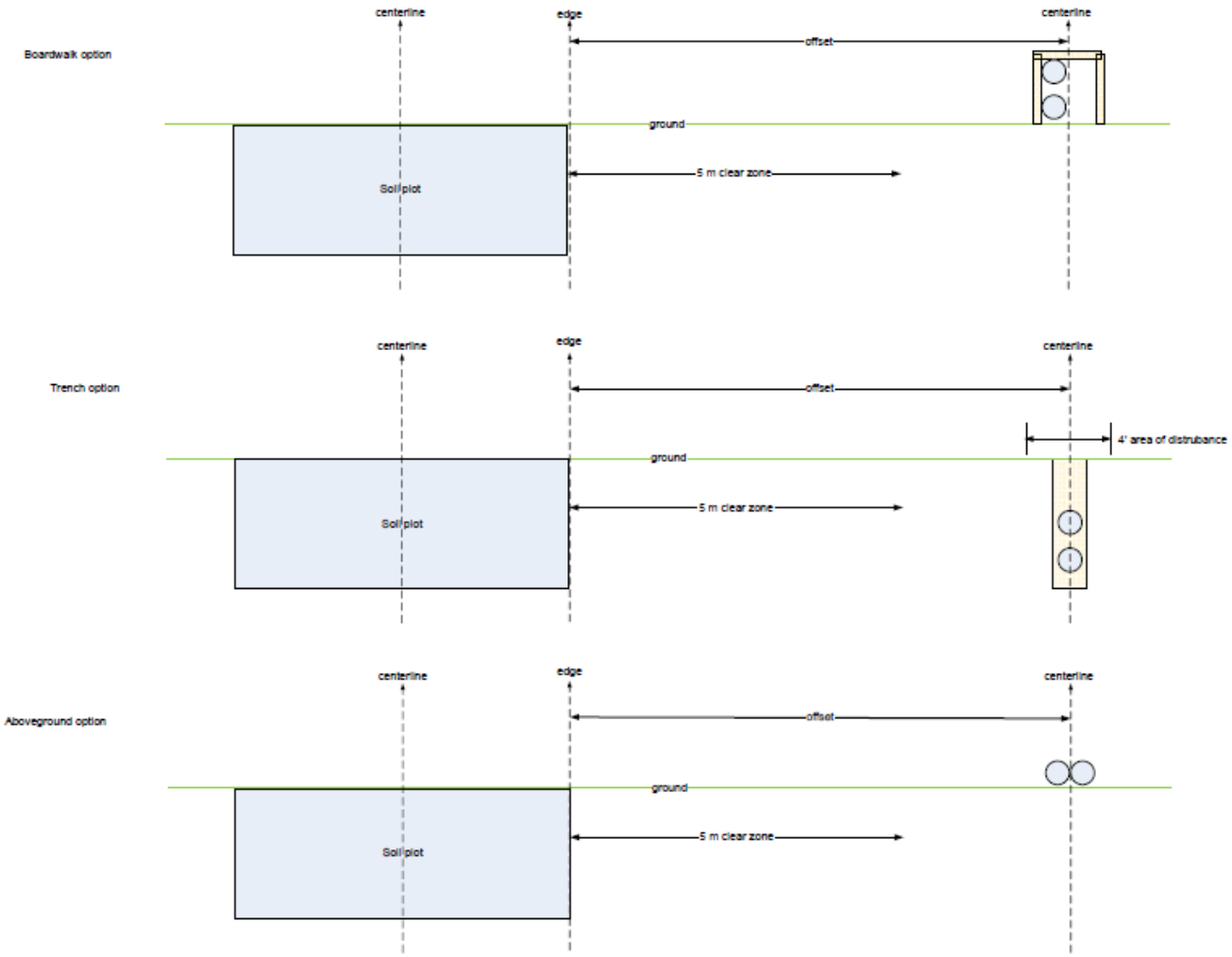



**Figure 5.** Conceptual diagram of power/communications line and boardwalk/path options in relation to FIU soil plots.

Boardwalk option: When a boardwalk is present the power and communication lines will typically follow the route of the boardwalk and be mounted aboveground (underneath the boardwalk). When no boardwalk is present (or the power/communication lines follow a different route than the boardwalk) the lines can be buried (Trench option) or run aboveground (Aboveground option). The aboveground option will be used instead of the trench option when trenching would be expected to cause significant disturbance to an ecosystem (e.g. cutting the roots of trees), pending landowner approval.

## 4 APPENDIX A. FCC SUMMARY TABLES

**Table 5.** FCC Summary Table for FIU site components at D20 Pu'u Maka'ala core site

| **Site Component** | | | | **units** |
|---|---|---|---|---|
| Tower location | 19.553089° | -155.317310° | | Lat, Long, in degrees |
| Tower location | 19°33'11.12"N | 155°19'2.32"W | | Lat, Long in deg min sec |
| Tower height[f] | 30.5 | | | meters |
| Tower guying | yes | | | yes/none, notes |
| Instrument Hut location | 19.553265° | -155.317279° | | Lat, Long, in degrees |
| Instrument Hut location | 19°33'11.75"N | 155°19'2.20"W | | Lat, Long in deg min sec |
| IH orientation[a] | 90°-270° | | | vector |
| boom orientation[b] | 205° | | | degrees |
| distance from center of tower to IH center (z) | | 20 | option 8 | distance (m), option #, (location chosen to meet National Park approval) |
| Air shed vector(s)[c] | 80° to 150° | 230° to 290° | | Vector, clock wise from first angle |
| Boardwalk from AP to IH | IH is on roadside. No boardwalk is needed. | | | yes/none, notes |
| how the Bwalk intersects the tower access | No boardwalk. Access tower on the north face. | | | description |
| Boardwalk to soil array | On-grade boardwalk | On-grade boardwalk to individual soil plots | | yes/none, notes |
| Boardwalk needed to DFIR | no | | | yes/none |
| Power and Communication trench | 10 m from edge of soil plot to the centerline of the power/comms line | whichever side is easiest [e], line above ground | | offset, notes |
| DFIR location | 19.556761° | -155.310330° | | Lat, Long in degrees, notes |
| DFIR location | 19°33'24.34"N | 155°18'37.19"W | | Lat, Long in deg min sec |

| DFIR power supply | Line power | | | description |
|---|---|---|---|---|
| Soil plot 1st location | 19.553010° | -155.317080° | | Lat, Long in degrees (center point) |
| Soil plot 1st location | 19°33'10.84"N | 155°19'1.49"W | | Lat, Long in deg min sec |
| Soil plot 2nd location | 19.552840° | -155.316680° | | Lat, Long in degrees (center point) |
| Soil plot 2nd location | 19°33'10.22"N | 155°19'0.05"W | | Lat, Long in deg min sec |
| Soil plot 3rd location | 19.552640° | -155.316380° | | Lat, Long in degrees (center point) |
| Soil plot 3rd location | 19°33'9.50"N | 155°18'58.97"W | | Lat, Long in deg min sec |
| Soil plot 4th location | 19.552470° | -155.315920° | | Lat, Long in degrees (center point) |
| Soil plot 4th location | 19°33'8.89"N | 155°18'57.31"W | | Lat, Long in deg min sec |
| Soil plot 5th location | 19.552310° | -155.315580° | | Lat, Long in degrees (center point) |
| Soil plot 5th location | 19°33'8.32"N | 155°18'56.09"W | | Lat, Long in deg min sec |
| Soil plot distance between plots (x) and from tower (y) | Varies | 40 m | 25 | x, y (meters) |
| Soil array pattern and vector[d] | Non-standard | NA | | A, B, or C, vector |
| Soil plot dimensions | 5 m x 5 m | | | L x W (meters) |
| Soil profile pit primary | 19.553320° | -155.317470° | 1.02-1.52 m | Lat, Long, and expected depth [ξ] |
| Soil profile pit primary | 19°33'11.95"N | 155°19'2.89"W | 1.02-1.52 m | Lat, Long in deg min sec |
| Soil profile pit alternative 1 | 19.553540° | -155.315320° | 1.02-1.52 m | Lat, Long, and expected depth [ξ] |
| Soil profile pit alternative 1 | 19°33'12.74"N | 155°18'55.15"W | 1.02-1.52 m | Lat, Long in deg min sec |
| Soil profile pit alternative 2 | 19.553310° | -155.316540° | 1.02-1.52 m | Lat, Long, and expected depth [ξ] |
| Soil profile pit alternative 2 | 19°33'11.92"N | 155°18'59.54"W | 1.02-1.52 m | Lat, Long in deg min sec |
| Fencing needs | none | none | none | IH, Soil Arrays, Guy anchors |
| Presence of large grazing animals | Wild pigs make dens on the ground, but may not graze. | | | description |
| Site management* | Managed as wild land. | | | description |
| Any additional site specific information | Understory is very dense. Lava tubes on the ground and may not be able to see due to dense vegetation. This is a potential safety hazard. | | | description |

| | | |
|---|---|---|
| Magnetic declination | 9° 51' E changing by 0° 03' W/year | At time of site visit |

ξ This expected soil depth is from NRCS. Actual soil depths may differ substantially from those shown here.

Notes;

[a]parallel to the long side of the IH

[b]From tower point to this direction

[c]Clockwise from first angle, recommend reviewing FIU site characterization summary report

[d]From 1st plot toward other plots if pattern B, from 1st plot toward nearest neighbor (see diagram of the patterns)

[e]see Appendix A. Options for Soil Array, second figure.

[f]Tower Height is for FIU requirements; actual tower height will increase toward the next section height.

IH = instrument hut

AP = auxillary portal

*burn information that may affect boardwalk, IH, or tower infrastructure, or other management activities