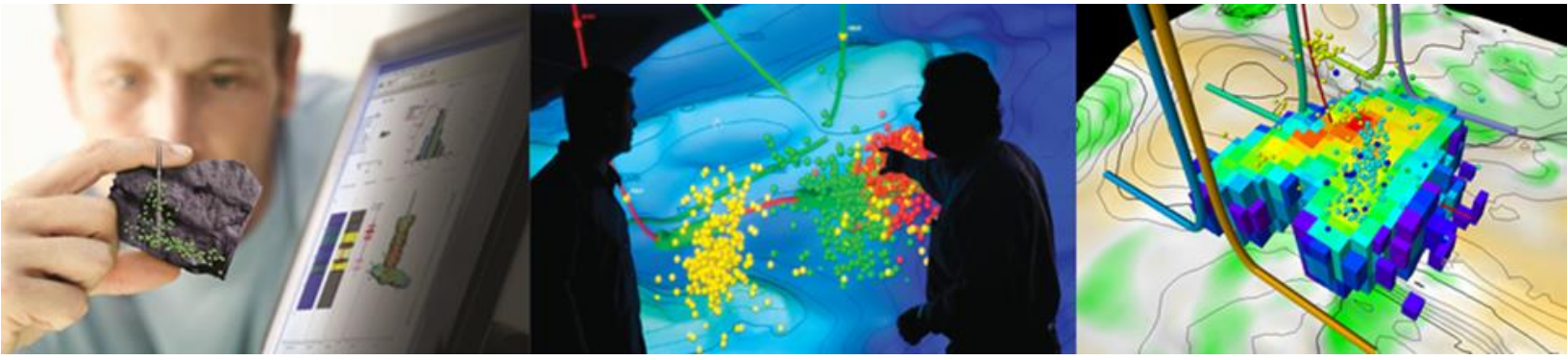
Schlumberger

**StimMAP Evaluation Report**

# Northeast Natural Energy

Marcellus
MIP 3H and MIP 5H
Marcellus Field
Monongalia County, West Virginia

Oct 29, 2015 - Nov 15, 2015



# StimMAP Evaluation Report

## MIP 3H and MIP 5H
## Marcellus Field
## Monongalia County, West Virginia
## Marcellus

## Prepared for
## Northeast Natural Energy

## Prepared by
## Schlumberger

## Jan 13, 2016

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For contact link and information about Schlumberger hydraulic fracture monitoring service, please go to:
http://www.slb.com/services/completions/stimulation/hydraulic_fracture_monitoring.aspx

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# 1. Summary

StimMAP microseismic data was acquired during the completion of the Marcellus formation in the MIP 3H and MIP 5H wells. The wells are located in the Marcellus field, Monongalia County, West Virginia. Schlumberger provided fracturing services during the project. A total of 52 out of 58 stimulation stages were monitored and evaluated.

This report contains an initial analysis of microseismic fracture dimensions, azimuths, and stimulated volumes. Microseismic events were acquired beginning with MIP 3H Stage 7 of the MIP 3H completion and finished with MIP 5H Stage 30 of MIP 5H. Geophones were deployed in MIP SW for monitoring. Figure 1-1 is a map view of the treatment and monitor wells showing the relative position of the geophones and perforation intervals.

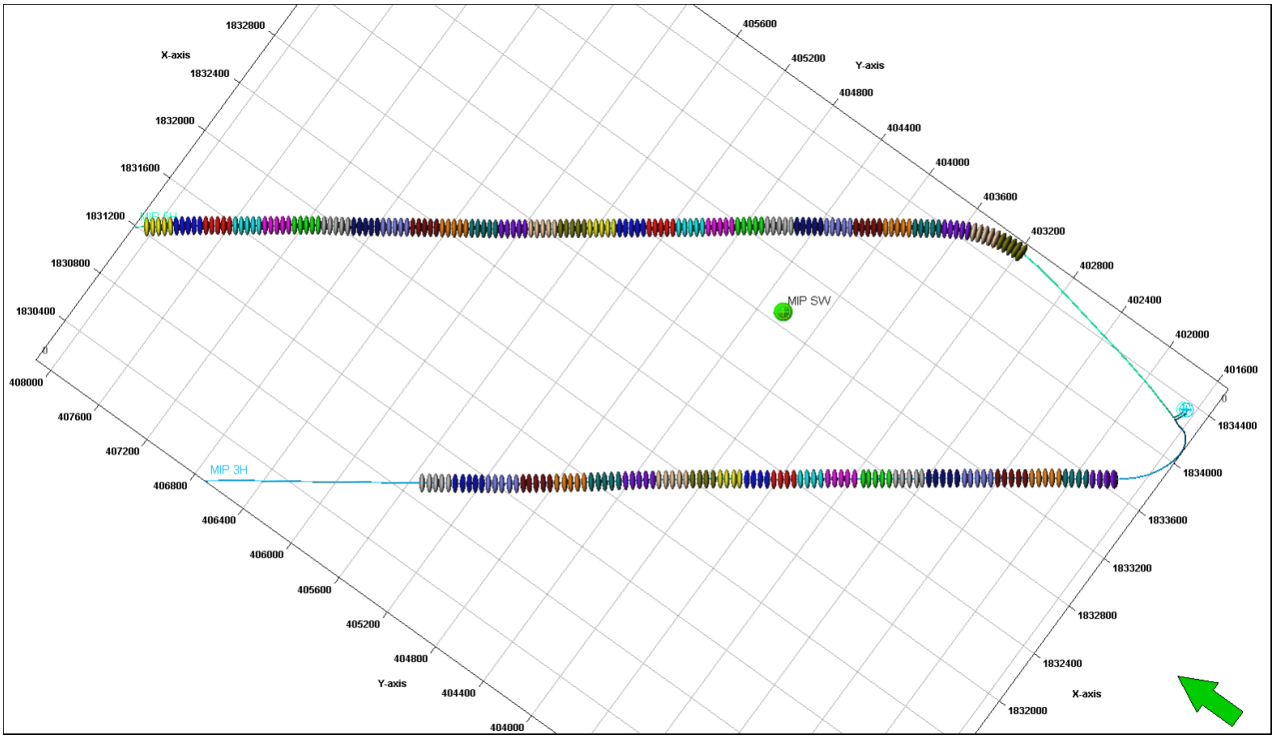



**Figure 1-1 - Location of treatment well perforations and geophones**

Figure 1-2 is a summary of the microseismic events shown in map view. Figure 1-3 is a side view of the microseismic events.

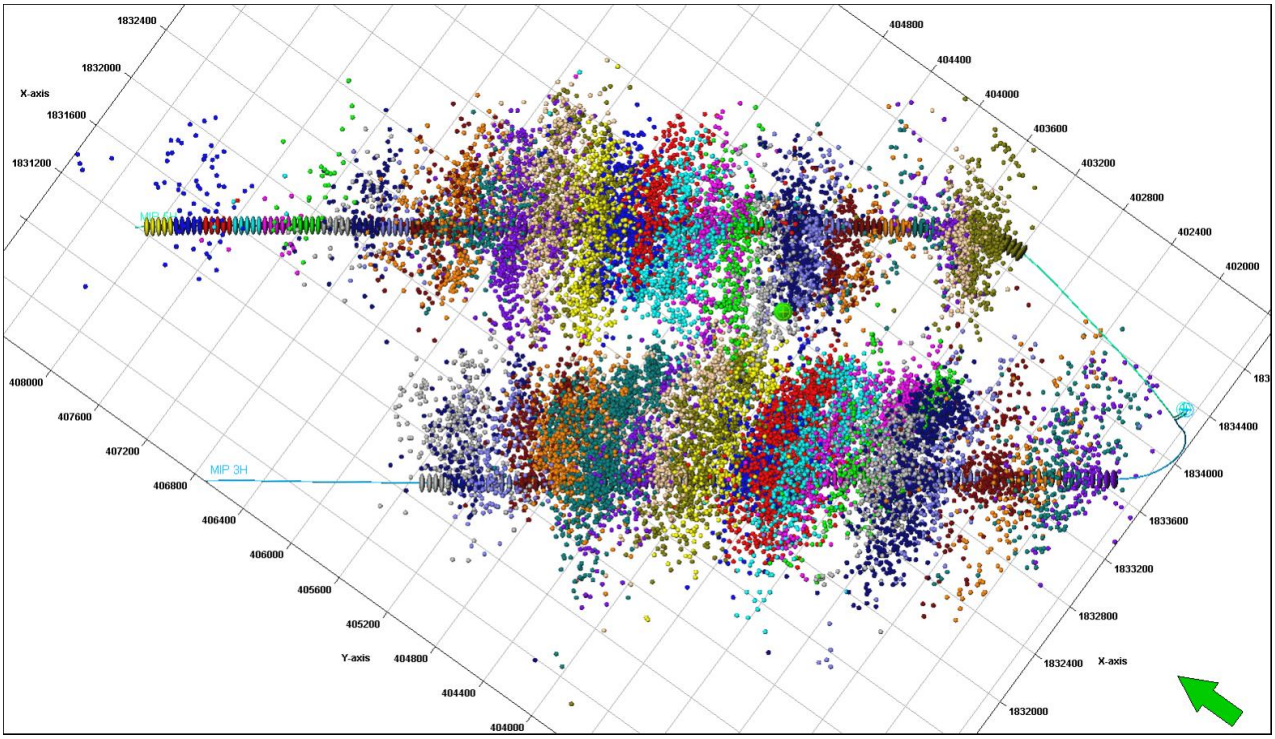



**Figure 1-2 - Map view summary of microseismic events**

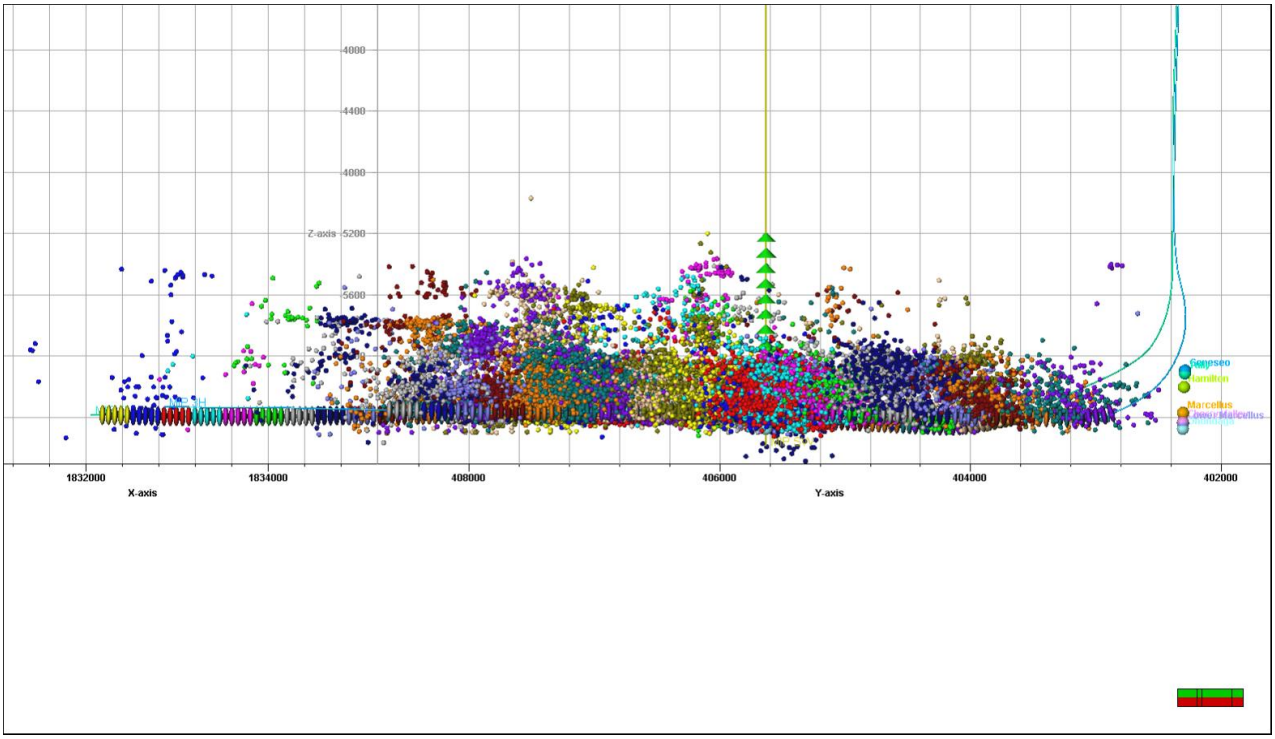



**Figure 1-3 - Depth view summary of microseismic events**

# 2. Introduction

## 2.1 Project Overview

This report contains the evaluation of StimMAP microseismic data acquired during completion of the Marcellus formation in the MIP 3H and MIP 5H wells. The wells are located in Marcellus field, Monongalia County, West Virginia. Schlumberger provided fracturing services during the project. Schlumberger provided integrated completion services including frac, perforation, plugs, fiber and microseismic monitoring.

## 2.2 Treatment Well Data

22 stimulation stages were monitored during the completion of the MIP 3H.

30 stimulation stages were monitored during the completion of the MIP 5H.

The well data is shown in Table 2.1.

**Table 2.1 - Treatment well data**

| Treatment wells | MIP 3H | MIP 5H |
|---|---|---|
| Well type | Horizontal | Horizontal |
| Completion | Plug/Perf | Plug/Perf |
| Kelly bushing - KB (ft) | 1082 | 1072 |
| Total measured depth - MD (ft) | 13874 | 14454 |
| Maximum vertical depth - TVD (ft) | 7484 | 7527 |
| Maximum pressure (psi) | N/A | N/A |

## 2.3 Monitoring Well Data

12 VSI geophone(s) spaced 100 ft apart in the MIP SW was/were used for microseismic monitoring. Microseismic monitoring was started during MIP 5H Stage 2 of the completion.

The locations of the monitoring tools are listed in Table 2.2

**Table 2.2 - Geophone depths and spacing in MIP SW**

| Geophone setting | First stage monitored | Last stage monitored | Number of geophones | Top geophone depth (MD) (ft) | Spacing (ft) | Orientation |
|---|---|---|---|---|---|---|
| VSI-12 (planned) | MIP 3H Stage 7 | MIP 5H Stage 30 | 12 | 6310 | 100 | |

The locations of the treatment and monitor wells, geophone positions, and stimulation stages are shown in Figure 2-1. The distances shown are the approximate monitoring distances from the center of the geophone array to the mid-perforation location for each stage.

| Geophone Array Position (Depth - ft) | Well | Stage | Distance to Mid Perf (ft) |
|---|---|---|---|
| VSI-12 MIP SW 6310 - 7110 MD | MIP 3H | 7 | 2654 |
| | MIP 3H | 8 | 2459 |
| | MIP 3H | 9 | 2290 |
| | MIP 3H | 10 | 2056 |
| | MIP 3H | 11 | 1890 |
| | MIP 3H | 12 | 1743 |
| | MIP 3H | 13 | 1577 |
| | MIP 3H | 14 | 1458 |
| | MIP 3H | 15 | 1348 |
| | MIP 3H | 16 | 1304 |
| | MIP 3H | 17 | 1264 |
| | MIP 3H | 18 | 1264 |
| | MIP 3H | 19 | 1269 |
| | MIP 3H | 20 | 1315 |
| | MIP 3H | 21 | 1388 |
| | MIP 3H | 22 | 1500 |
| | MIP 3H | 23 | 1655 |
| | MIP 3H | 24 | 1811 |
| | MIP 3H | 25 | 1986 |
| | MIP 3H | 26 | 2157 |
| | MIP 3H | 27 | 2350 |
| | MIP 3H | 28 | 2481 |

| Geophone Array Position (Depth - ft) | Well | Stage | Distance to Mid Perf (ft) |
|---|---|---|---|
| VSI-12 MIP SW 6310 - 7110 MD | MIP 5H | 1 | 4272 |
| | MIP 5H | 2 | 4067 |
| | MIP 5H | 3 | 3885 |
| | MIP 5H | 4 | 3684 |
| | MIP 5H | 5 | 3498 |
| | MIP 5H | 6 | 3303 |
| | MIP 5H | 7 | 3127 |
| | MIP 5H | 8 | 2909 |
| | MIP 5H | 9 | 2731 |
| | MIP 5H | 10 | 2522 |
| | MIP 5H | 11 | 2332 |
| | MIP 5H | 12 | 2156 |
| | MIP 5H | 13 | 1960 |
| | MIP 5H | 14 | 1777 |
| | MIP 5H | 15 | 1614 |
| | MIP 5H | 16 | 1433 |
| | MIP 5H | 17 | 1267 |
| | MIP 5H | 18 | 1138 |
| | MIP 5H | 19 | 997 |
| | MIP 5H | 20 | 879 |
| | MIP 5H | 21 | 811 |
| | MIP 5H | 22 | 791 |
| | MIP 5H | 23 | 807 |
| | MIP 5H | 24 | 872 |
| | MIP 5H | 25 | 983 |
| | MIP 5H | 26 | 1110 |
| | MIP 5H | 27 | 1256 |
| | MIP 5H | 28 | 1410 |
| | MIP 5H | 29 | 1553 |
| | MIP 5H | 30 | 1667 |

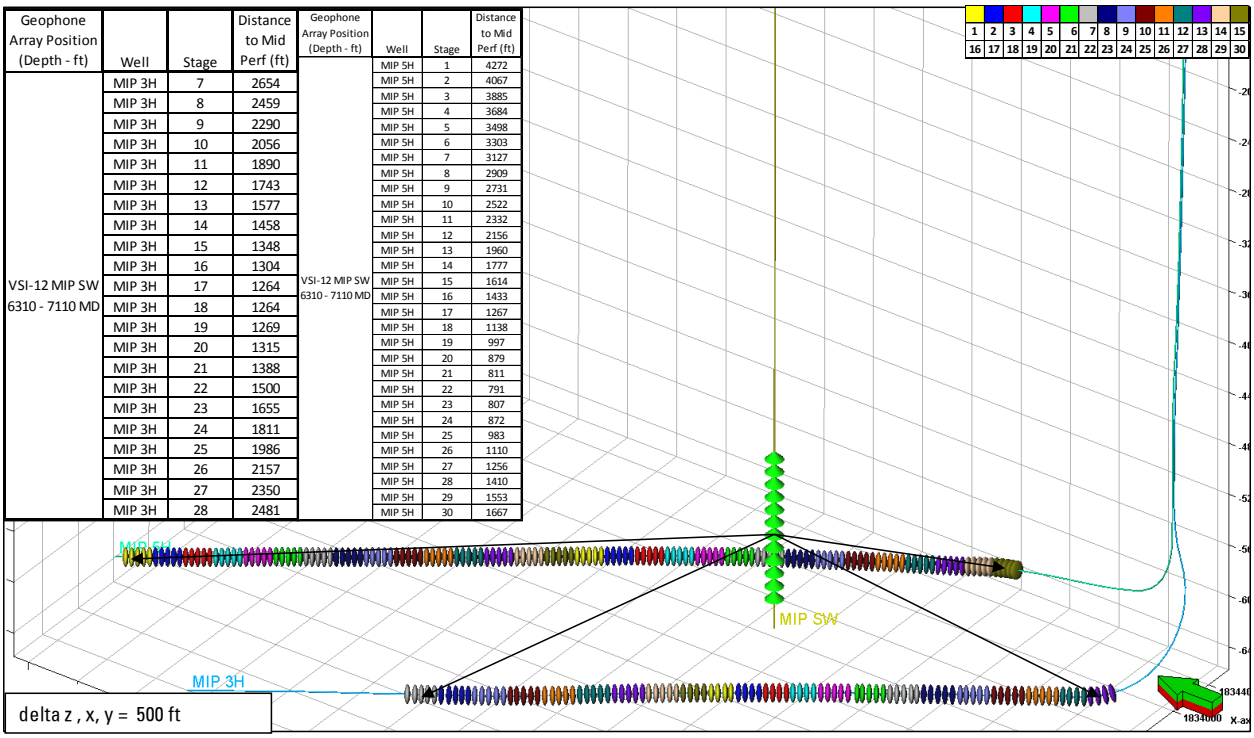



**Figure 2-1 - Location of the treatment and monitor wells**

## 2.4 Completion Design and Execution Summary

The designed stimulation stage intervals, total fluid volume, and total proppant for each stage are summarized in Table 2.3. The treatment execution data and a summary of the microseismic evaluation are shown in Table 2.4.

**Table 2.3 - Completion design summary**

| Stage | Bottom perf (MD) (ft) | Top perf (MD) (ft) | Clusters | Total fluid (1000_gal) | Total proppant (1000_lbm) | Desired rate (bbl/min) |
|---|---|---|---|---|---|---|
| MIP 3H Stage 7 | 12418 | 12239 | 1 | 346.7 | 440 | 90 |
| MIP 3H Stage 8 | 12194 | 12015 | 1 | 346.7 | 440 | 90 |
| MIP 3H Stage 9 | 11971 | 11782 | 1 | 346.7 | 440 | 90 |
| MIP 3H Stage 10 | 11735 | 11557 | 1 | 346.7 | 440 | 90 |
| MIP 3H Stage 11 | 11509 | 11324 | 1 | 346.7 | 440 | 90 |
| MIP 3H Stage 12 | 11277 | 11093 | 1 | 346.7 | 440 | 90 |
| MIP 3H Stage 13 | 11046 | 10863 | 1 | 369.1 | 440 | 90 |
| MIP 3H Stage 14 | 10822 | 10639 | 1 | 369.1 | 440 | 90 |
| MIP 3H Stage 15 | 10594 | 10456 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 16 | 10408 | 10278 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 17 | 10229 | 10092 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 18 | 10048 | 9912 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 19 | 9869 | 9732 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 20 | 9685 | 9504 | 1 | 425 | 440 | 90 |
| MIP 3H Stage 21 | 9445 | 9271 | 1 | 425 | 440 | 90 |
| MIP 3H Stage 22 | 9227 | 9051 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 23 | 9005 | 8814 | 1 | 311.8 | 360 | 72 |
| MIP 3H Stage 24 | 8763 | 8587 | 1 | 369.1 | 440 | 90 |
| MIP 3H Stage 25 | 8541 | 8356 | 1 | 369.1 | 440 | 90 |
| MIP 3H Stage 26 | 8310 | 8128 | 1 | 369.1 | 440 | 90 |
| MIP 3H Stage 27 | 8085 | 7944 | 1 | 369.1 | 440 | 90 |
| MIP 3H Stage 28 | 7901 | 7753 | 1 | 369.1 | 440 | 90 |
| MIP 5H Stage 1 | 14228 | 14186 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 2 | 14148 | 13988 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 3 | 13950 | 13790 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 4 | 13752 | 13592 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 5 | 13554 | 13394 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 6 | 13356 | 13196 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 7 | 13158 | 12998 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 8 | 12960 | 12800 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 9 | 12762 | 12602 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 10 | 12564 | 12404 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 11 | 12366 | 12206 | 1 | 247.8 | 400 | 80 |

| | | | | | | |
|---|---|---|---|---|---|---|
| MIP 5H Stage 12 | 12168 | 12008 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 13 | 11970 | 11810 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 14 | 11772 | 11612 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 15 | 11574 | 11414 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 16 | 11376 | 11216 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 17 | 11178 | 11018 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 18 | 10980 | 10820 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 19 | 10782 | 10622 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 20 | 10584 | 10424 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 21 | 10386 | 10226 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 22 | 10188 | 10028 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 23 | 9990 | 9830 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 24 | 9792 | 9632 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 25 | 9594 | 9434 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 26 | 9396 | 9236 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 27 | 9198 | 9038 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 28 | 9000 | 8840 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 29 | 8802 | 8642 | 1 | 247.8 | 400 | 80 |
| MIP 5H Stage 30 | 8604 | 8444 | 1 | 247.8 | 400 | 80 |

**Table 2.4 - Stimulation execution summary with microseismic evaluation results**

| Stage | Total fluid (1000_gal) | Total proppant (1000_lbm) | Average rate (bbl/min) | Average pressure (psi) | ISIP (psi) | Total MS length (ft) | Total MS height (ft) | MS volume (million ft3) | Fracture azimuth (deg) |
|---|---|---|---|---|---|---|---|---|---|
| MIP 3H Stage 7 | 386.9 | 440.9 | 87.1 | 8328 | 5867 | 1387 | 512 | 5.9 | 42 |
| MIP 3H Stage 8 | 368.5 | 440.5 | 95 | 8951 | 5992 | 1097 | 387 | 3.3 | 91 |
| MIP 3H Stage 9 | 365.3 | 441 | 98.6 | 8991 | 6210 | 1156 | 545 | 6 | 66 |
| MIP 3H Stage 10 | 353.1 | 440 | 100 | 8253 | 6241 | 1250 | 335 | 6.7 | 78 |
| MIP 3H Stage 11 | 338.2 | 440.5 | 99.9 | 8135 | 6022 | 1233 | 378 | 8.6 | 57 |
| MIP 3H Stage 12 | 377.3 | 440.7 | 99.2 | 8201 | 5898 | 1453 | 480 | 19.3 | 74 |
| MIP 3H Stage 13 | 313.6 | 360.3 | 95.1 | 8696 | 6015 | 1924 | 516 | 4.8 | 80 |
| MIP 3H Stage 14 | 369.4 | 437.1 | 98.3 | 8694 | 5867 | 1227 | 500 | 6.7 | 88 |
| MIP 3H Stage 15 | 344.7 | 360 | 79.9 | 8131 | 5681 | 1510 | 723 | 6.8 | 78 |
| MIP 3H Stage 16 | 257.8 | 188.5 | 77.8 | 8573 | 5961 | 1575 | 711 | 4.1 | 76 |
| MIP 3H Stage 17 | 293.2 | 351.1 | 79.4 | 8114 | 0 | 1189 | 658 | 2.2 | 70 |
| MIP 3H Stage 18 | 290 | 291.9 | 92.4 | 8561 | 6427 | 1496 | 516 | 7.9 | 70 |
| MIP 3H Stage 19 | 327.9 | 360.7 | 98.8 | 8588 | 5992 | 1552 | 507 | 7.9 | 80 |
| MIP 3H Stage 20 | 314.8 | 439.3 | 96.7 | 8270 | 5867 | 1472 | 395 | 6.2 | 95 |
| MIP 3H Stage 21 | 305.7 | 440.6 | 94.6 | 8365 | 5898 | 1508 | 534 | 2.5 | 95 |
| MIP 3H Stage 22 | 452.7 | 437.7 | 93.3 | 8089 | 6022 | 1576 | 492 | 6.9 | 71 |
| MIP 3H Stage 23 | 363.2 | 436.1 | 99.8 | 8418 | 6223 | 1602 | 516 | 7.2 | 77 |
| MIP 3H Stage 24 | 347.2 | 440.3 | 98.8 | 8562 | 6333 | 2403 | 410 | 3.1 | 83 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIP 3H Stage 25 | 338.7 | 442.7 | 98.7 | 8560 | 6459 | 1679 | 419 | 2.4 | 67 |
| MIP 3H Stage 26 | 304.1 | 440.1 | 99.7 | 8472 | 6205 | 2055 | 478 | 1.9 | 82 |
| MIP 3H Stage 27 | 274.6 | 453.3 | 93.4 | 8469 | 6335 | 1662 | 482 | 2.9 | 83 |
| MIP 3H Stage 28 | 309.8 | 366 | 94.1 | 8324 | 6335 | 1372 | 1059 | 2 | 78 |
| MIP 5H Stage 1 | 267.6 | 328.9 | 69.8 | 8305 | 0 | N/A | N/A | N/A | N/A |
| MIP 5H Stage 2 | 290.4 | 329 | 68.5 | 8619 | 5965 | 1003 | 1101 | 7.9 | 33 |
| MIP 5H Stage 3 | 234.8 | 265.6 | 81.8 | 8827 | 5885 | N/A | N/A | N/A | N/A |
| MIP 5H Stage 4 | 220.6 | 260.5 | 77.4 | 8735 | 0 | N/A | N/A | N/A | N/A |
| MIP 5H Stage 5 | 257.8 | 272.3 | 75.1 | 8111 | 5278 | 180 | 213 | N/A | 70 |
| MIP 5H Stage 6 | 326.3 | 267.4 | 87.5 | 8691 | 5817 | 1042 | 564 | N/A | 79 |
| MIP 5H Stage 7 | 358.6 | 401.5 | 78.8 | 8330 | 6041 | 1091 | 538 | N/A | 83 |
| MIP 5H Stage 8 | 323.4 | 400.2 | 81.2 | 8455 | 6156 | 1137 | 655 | 2.9 | 71 |
| MIP 5H Stage 9 | 317.4 | 398.6 | 84.7 | 8217 | 5312 | 790 | 743 | N/A | 61 |
| MIP 5H Stage 10 | 324.5 | 398.9 | 91.2 | 8644 | 5401 | 1565 | 957 | 2.6 | 75 |
| MIP 5H Stage 11 | 315.6 | 358.2 | 83.7 | 8566 | 5408 | 1204 | 727 | 5.9 | 71 |
| MIP 5H Stage 12 | 332.4 | 403.4 | 85.9 | 8747 | 0 | 1147 | 678 | 4.7 | 86 |
| MIP 5H Stage 13 | 372.2 | 394.6 | 92.8 | 8672 | 5898 | 1447 | 1059 | 9.1 | 59 |
| MIP 5H Stage 14 | 325.7 | 400.1 | 92.7 | 8702 | 5820 | 1488 | 955 | 8.5 | 60 |
| MIP 5H Stage 15 | 322.3 | 403.2 | 93.7 | 8648 | 5403 | 1660 | 895 | 2.5 | 59 |
| MIP 5H Stage 16 | 306.1 | 347.1 | 89.6 | 8861 | 5983 | 1354 | 812 | 6 | 61 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MIP 5H Stage 17 | 328.5 | 400.5 | 90 | 8927 | 6465 | 1155 | 695 | 4.8 | 57 |
| MIP 5H Stage 18 | 323 | 397.2 | 88.7 | 8892 | 6814 | 1210 | 639 | 3.7 | 70 |
| MIP 5H Stage 19 | 325.7 | 400.5 | 93.9 | 8782 | 6219 | 1198 | 831 | 5.7 | 69 |
| MIP 5H Stage 20 | 313.5 | 378.6 | 94.4 | 8613 | 5535 | 1755 | 1124 | 1.6 | 60 |
| MIP 5H Stage 21 | 322.8 | 442.6 | 99.5 | 8773 | 6145 | 1516 | 823 | 2.5 | 53 |
| MIP 5H Stage 22 | 327.3 | 401.8 | 94.7 | 8718 | 5788 | 1419 | 965 | 1.9 | 54 |
| MIP 5H Stage 23 | 242.8 | 290.9 | 92.8 | 8900 | 6907 | 1294 | 888 | 3.9 | 53 |
| MIP 5H Stage 24 | 305 | 334.6 | 97.7 | 8797 | 6697 | 1186 | 439 | 1.1 | 64 |
| MIP 5H Stage 25 | 316.5 | 358.3 | 97.6 | 8609 | 5596 | 1121 | 841 | 2.1 | 57 |
| MIP 5H Stage 26 | 340 | 402.1 | 96.9 | 8577 | 6323 | 1349 | 1022 | 1.2 | 81 |
| MIP 5H Stage 27 | 336.6 | 398.8 | 93.9 | 8829 | 6250 | 1415 | 856 | 0.2 | 70 |
| MIP 5H Stage 28 | 351.3 | 394.8 | 91.2 | 8899 | 6358 | 1192 | 473 | 2.5 | 30 |
| MIP 5H Stage 29 | 337.2 | 399.7 | 99.6 | 8229 | 6513 | 773 | 662 | 4.1 | 48 |
| MIP 5H Stage 30 | 342 | 400.6 | 99.2 | 8368 | 6482 | 1334 | 567 | 6.2 | 70 |

### 2.5 Microseismic Events Summary

Summaries of the microseismic events are shown in map view in Figure 2-2 and in depth view in Figure 2-3.

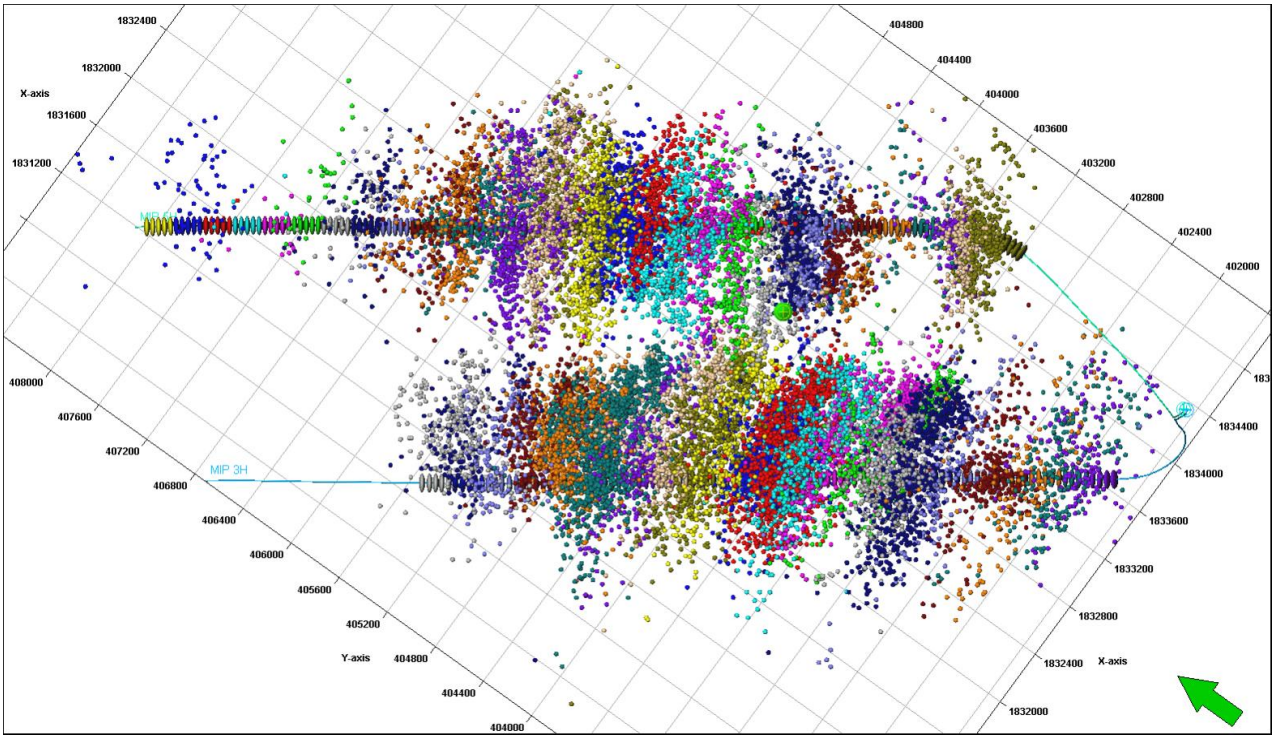



**Figure 2-2 - Map view of microseismic events**

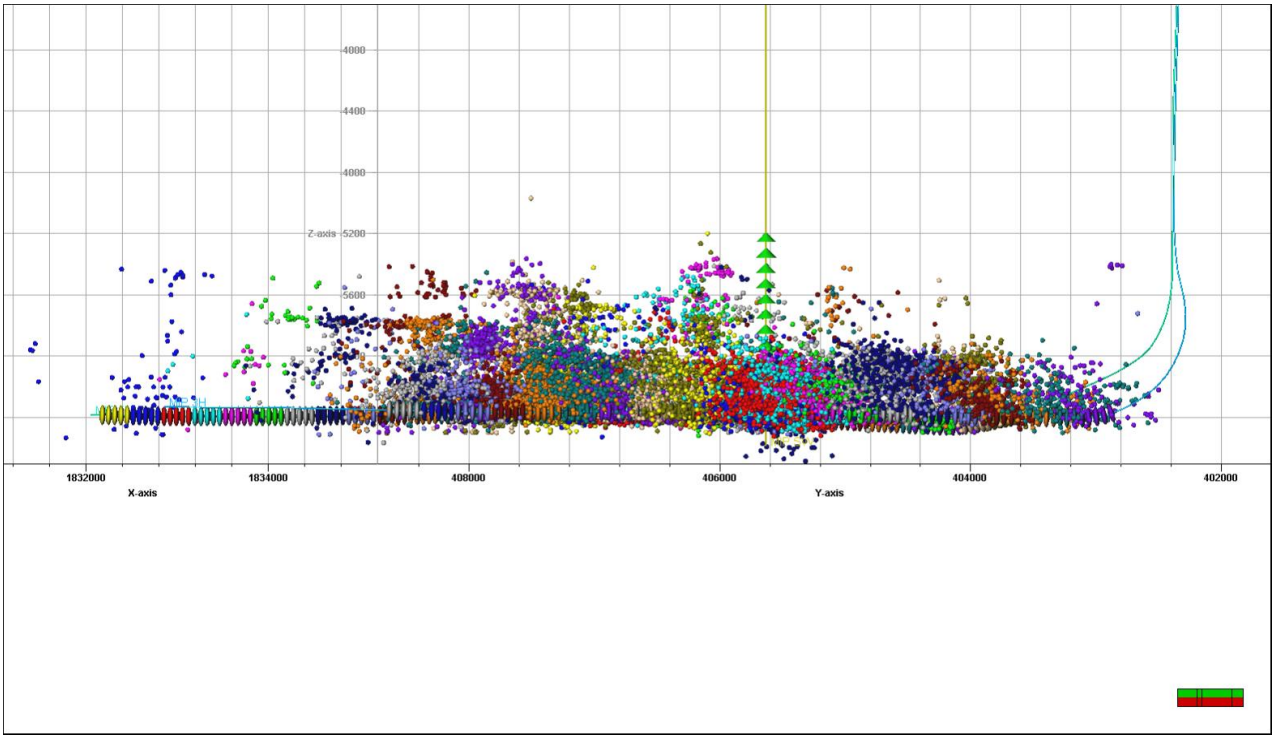



**Figure 2-3 - Side view of microseismic events**

# 3. Evaluation

## 3.1 Evaluation for treatment well: MIP 3H

### 3.1.1 Magnitude versus Distance

The magnitude versus distance plot is used for both quality assurance and for evaluation. The detection threshold is the minimum magnitude necessary to locate a microseismic event at a given distance. A consistent detection threshold indicates that the microseismic event location acquisition and processing has been consistent. Changes in the detection threshold might be caused by environmental conditions such as background noise or changing reservoir properties. Anomalies are reviewed prior to conducting the interpretation.

The magnitude versus distance plot for all monitored completion stages is shown below in Figure 3-1.

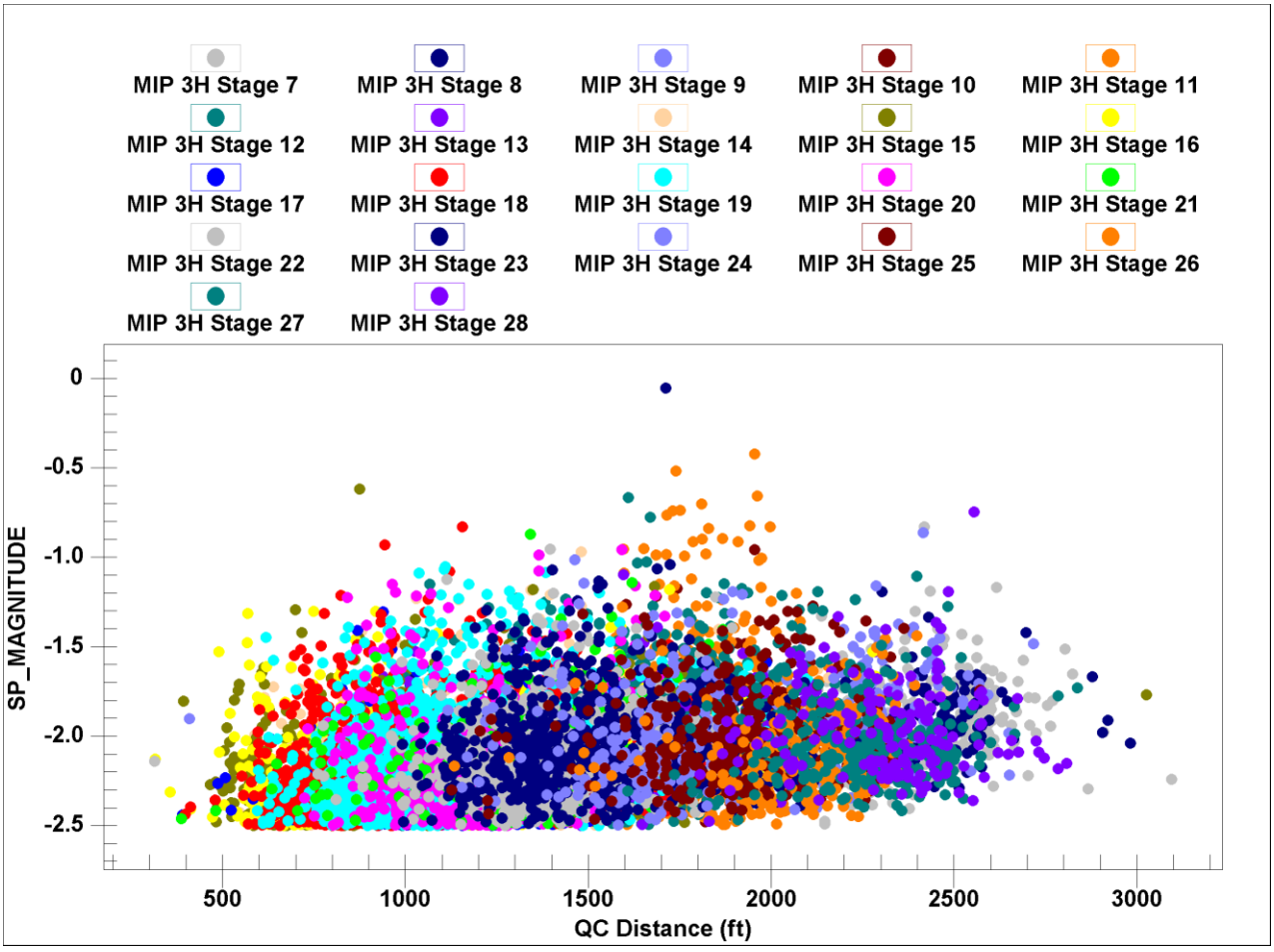



**Figure 3-1 - Magnitude versus distance plot**

### 3.1.2 Geologic Context of Events

Figure 3-2 shows the location of the microseismic events in relation to the formation tops and/or surfaces.

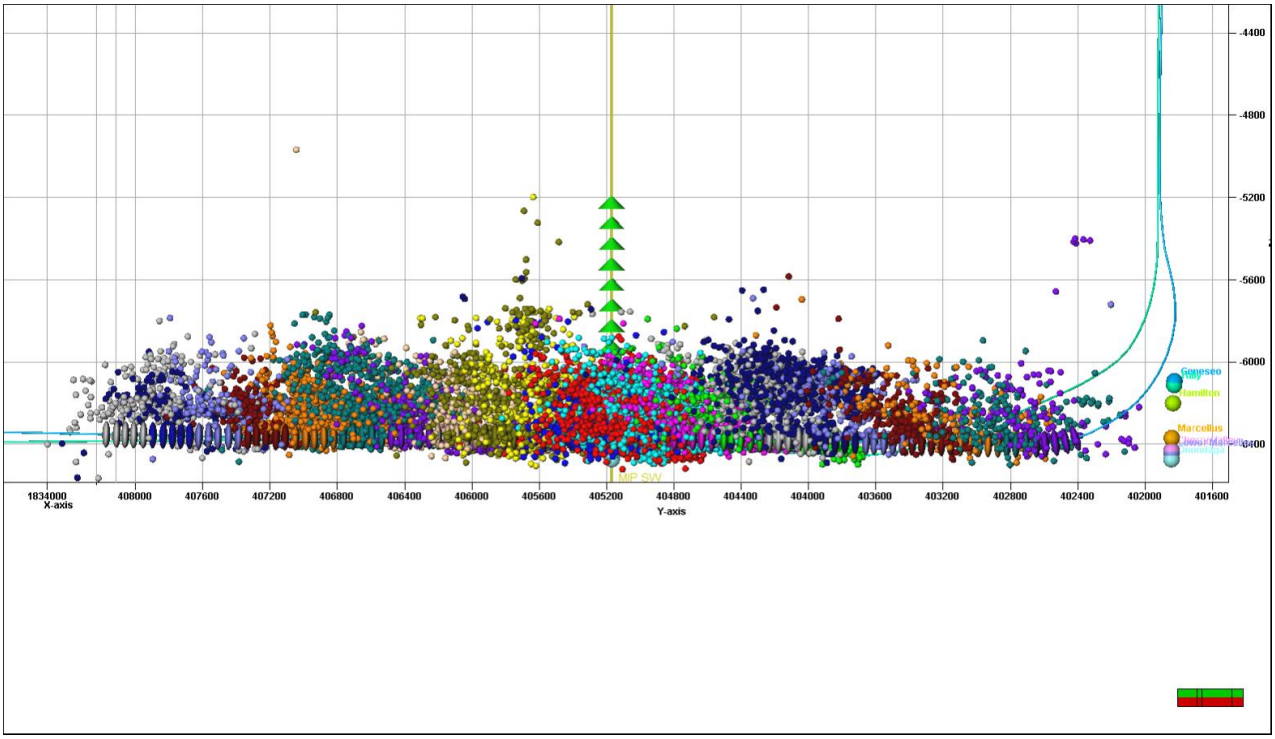



**Figure 3-2 - Geologic context of microseismic events**

### 3.1.3 Microseismic Geometry (Length, Height, and Azimuth) and Microseismic Volume

The microseismic dimensions and azimuth are calculated for each stimulation stage. Length and azimuth are based on the longest horizontal dimension within the event cloud. Height and width are oriented with respect to the length. The microseismic volume for each stage is based on a microseismic event density calculation. The same evaluation parameters are used for all the microseismic dimensions and volume calculations.

The microseismic lengths and azimuths for each treatment stage are shown in Figure 3-3. Figure 3-4 is a side view showing the fracture heights relative to the wellbore. Figure 3-5 and Figure 3-6 show the microseismic volume visual projections in map and depth view.

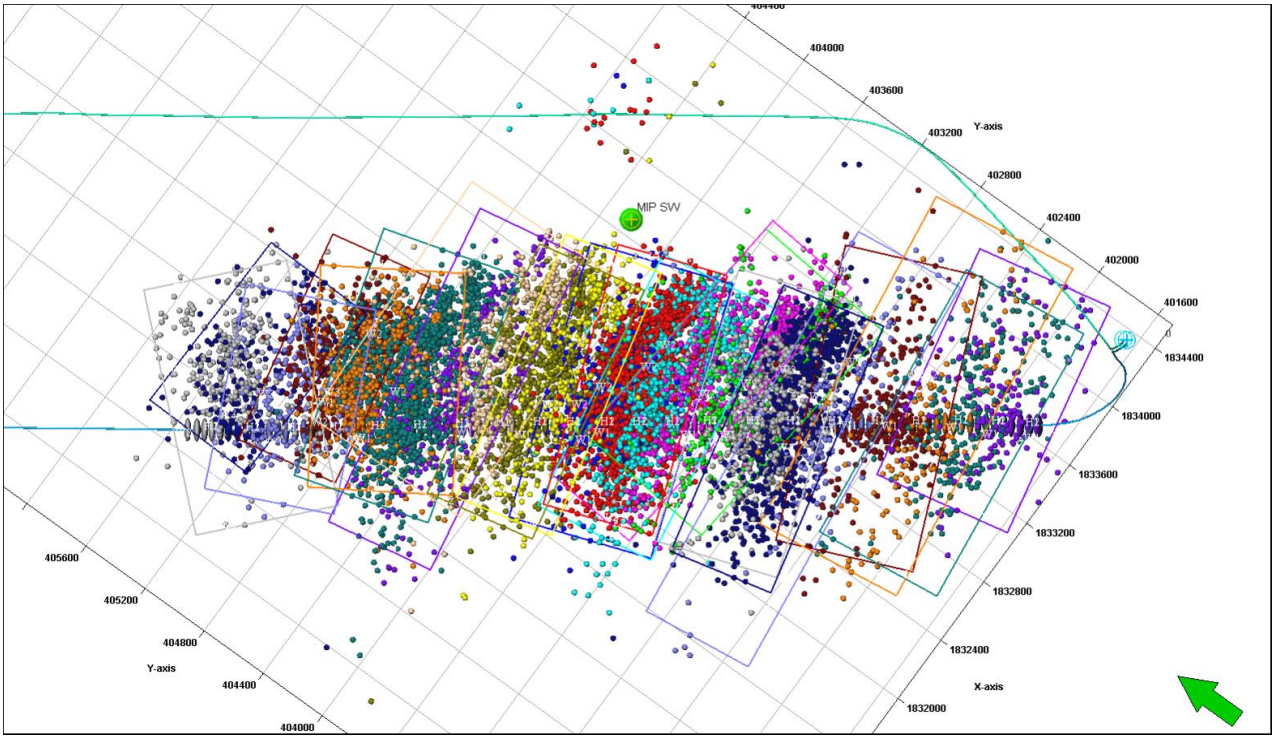



**Figure 3-3 - Map view of MIP 3H showing the microseismic fracture dimensions and azimuths**

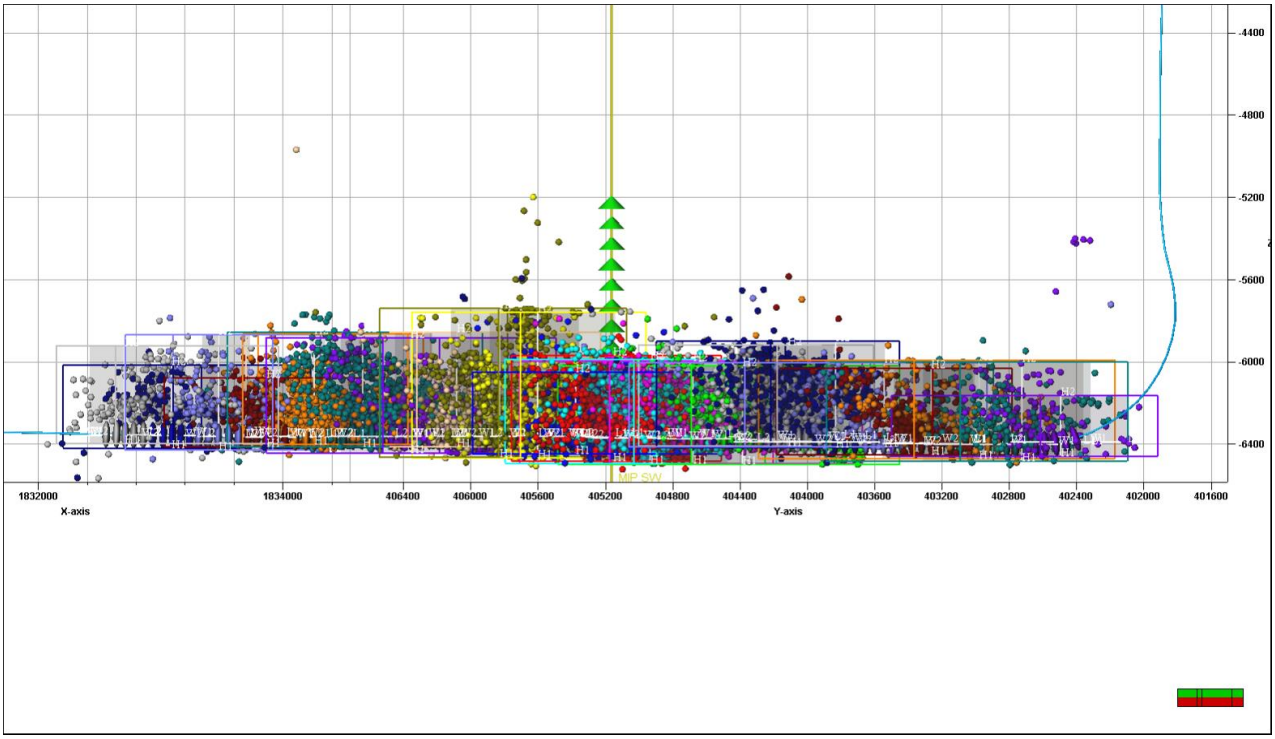



**Figure 3-4 - Side view of MIP 3H showing fracture heights**

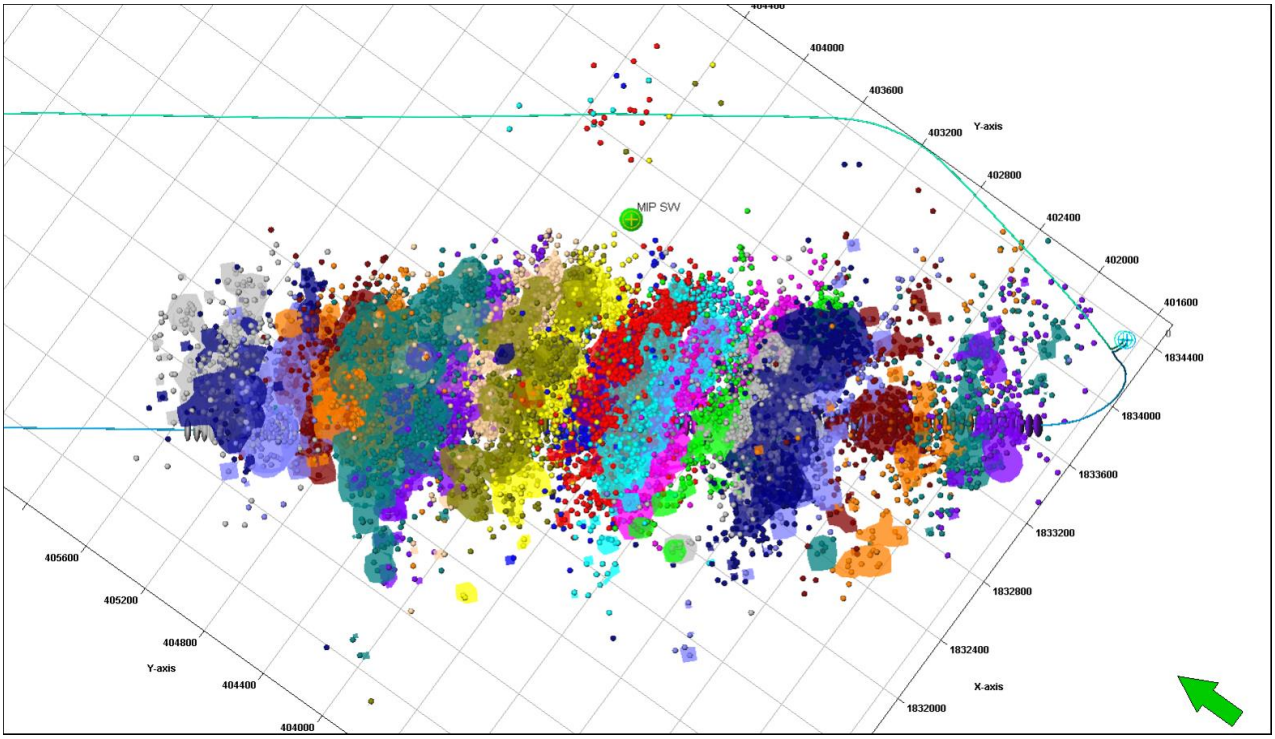



**Figure 3-5 - Map view of MIP 3H showing microseismic volume**

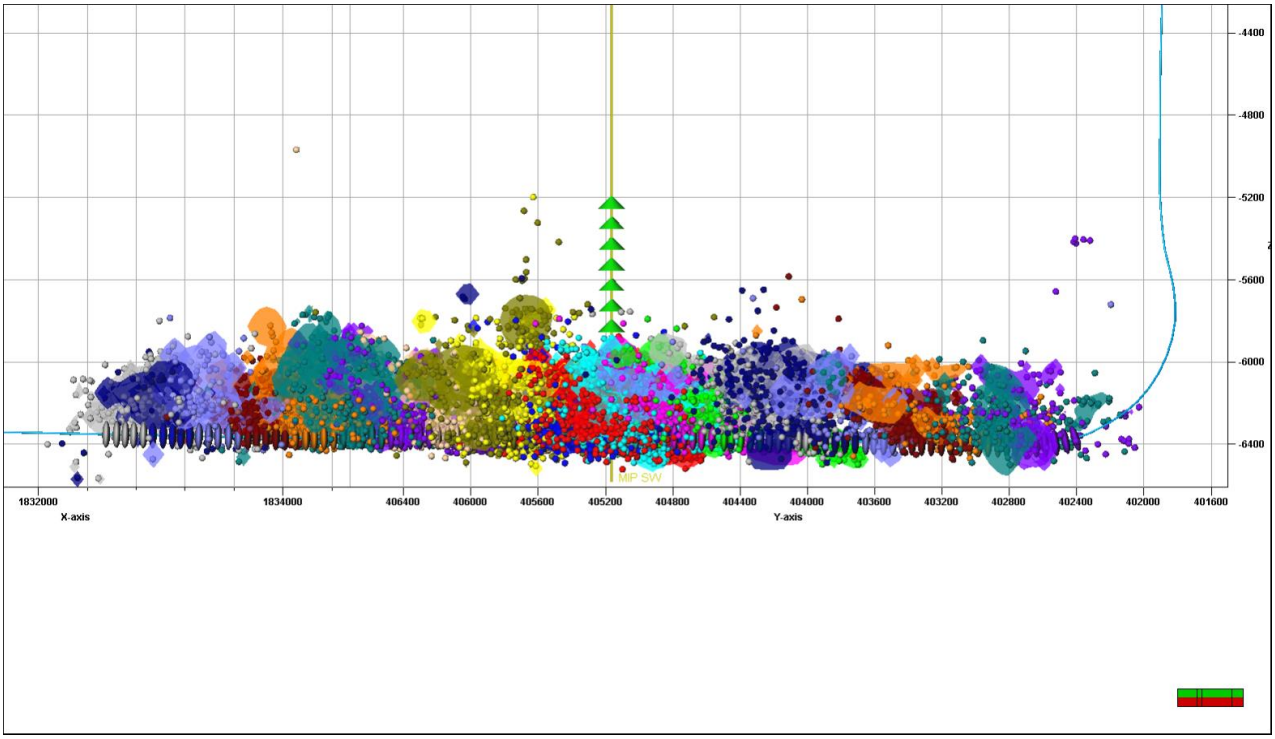



**Figure 3-6 - Side view of MIP 3H showing microseismic volume**

### 3.1.4 Location Uncertainty

All location estimates have an associated uncertainty due to a variety of factors, including uncertainties in time picks, wellbore location, velocity model, and a variety of other factors. During processing this uncertainty is estimated for each event. The uncertainty can be represented as the ellipsoid in space whose major axis represents the magnitude of the estimated maximum uncertainty for an event location. The major axis orientation indicates the direction that uncertainty applies.

Figure 3-7 shows a map view of all events located during this project, along with their associated uncertainty ellipsoids. Figure 3-8 shows the events and their uncertainty ellipsoids in a side view.

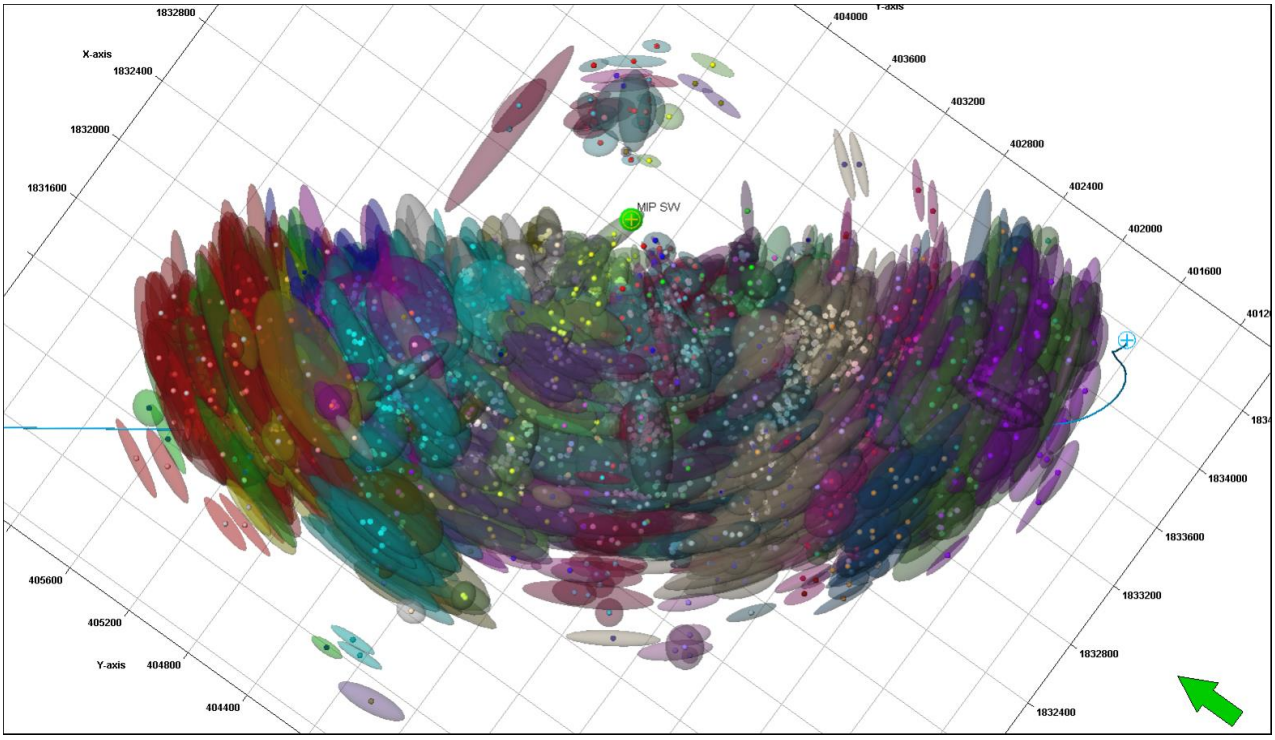



**Figure 3-7 - Event location uncertainty ellipsoids – map view**

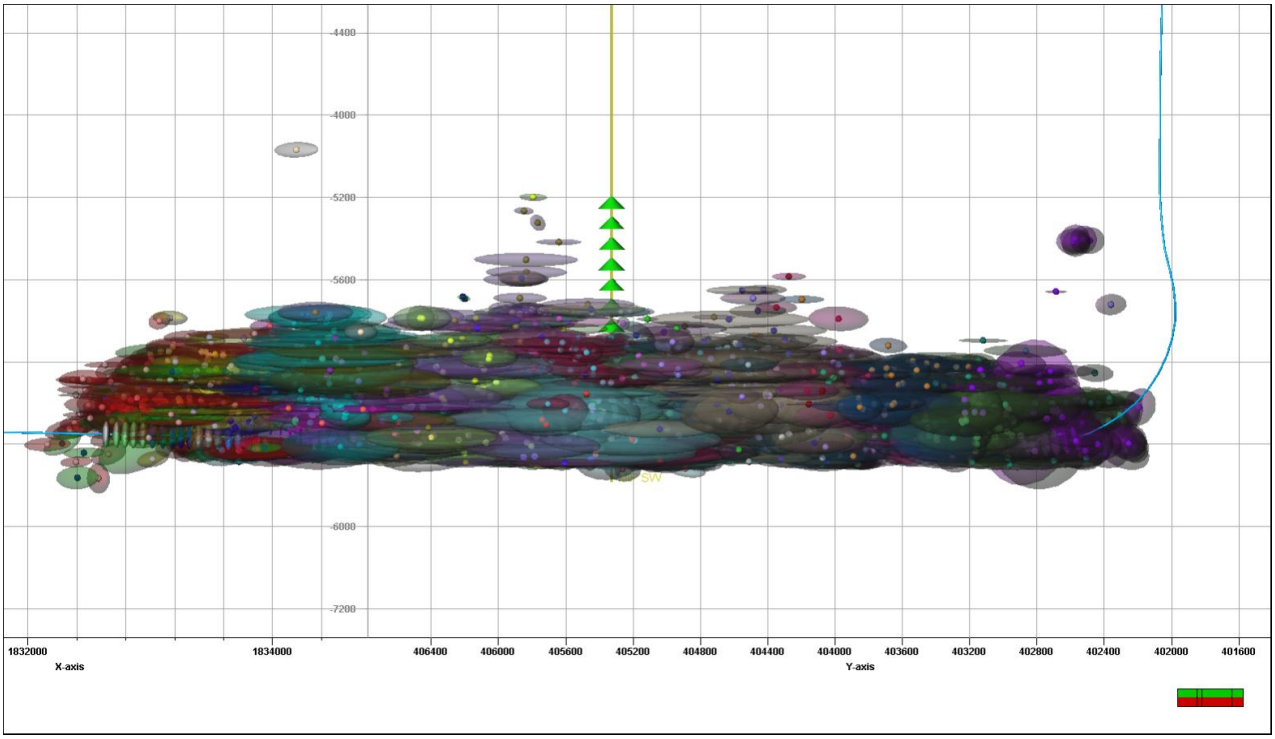



**Figure 3-8 - Event location uncertainty ellipsoids – side view**

### 3.1.5 Observations, Results, and Conclusions

The key points for MIP 3H microseismic interpretation are summarized below:

- MIP 3H and 5H comparisons are done in the next section.
- MIP 3H Average Half Length: 784ft, Average Height: 496ft, Average Azimuths N76°E.
- Overall fracture geometries do not vary significantly based on microseismic. A detailed comparison of the multiple fluid systems are compared in a subsequent section.
- Event count was higher in MIP 3H as expected. The MIP 5H was the first well in the pad to receive a hydraulic treatment. This caused an altered stress region in the pad. Altered stress regions caused by previous fracturing jobs or depletion are known to cause increased microseismic activity.

Treatment Execution

A total of four pump schedules and 2 cluster spacing were used during the execution of MIP 3H in several completion scenarios. Table 3-1,

Table 3-2 and Figure 3-9 summarize the pumping schedules and completion plans.

**Table 3-1 – Pump Schedules for MIP 3H**

| Section | | Stage | Pump Schedule |
|---|---|---|---|
| A | NNE Standard 35% 100-Mesh | 1 – 6 | A – NNE 440K 35% 100-Mesh |
| B | NNE 75% 100-Mesh | 7 – 12 | B – NNE 440K 75% 100-Mesh |
| C | Perforation Design | 13 – 14 | A – NNE 440K 35% 100-Mesh |
| | | 15 – 19 | C – NNE 360K 35% 100-Mesh |
| D | Sapphire VEF | 20 – 21 | D – SLB VEF 440K 35% 100-Mesh |
| E | Best Practices | 22 – 23 | C – NNE 360K 35% 100-Mesh |
| | | 24 – 28 | A – NNE 440K 35% 100-Mesh |

**Table 3-2 - Completions for MIP 3H**

| Section | | Stage | Pump Schedule | Clusters | Shot Density |
|---|---|---|---|---|---|
| A | NNE Standard 35% 100-Mesh | 1 – 6 | A | 5 | 10 |
| B | NNE 75% 100-Mesh | 7 – 12 | B | 5 | 10 |
| C | Perforation Design | 13 – 14 | A | 5 | 6 |
| | | 15 – 16 | C | 4 | 6 |
| | | 17 – 19 | C | 4 | 8 |
| D | Sapphire VEF | 20 – 21 | D | 5 | 10 |
| E | Best Practices | 22 – 23 | C | 4 | 10 |
| | | 24 – 28 | A | 5 | 8 |

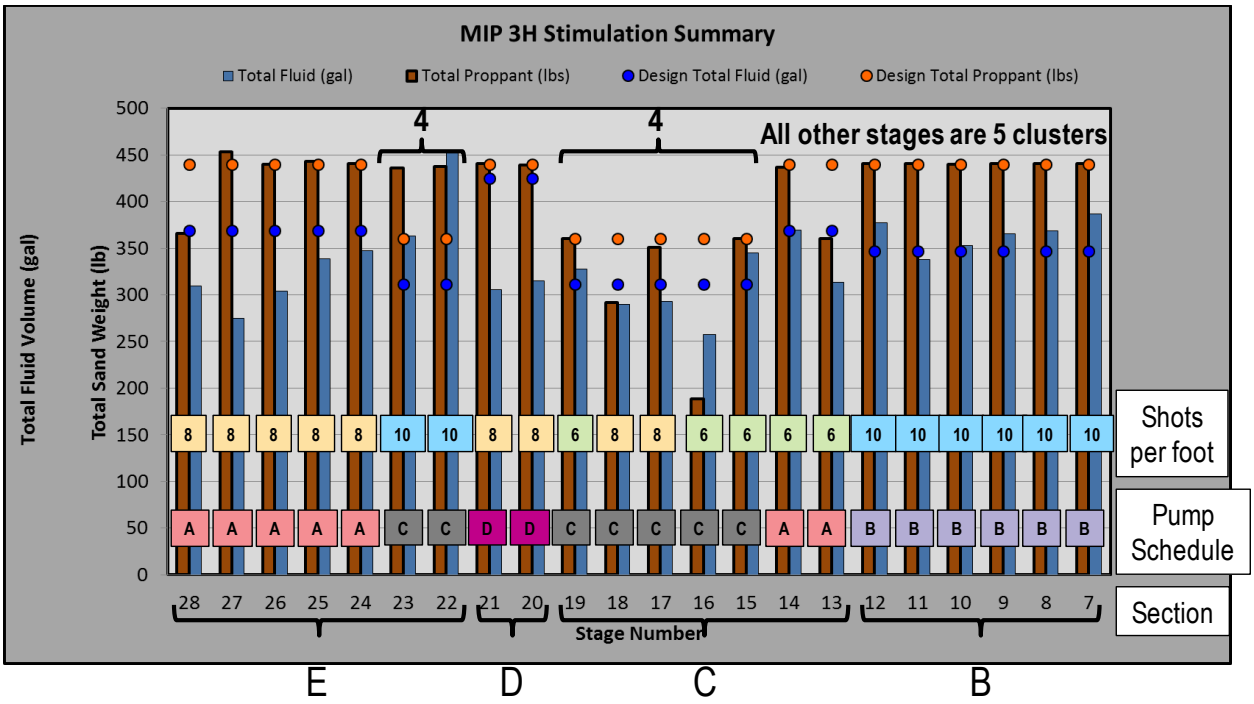



**Figure 3-9 – MIP 3H Stimulation Summary**

- The following stages deviated by more than 10% from the design: Stage 1, 7, 15, 20, 21, 22 and 23.
- The following stages deviated by more than -10% from the design: Stage 2, 5, 13, 16, 18, 26, 27 and 28.
- Screen outs or pressure outs occurred in the following stages: Stage 1, 2, 3, 5, 15, 16, 17, 18 and 22.
- Stage 22 had an extended shut down period caused by issues with the POD. The field crew eventually had to switch out the POD and restart the stage.

Completion Integrity Indication

- Based on visual inspection of the mapped microseismic events, all stages appear to have been successfully isolated, i.e., the fracture stages/treatments appear to have entered the formation via the planned perforation interval.
- It is important to note that some of the stages appeared to overlap with previous stages, although this could be attributed to the monitoring distance.

Offset Well Interference

- Based on visual inspection of the mapped microseismic events, a few isolated events of the fracture stages/treatments from the wells (laterals) in this project appear to have made contact with the region- fractured/stimulated from other wells (laterals) in the project.

- Based on visual inspection of the mapped microseismic events, none of the treatments from the wells (laterals) in this project appear to have made contact with offset wells located near the treatment well(s).

Geohazard Avoidance

- No known geohazards were identified prior to the job

## 3.2 Evaluation for treatment well: MIP 5H

### 3.2.1 Magnitude versus Distance

The magnitude versus distance plot is used for both quality assurance and for evaluation. The detection threshold is the minimum magnitude necessary to locate a microseismic event at a given distance. A consistent detection threshold indicates that the microseismic event location acquisition and processing has been consistent. Changes in the detection threshold might be caused by environmental conditions such as background noise or changing reservoir properties. Anomalies are reviewed prior to conducting the interpretation.

The magnitude versus distance plot for all monitored completion stages is shown below in Figure 3-10.

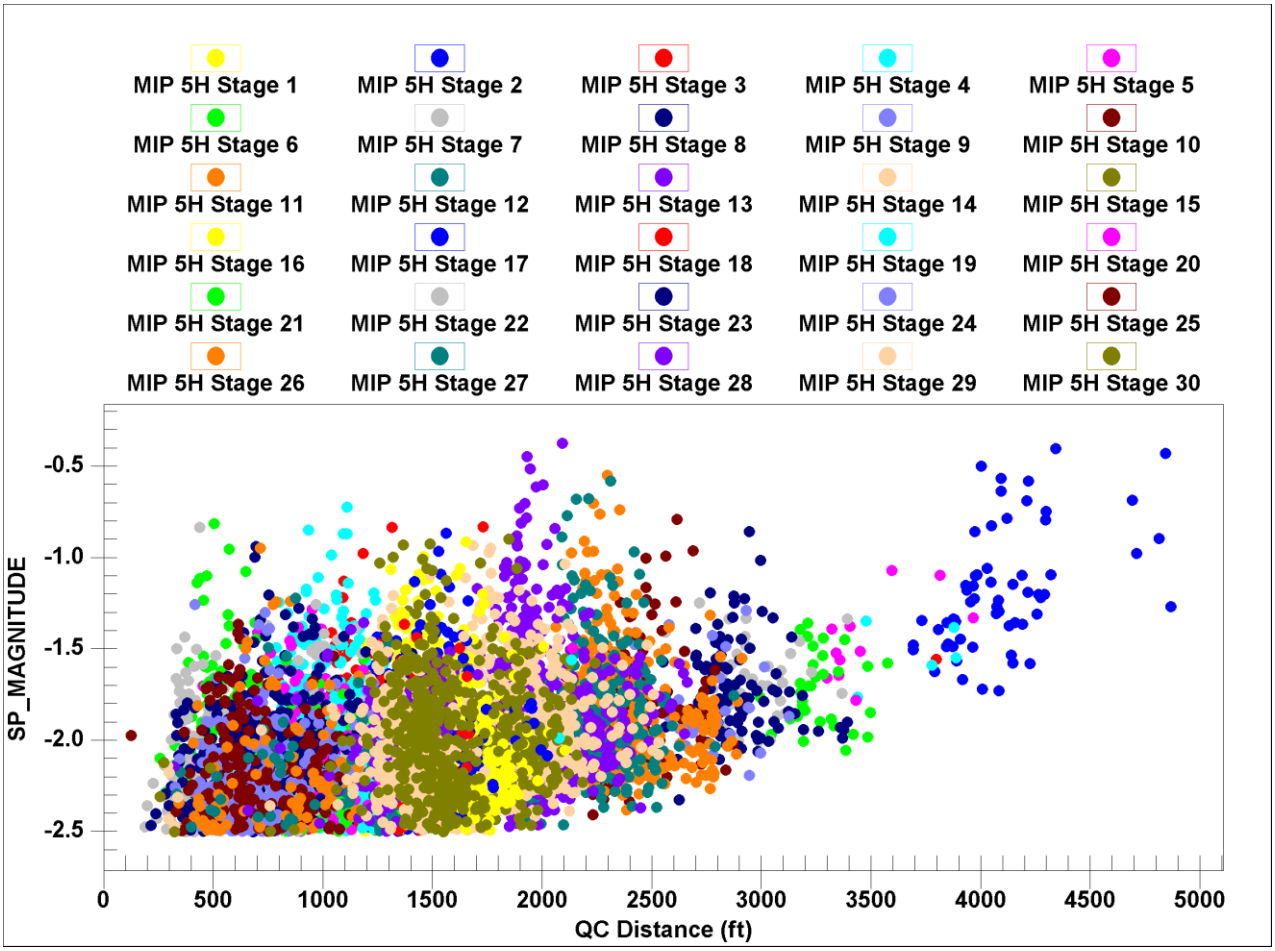



**Figure 3-10 - Magnitude versus distance plot**

### 3.2.2 Geologic Context of Events

Figure 3-11 shows the location of the microseismic events in relation to the formation tops and/or surfaces.

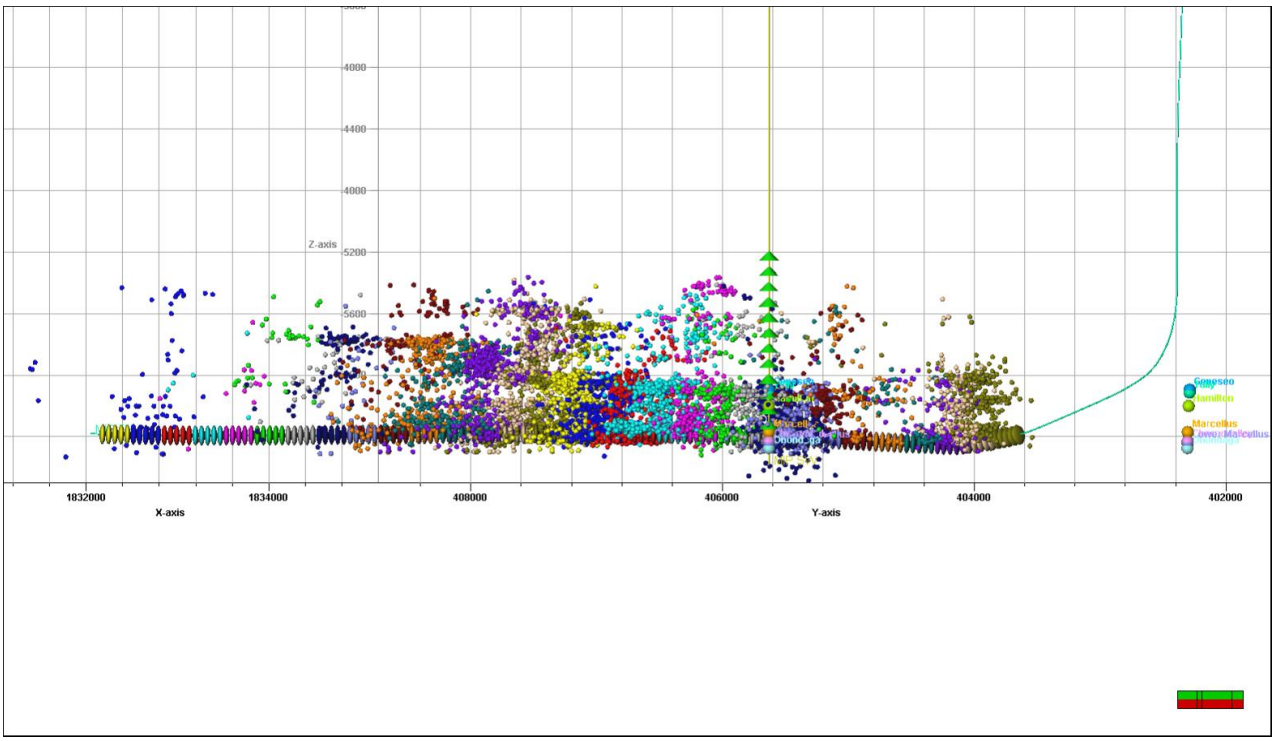



**Figure 3-11 - Geologic context of microseismic events**

### 3.2.3 Microseismic Geometry (Length, Height, and Azimuth) and Microseismic Volume

The microseismic dimensions and azimuth are calculated for each stimulation stage. Length and azimuth are based on the longest horizontal dimension within the event cloud. Height and width are oriented with respect to the length. The microseismic volume for each stage is based on a microseismic event density calculation. The same evaluation parameters are used for all the microseismic dimensions and volume calculations.

The microseismic lengths and azimuths for each treatment stage are shown in Figure 3-12. Figure 3-13 is a side view showing the fracture heights relative to the wellbore. Figure 3-14 and Figure 3-15 show the microseismic volume visual projections in map and depth view.

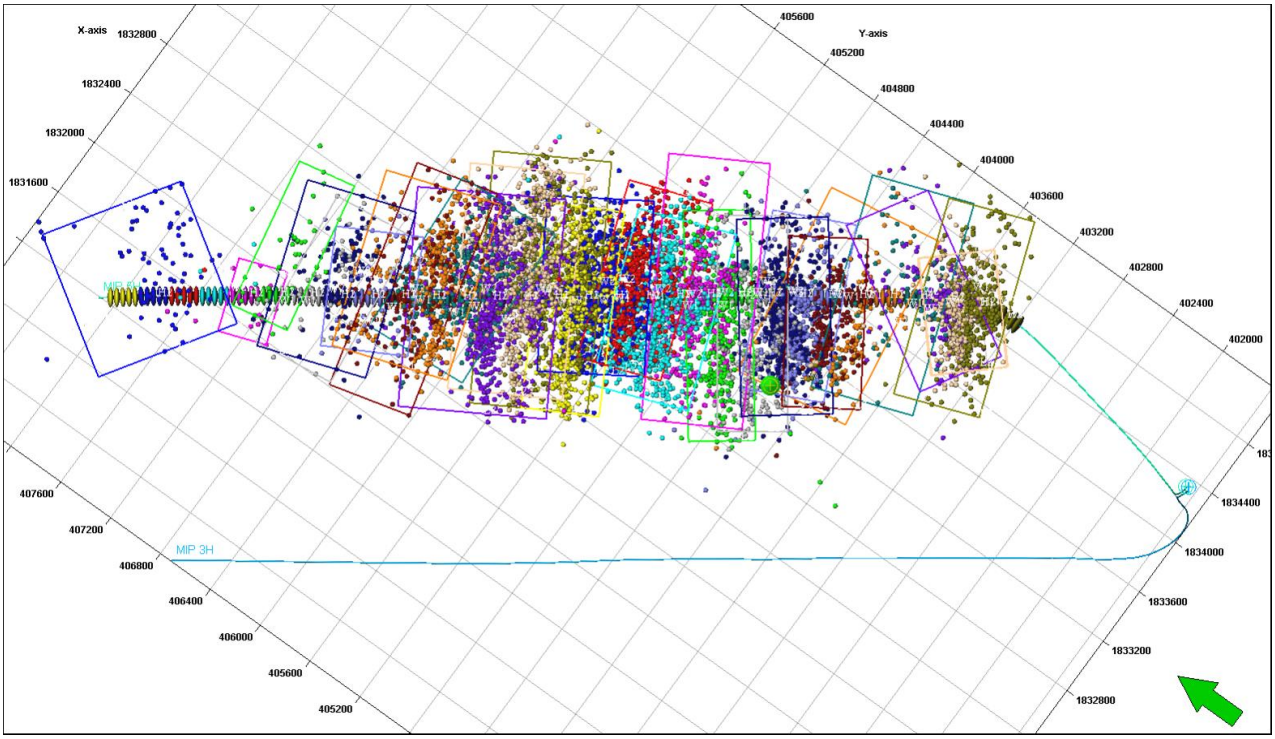



**Figure 3-12 - Map view of MIP 5H showing the microseismic fracture dimensions and azimuths**

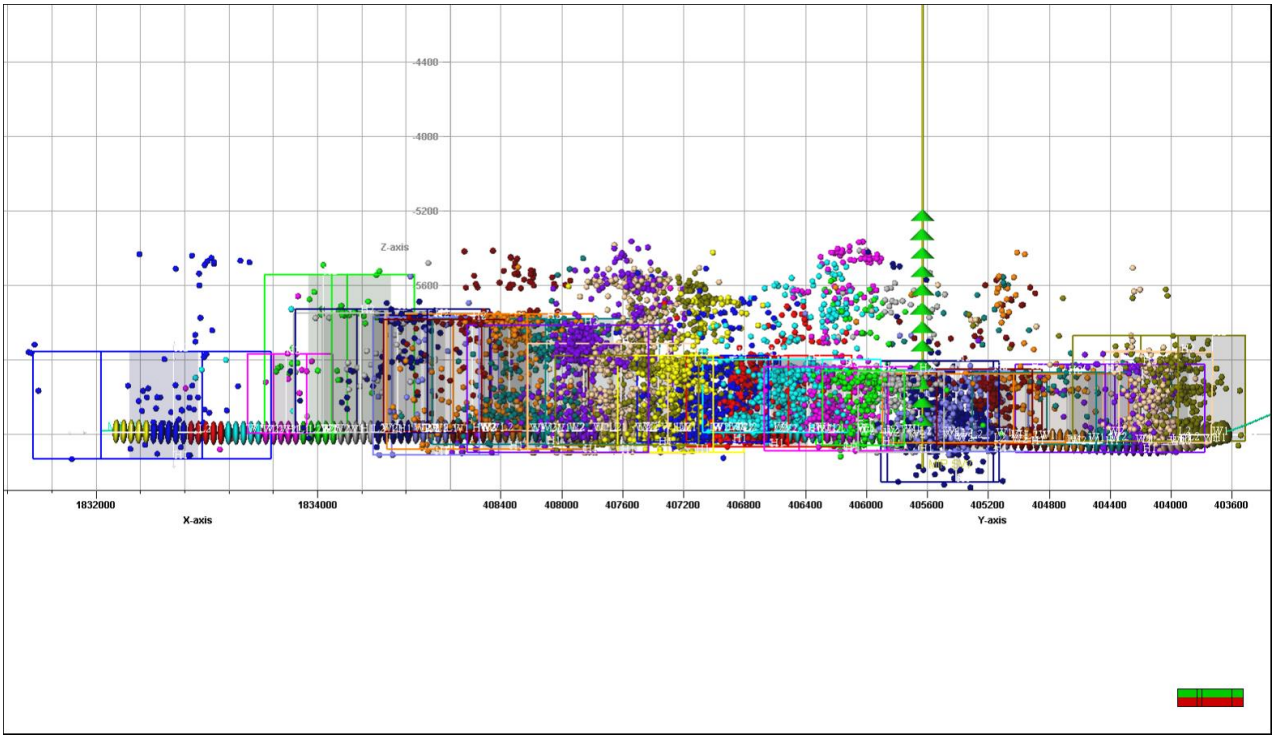



**Figure 3-13 - Side view of MIP 5H showing fracture heights**

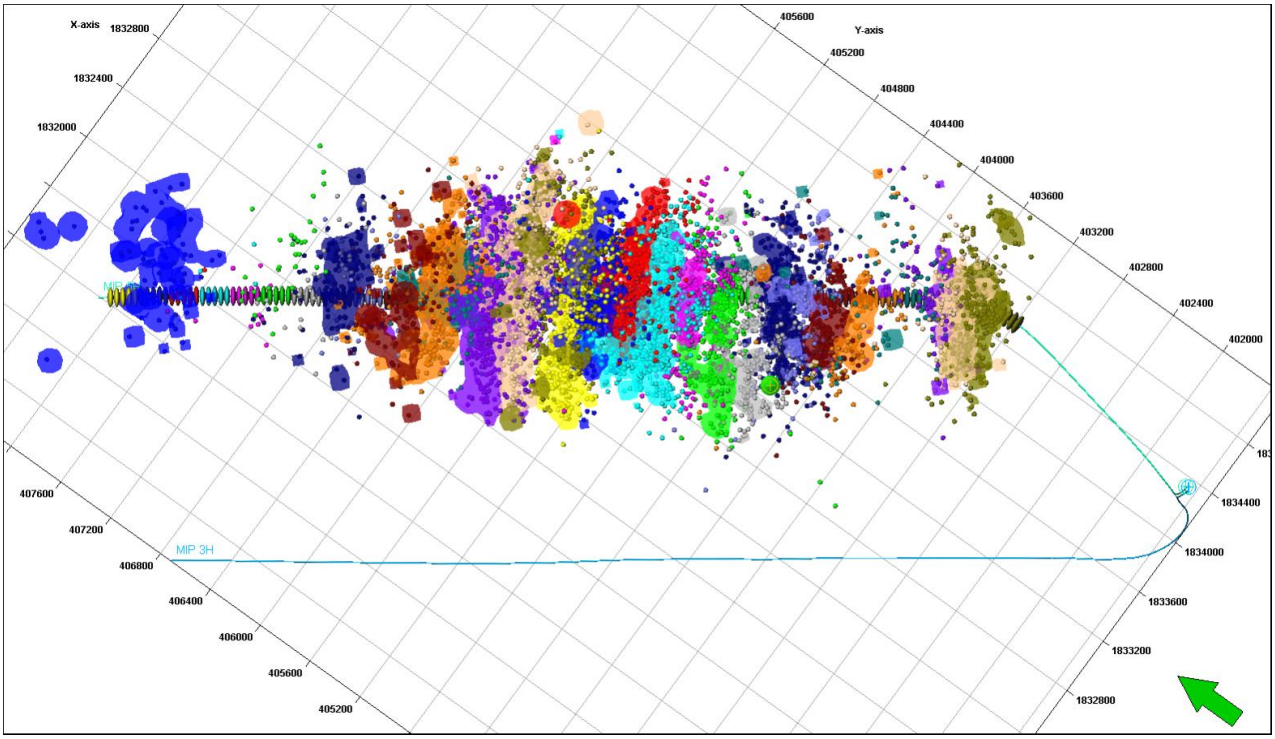



**Figure 3-14 - Map view of MIP 5H showing microseismic volume**

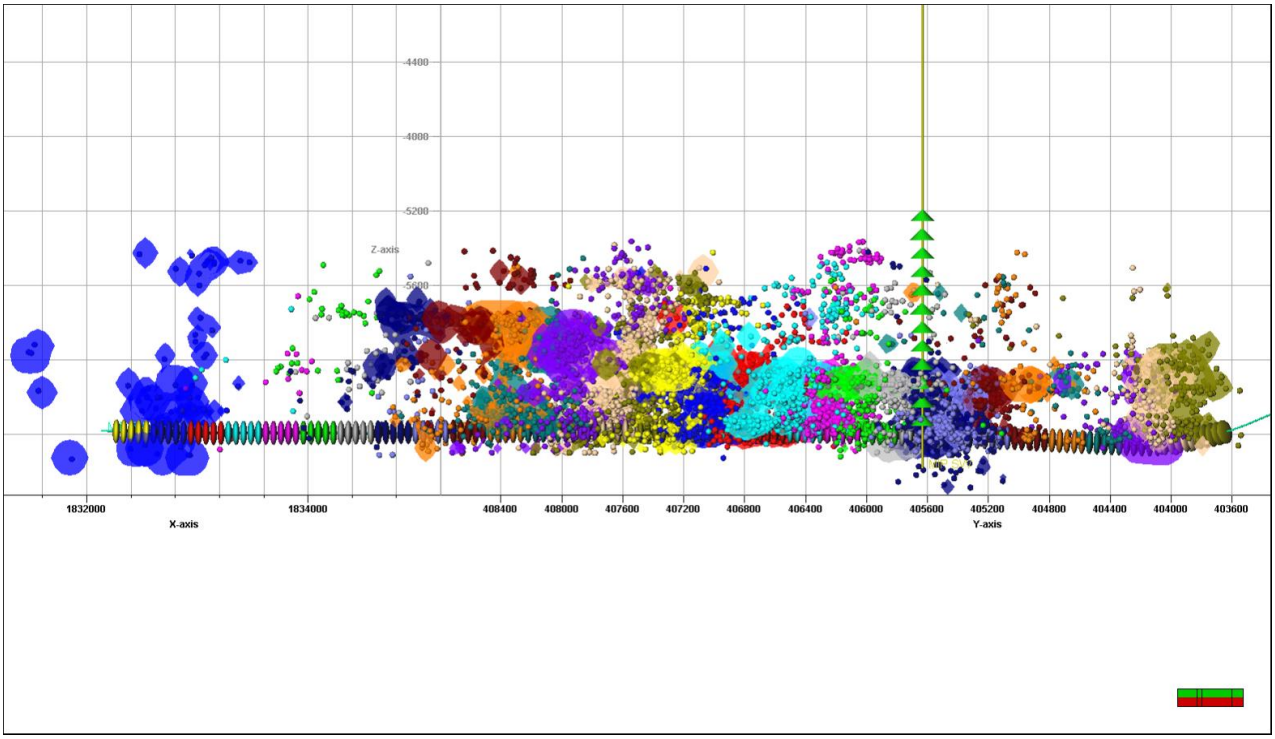



**Figure 3-15 - Side view of MIP 5H showing microseismic volume**

### 3.2.4 Location Uncertainty

All location estimates have an associated uncertainty due to a variety of factors, including uncertainties in time picks, wellbore location, velocity model, and a variety of other factors. During processing this uncertainty is estimated for each event. The uncertainty can be represented as the ellipsoid in space whose major axis represents the magnitude of the estimated maximum uncertainty for an event location. The major axis orientation indicates the direction that uncertainty applies.

Figure 3-16 shows a map view of all events located during this project, along with their associated uncertainty ellipsoids. Figure 3-17 shows the events and their uncertainty ellipsoids in a side view.

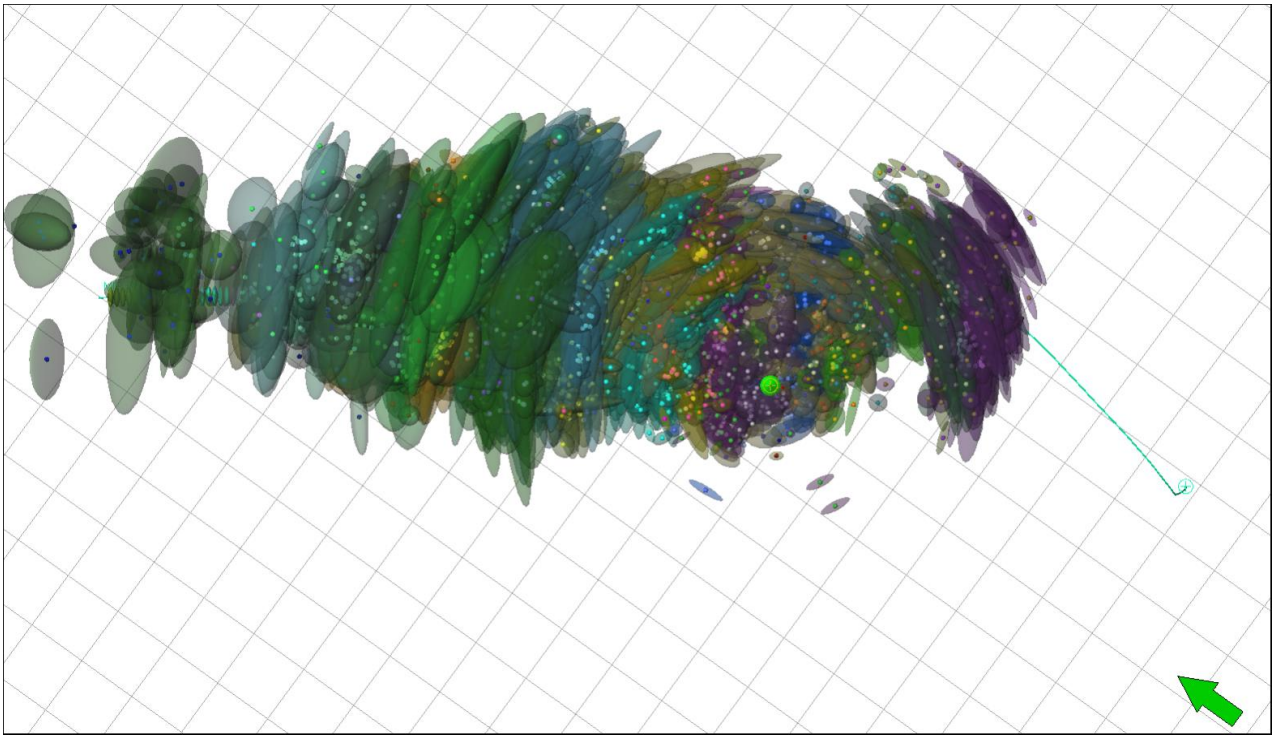


**Figure 3-16 - Event location uncertainty ellipsoids – map view**

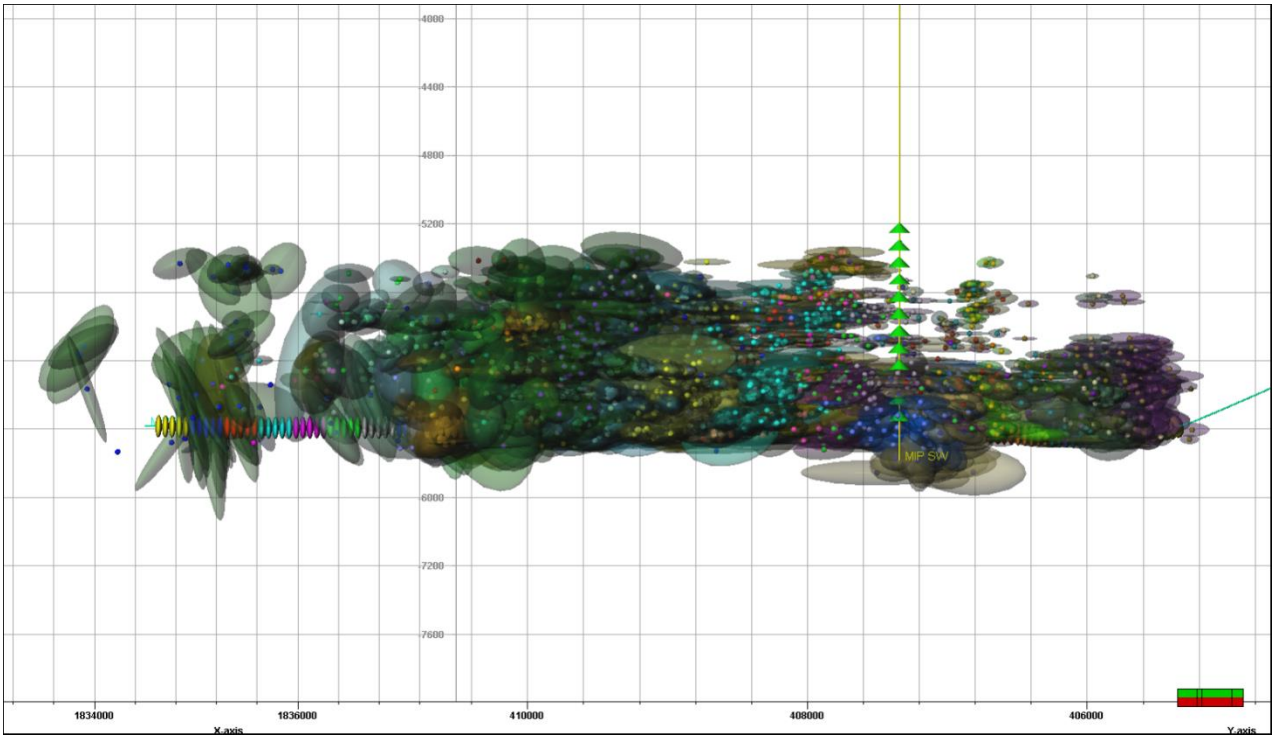



**Figure 3-17 - Event location uncertainty ellipsoids – side view**

### 3.2.5 Observations, Results, and Conclusions

The key points for MIP 5H microseismic interpretation are summarized below:

- MIP 3H and 5H comparisons are done in the next section.
- MIP 5H Average Half Length: 618ft, Average Height: 540ft, Average Azimuths N63°E
- Upward fracture height growth was large, extending past the Genesco formation.

## Treatment Execution

A single pump schedule was used for the entirety of the well.

- Most of the stimulation treatments did not deviate significantly from the proposed treatment schedule. It is presumed the design was changed on the field.

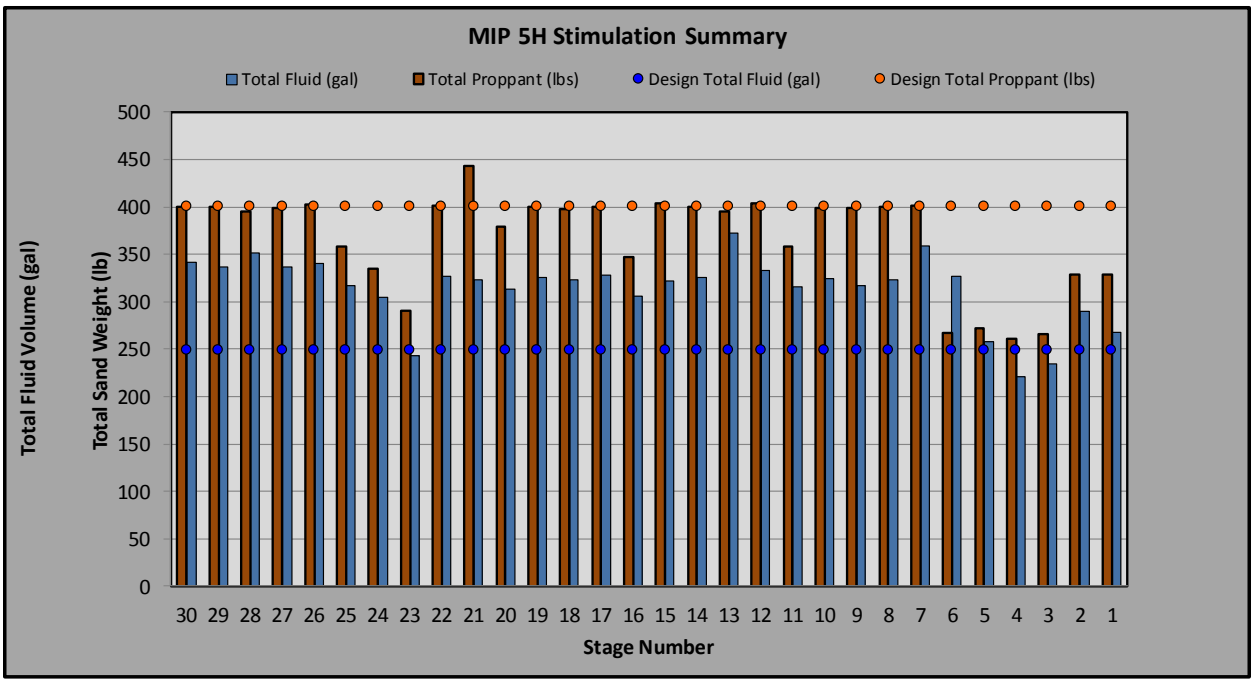



**Figure 3-18 – MIP 3H Stimulation Summary**

## Completion Integrity Indication

- Based on visual inspection of the mapped microseismic events, all stages appear to have been successfully isolated, i.e., the fracture stages/treatments appear to have entered the formation via the planned perforation interval.

## Offset Well Interference

- Based on visual inspection of the mapped microseismic events, none of the fracture stages/treatments from the wells (laterals) in this project appear to have made contact with the region- fractured/stimulated from other wells (laterals) in the project.

- Based on visual inspection of the mapped microseismic events, none of the treatments from the wells (laterals) in this project appear to have made contact with offset wells located near the treatment well(s).

Geohazard Avoidance

- No known geohazards were identified prior to the job

## 4. Well Comparisons

This section will compare the effect of different pump schedules and completion strategies on fracture geometry in MIP 3H and MIP 5H.

The following figures compare fracture geometries.

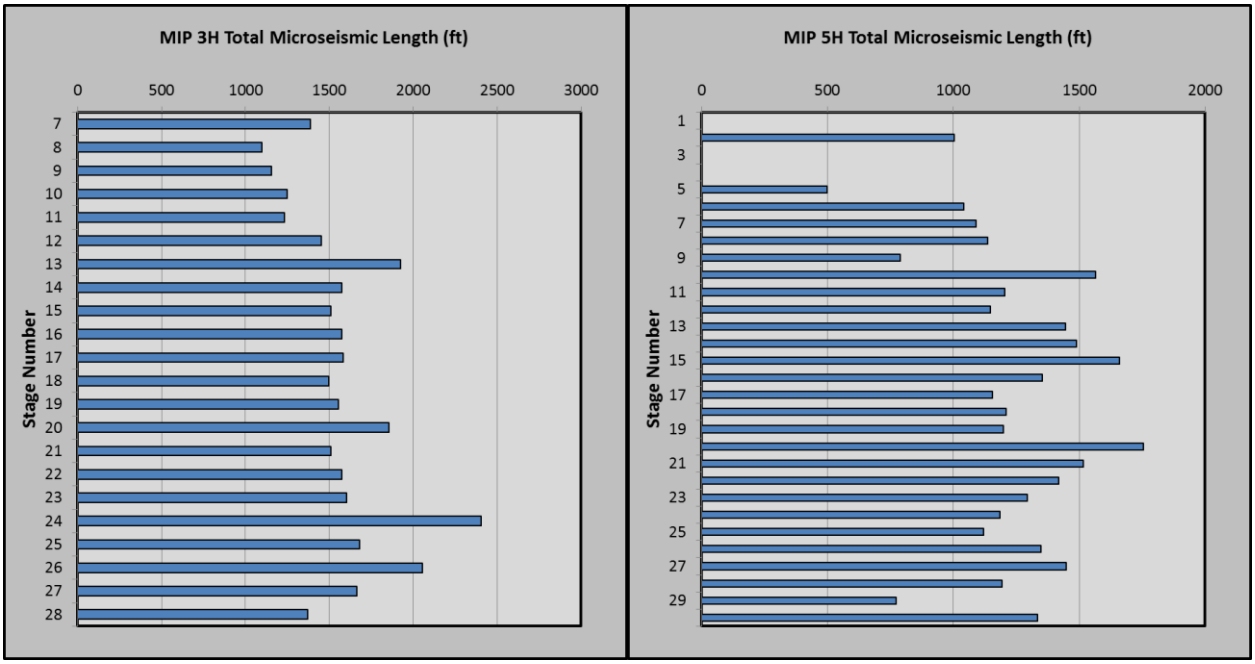



**Figure 4-1 – MIP 3H and MIP 5H total length**

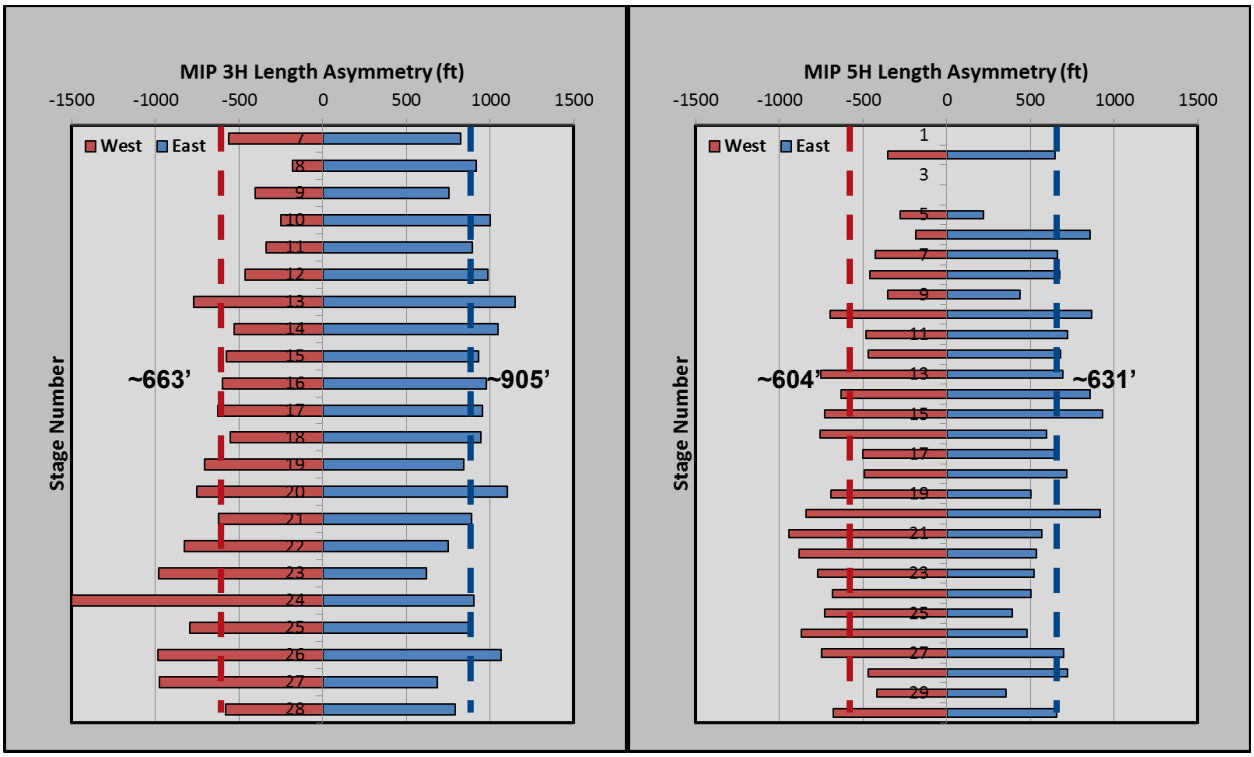



**Figure 4-2 – MIP 3H and MIP 5H length asymmetry**

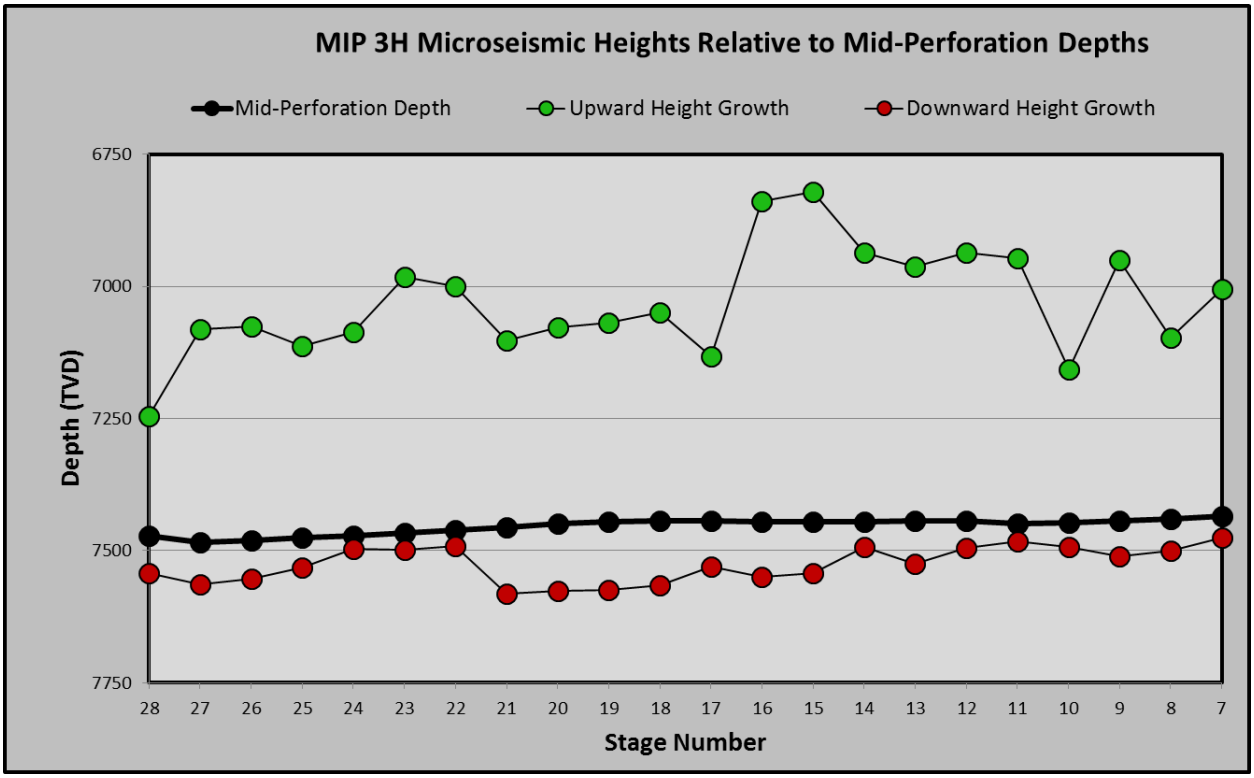



**Figure 4-3 – MIP 3H height growth**

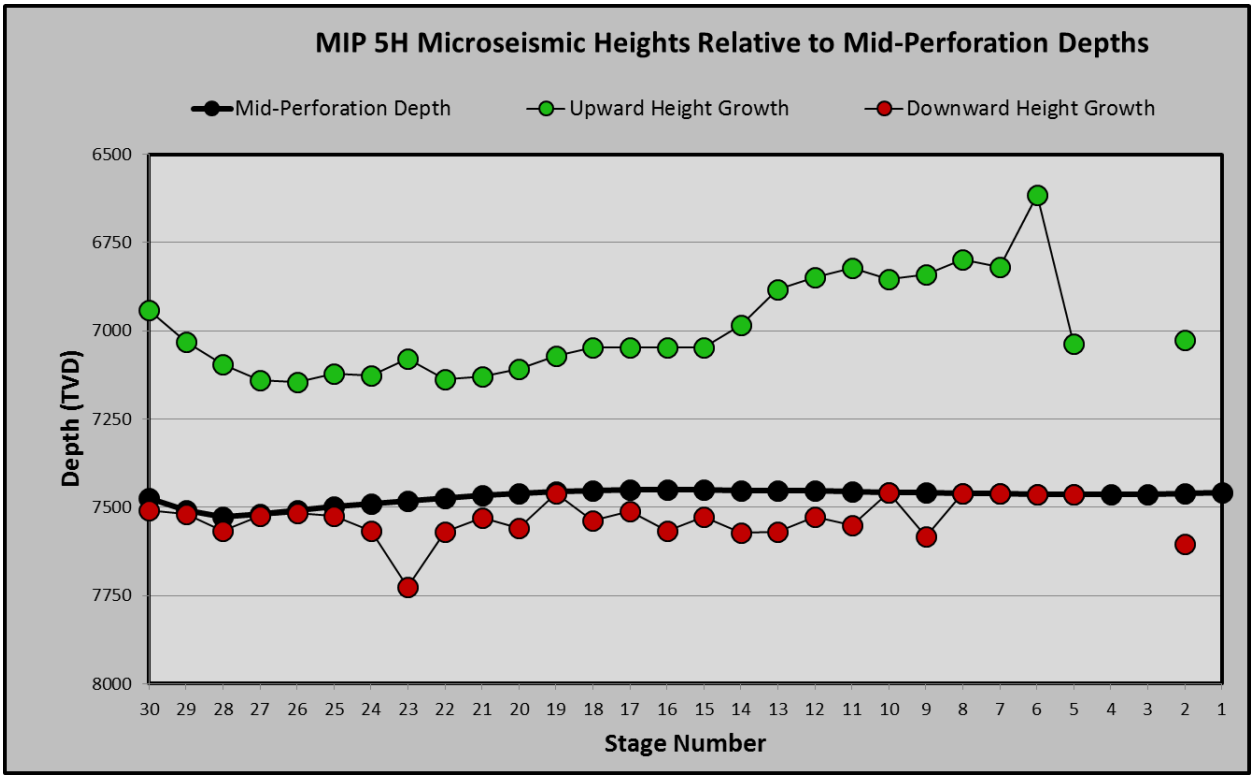



**Figure 4-4 – MIP 5H height growth**

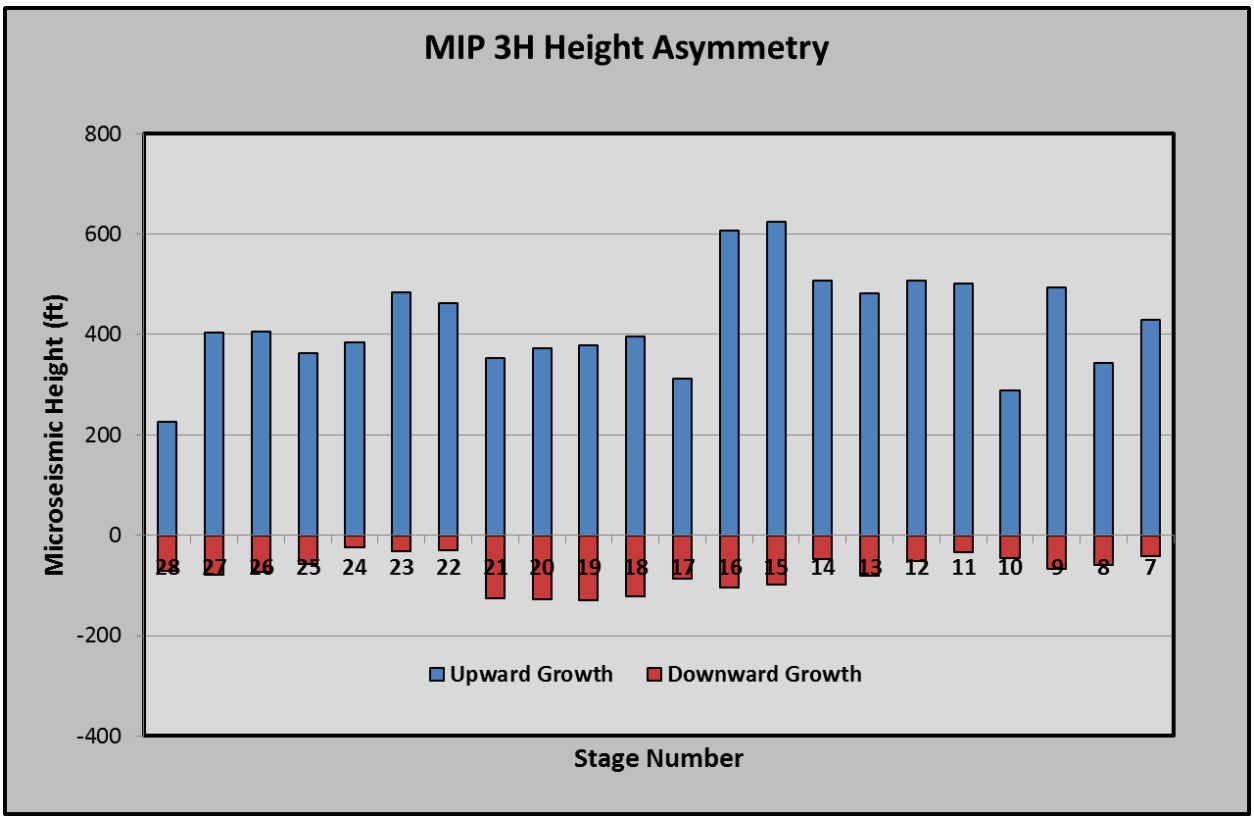



**Figure 4-5 – MIP 3H height asymmetry**

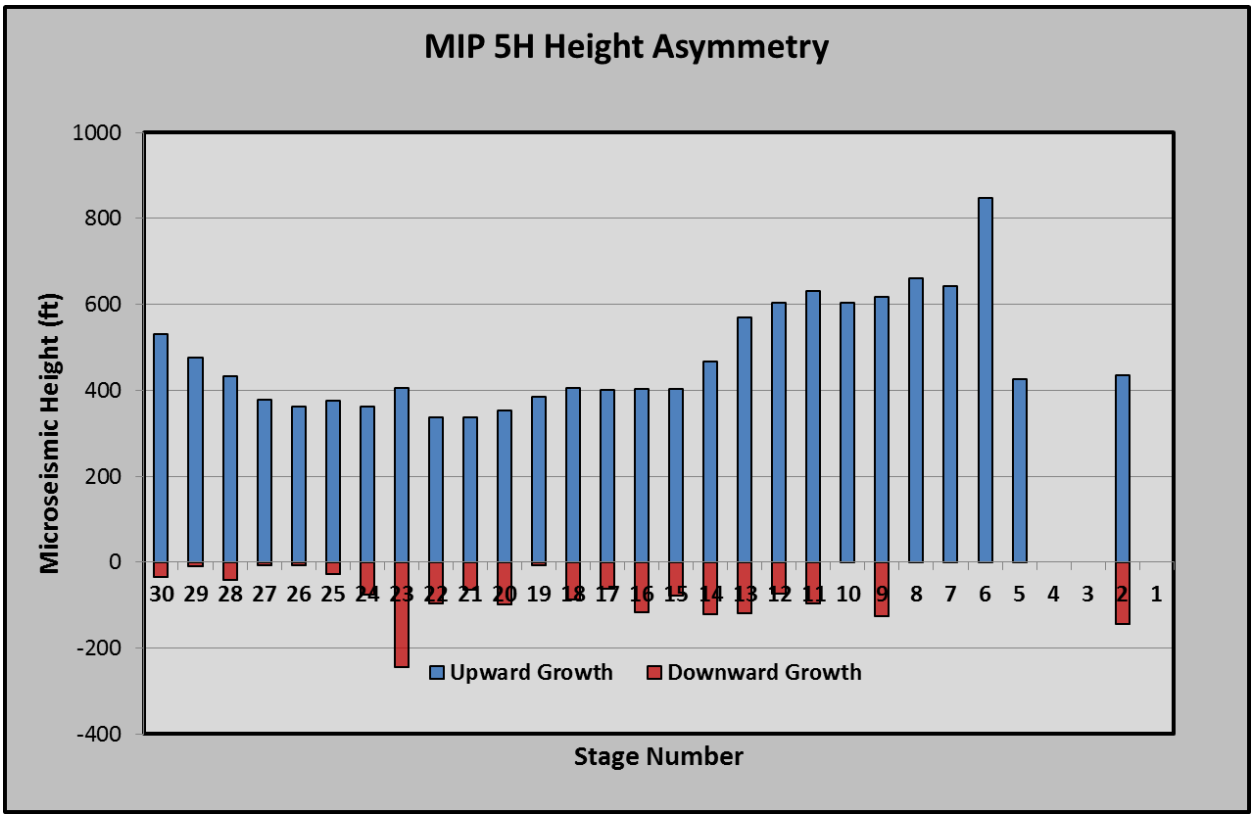



**Figure 4-6 – MIP 5H height asymmetry**

### Completion Comparisons and Pressure Response

The average treating pressure for MIP 3H was 8,443 psi

The average treating pressure for MIP 5H was 8,634 psi

The change in treating pressures is about 2%. This is an indication of similar landing points although the surface was built using MIP 3H pilot log data.

The ISIP difference is even lower, at 1%. ISIP data can only be used in a qualitative manner. This indicates similar pressure buildup, not to be confused with net pressure.

| | MIP 3H | MIP 5H |
|---|---|---|
| Lateral Landing | Upper Marcellus | Upper Marcellus |
| Lateral Length | ~5,800 | ~6,000 |
| Monitored / Total Stages | 22 / 28 | 30 / 30 |
| Perf Design | Multiple | 5 Clusters, 40' Spacing |
| Fluid & Prop | Multiple | SW, 100-Mesh and 40/70 White |

**Figure 4-7 – MIP 3H and MIP 5H completion summary**

| Section | | Stage | Pump Schedule | Clusters | Shot Density |
|---|---|---|---|---|---|
| A | NNE Standard 35% 100-Mesh | 1 – 6 | A | 5 | 10 |
| B | NNE 75% 100-Mesh | 7 – 12 | B | 5 | 10 |
| C | Perforation Design | 13 – 14 | A | 5 | 6 |
| | | 15 – 16 | C | 4 | 6 |
| | | 17 – 19 | C | 4 | 8 |
| D | Sapphire VEF | 20 – 21 | D | 5 | 10 |
| E | Best Practices | 22 – 23 | C | 4 | 10 |
| | | 24 – 28 | A | 5 | 8 |

**Figure 4-8 – MIP 3H pump schedule and completion summary**

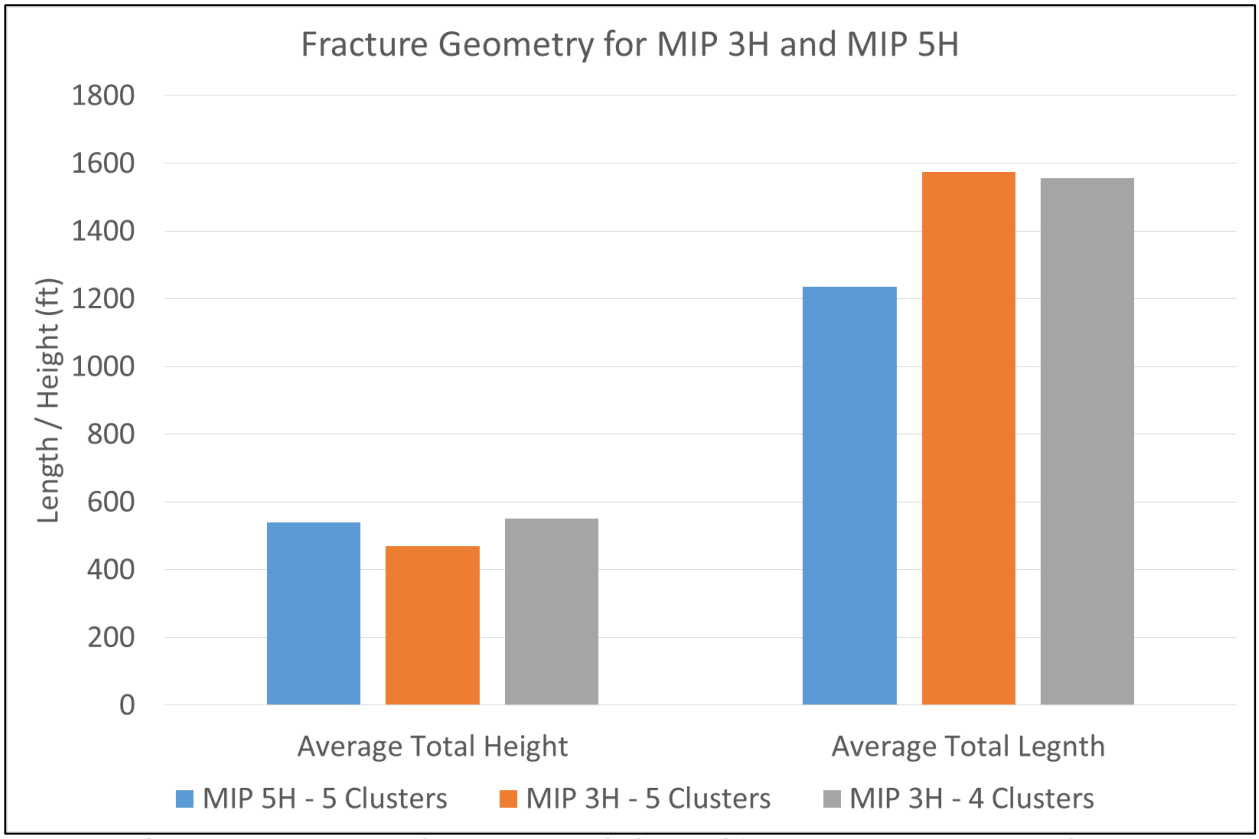



**Figure 4-9 – MIP 3H and MIP 5H completion and fracture geometry comparison**

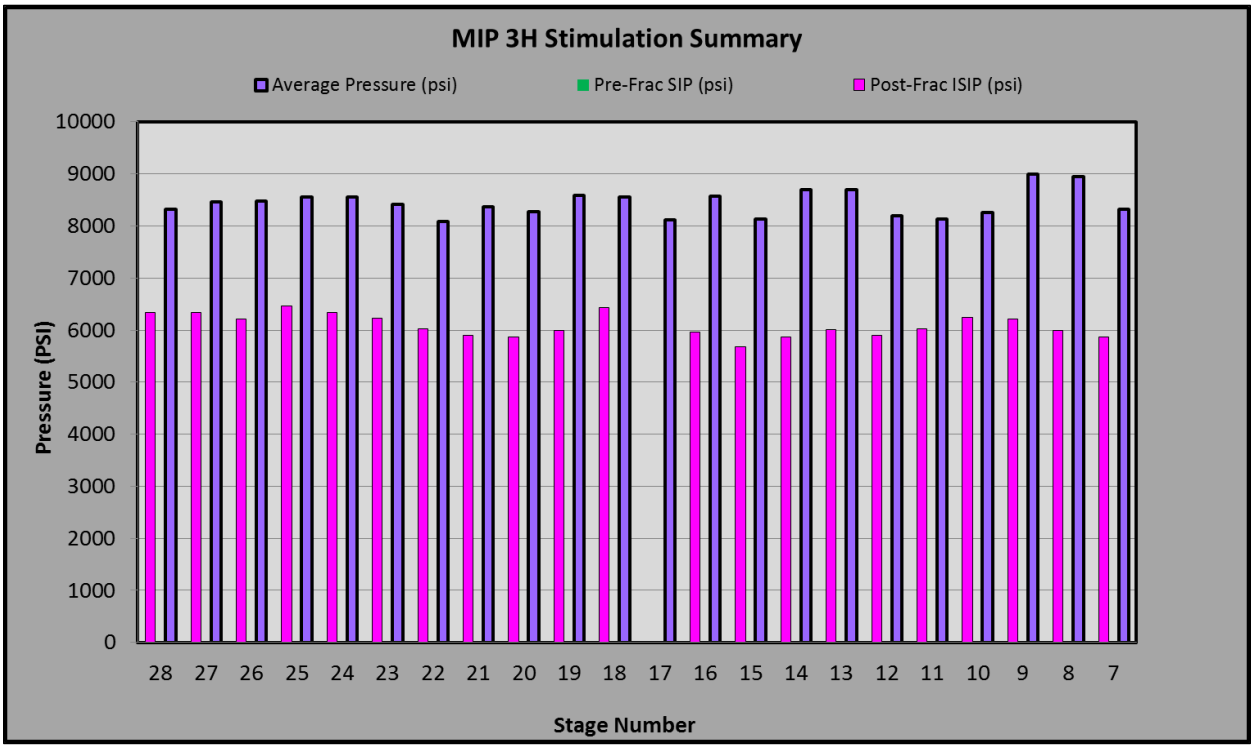



**Figure 4-10 – MIP 3H pressure response**

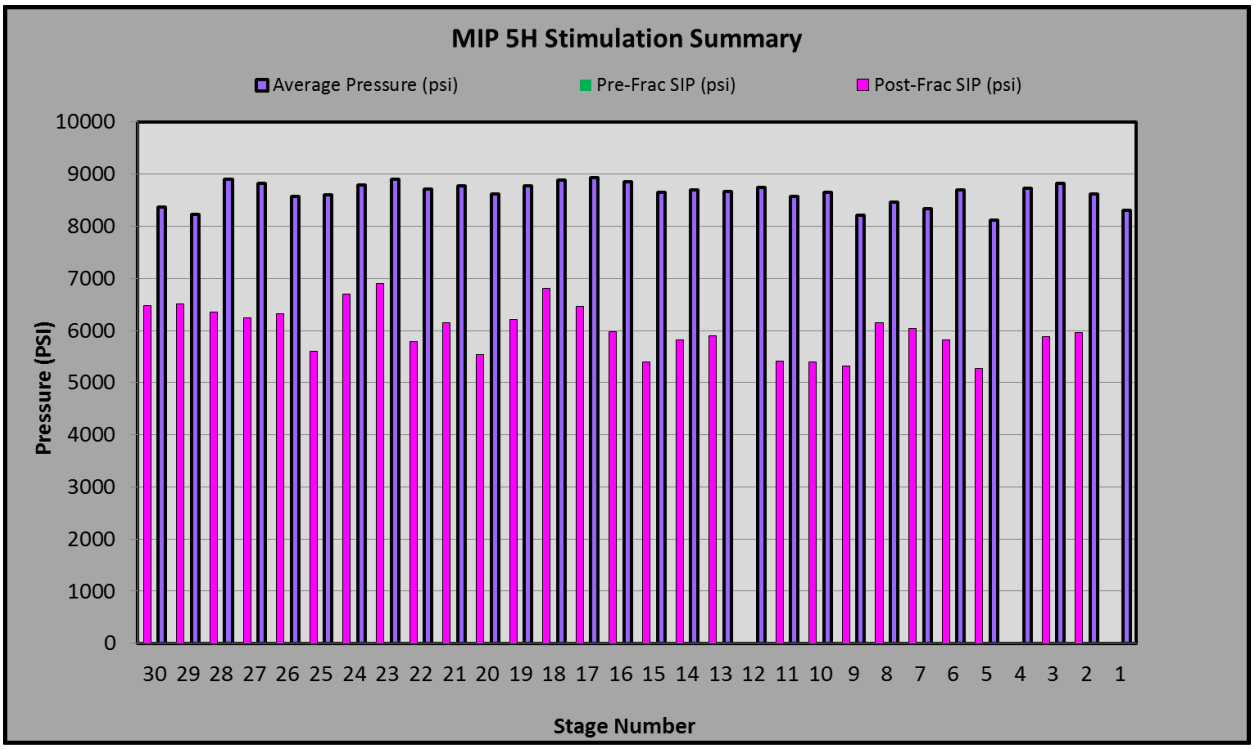



**Figure 4-11 – MIP 5H pressure response**

## Pump Schedule Comparisons

| Well | Section | | Stage | Pump Schedule |
|---|---|---|---|---|
| MIP 3H | A | NNE Standard 35% 100-Mesh | 1 – 6 | A – NNE 440K 35% 100-Mesh |
| | B | NNE 75% 100-Mesh | 7 – 12 | B – NNE 440K 75% 100-Mesh |
| | C | Perforation Design | 13 – 14 | A – NNE 440K 35% 100-Mesh |
| | | | 15 – 19 | C – NNE 360K 35% 100-Mesh |
| | D | Sapphire VEF | 20 – 21 | D – SLB VEF 440K 35% 100-Mesh |
| | E | Best Practices | 22 – 23 | C – NNE 360K 35% 100-Mesh |
| | | | 24 – 28 | A – NNE 440K 35% 100-Mesh |
| MIP 5H | N/A | | 1 – 30 | Smaller A – NNE 400K 35% 100-Mesh |

**Figure 4-12 – MIP 3H and MIP 5H pump schedules**

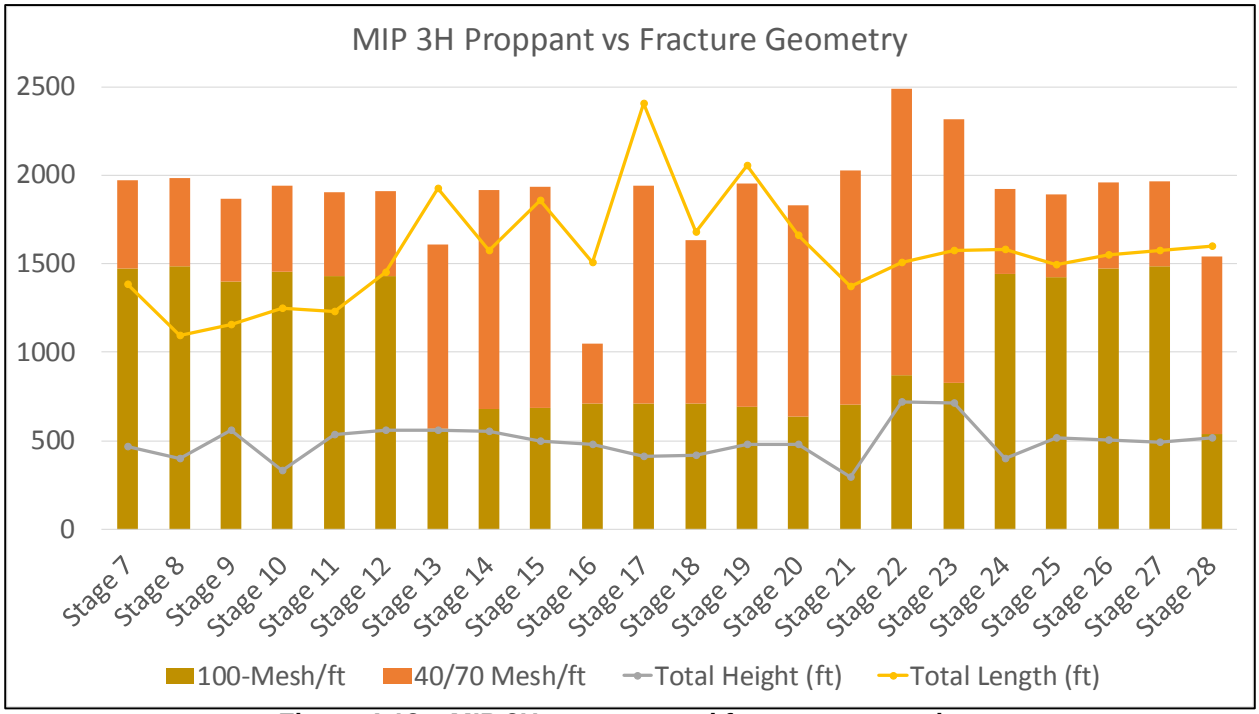



**Figure 4-13 – MIP 3H proppant and fracture geometries**

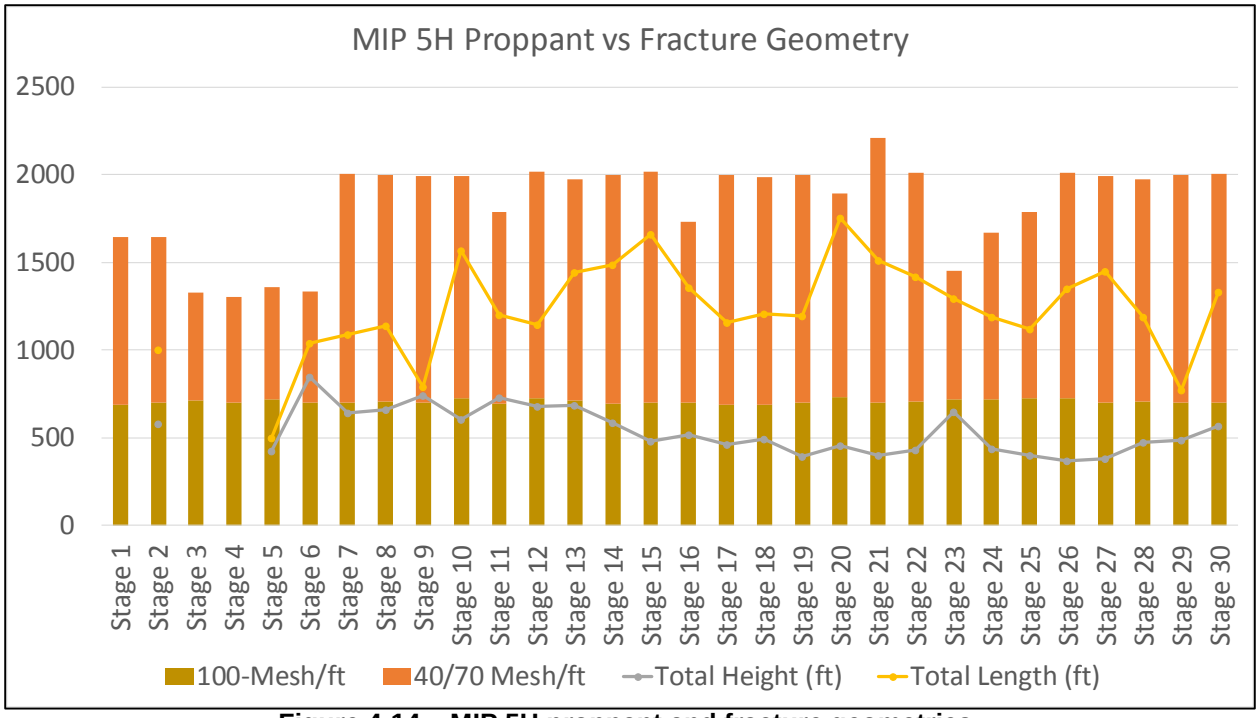



**Figure 4-14 – MIP 5H proppant and fracture geometries**

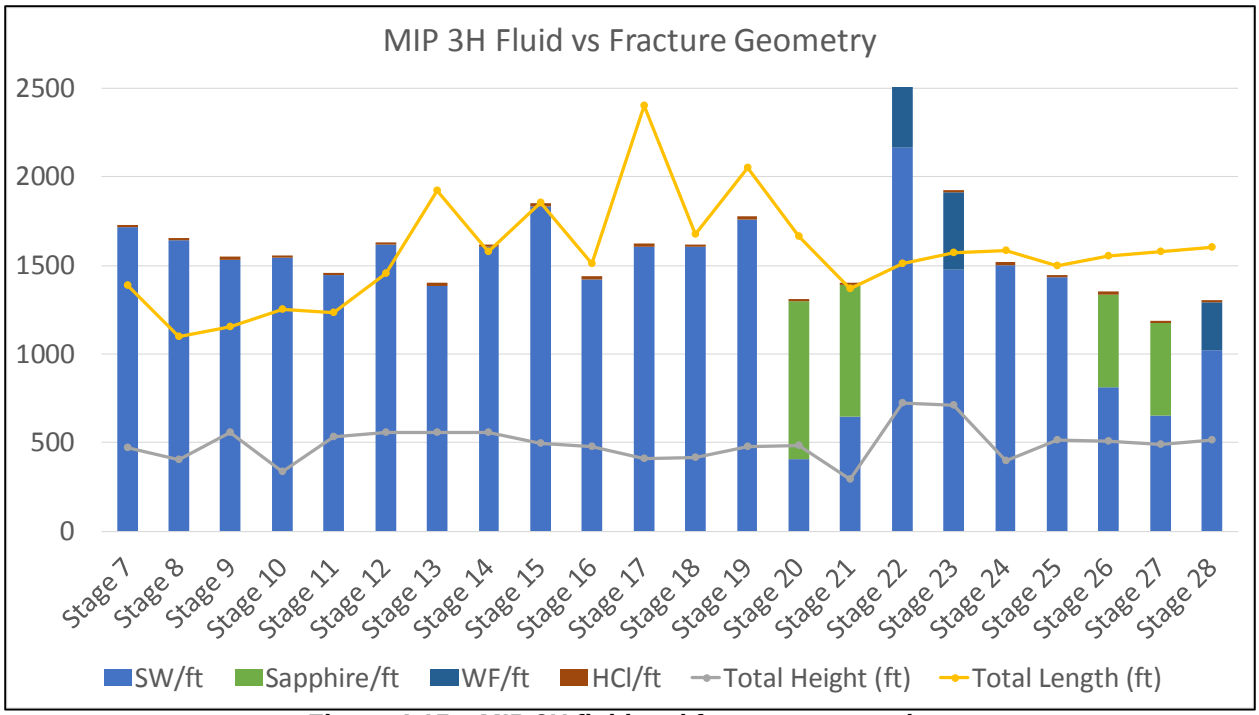



**Figure 4-15 – MIP 3H fluid and fracture geometries**

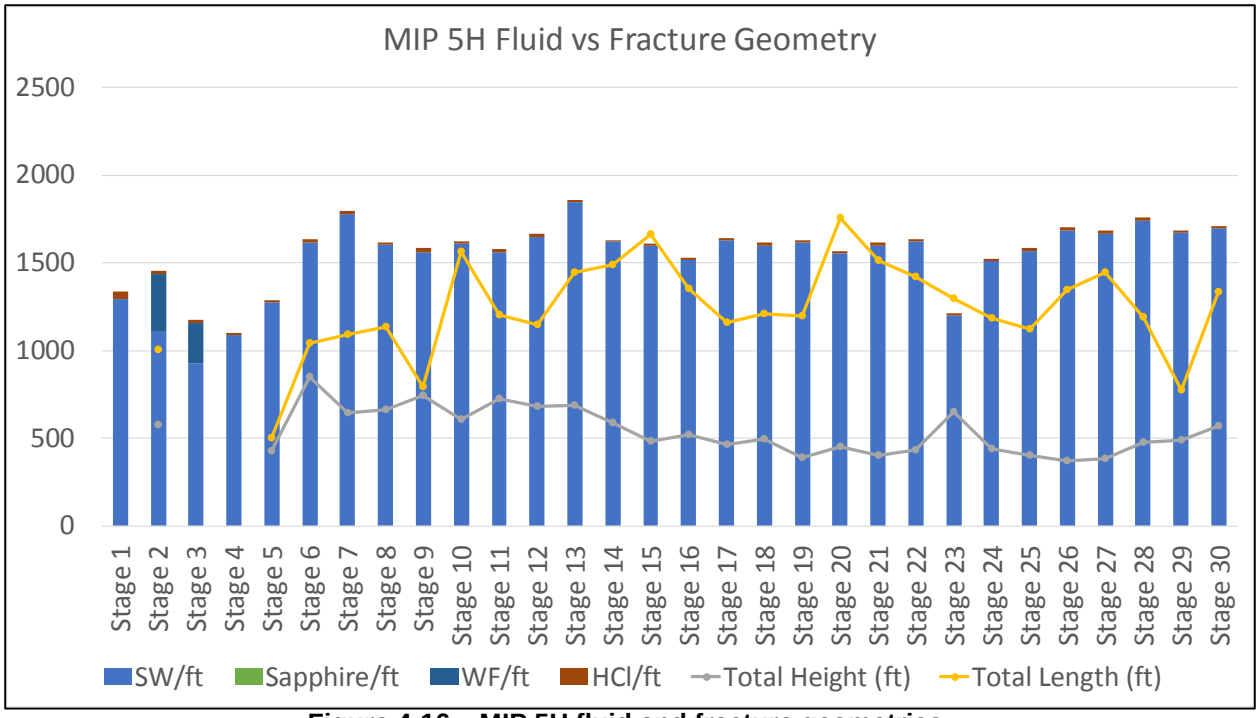



**Figure 4-16 – MIP 5H fluid and fracture geometries**

# 5. Appendix A – Treatment Data and Microseismic Events Summary by Stage

## 5.1 MIP 3H Stage 7

The MIP 3H Stage 7 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

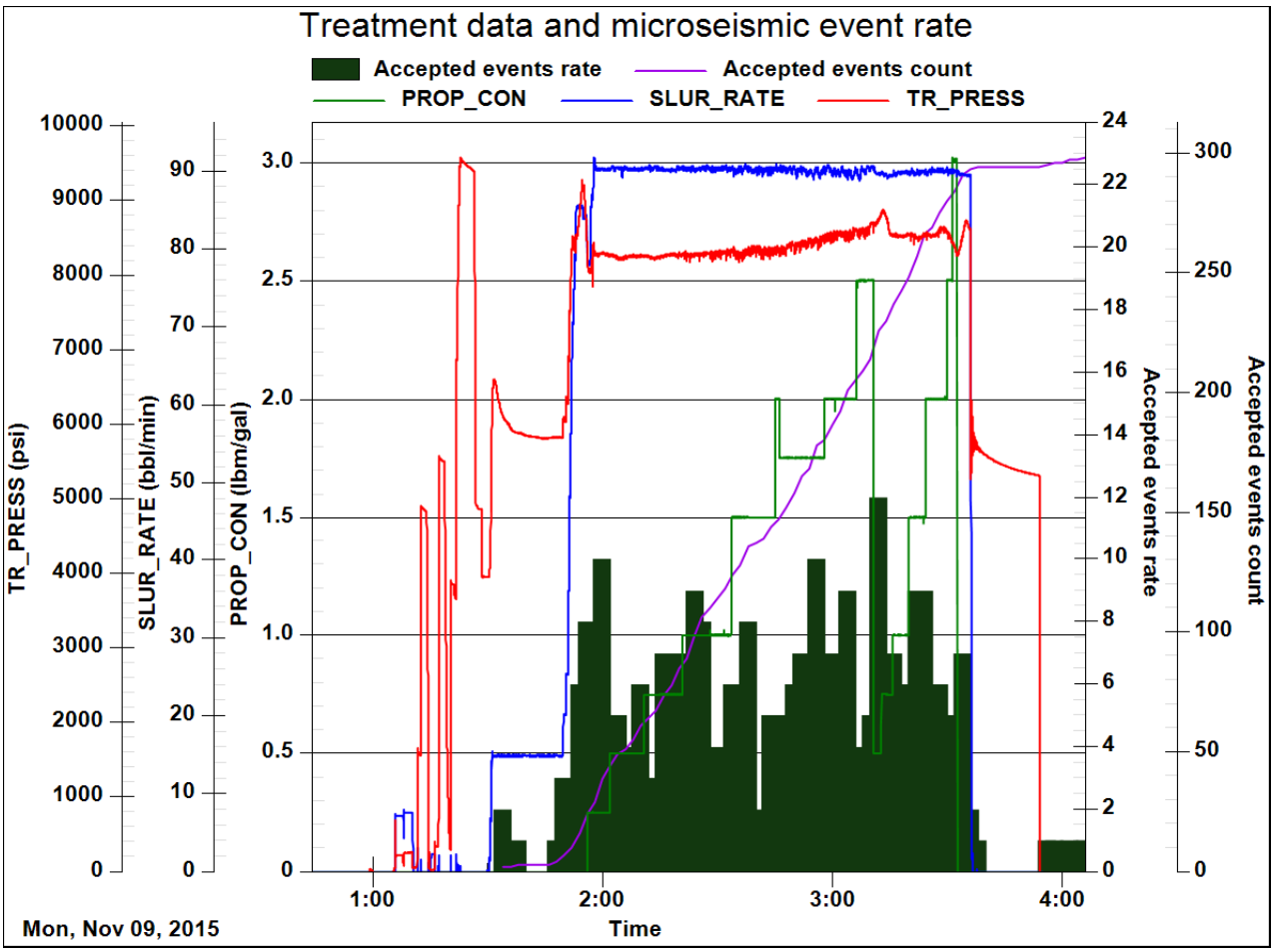



**Figure 5-1 - MIP 3H Stage 7 treatment data and microseismic event rate**

**Table 5.1 - MIP 3H Stage 7 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 343743 | 383921 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 346743 | 386921 |
| 100 Mesh (lbm) | 330000 | 330440 |
| 40/70 White (lbm) | 110000 | 110440 |
| Total proppants (lbm) | 440000 | 440880 |

**Table 5.2 - MIP 3H Stage 7 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 87.1 |
| Average pressure (psi) | 8328 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5867 |
| Maximum PPA (lbm/gal) | 3.022 |

**Table 5.3 - MIP 3H Stage 7 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 42 |
| MS length (ft) | 1387 |
| MS height (ft) | 471 |
| MS volume (million ft3) | 59.4 |

The microseismic data from MIP 3H Stage 7 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

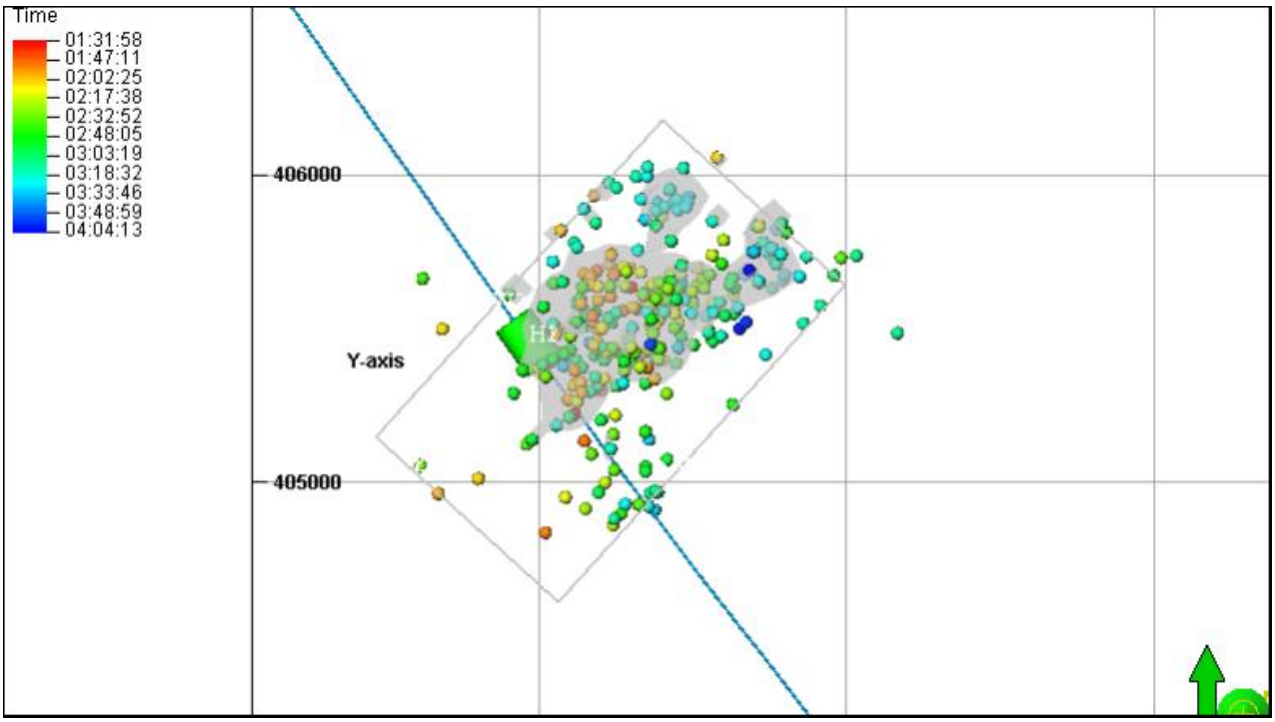



**Figure 5-2 - MIP 3H Stage 7 map view (length and width)**

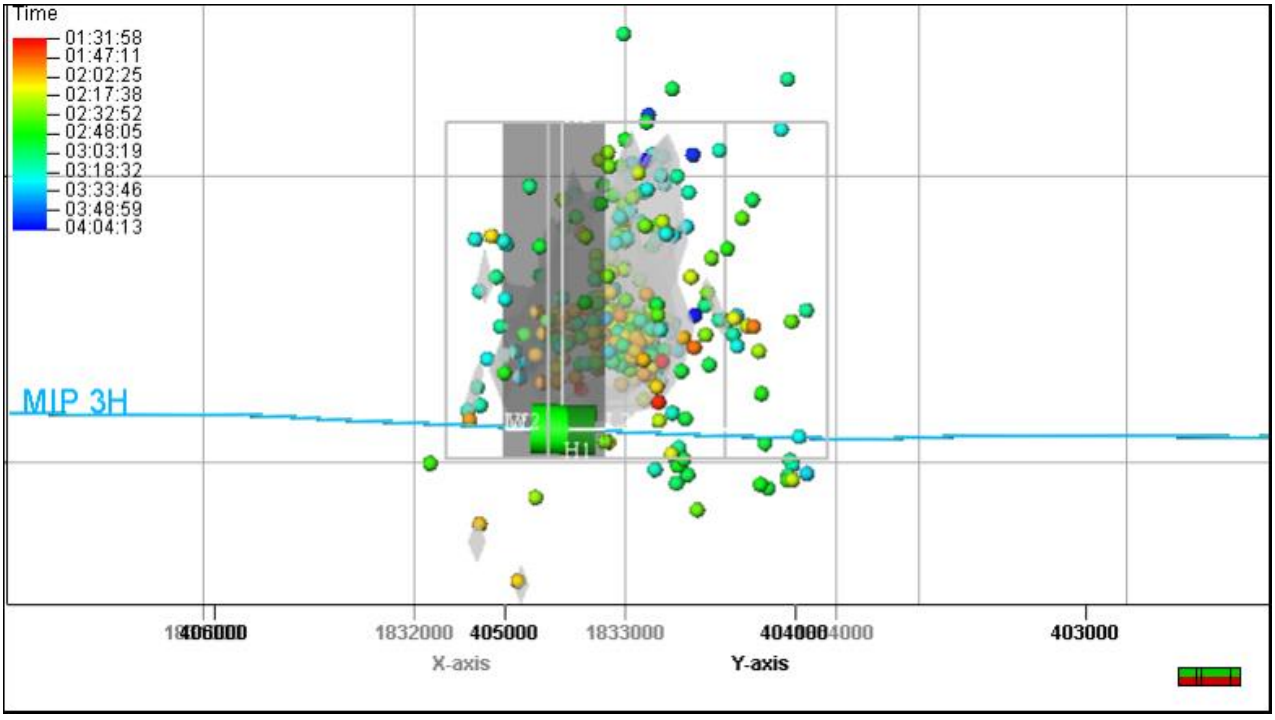



**Figure 5-3 - MIP 3H Stage 7 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 7 are shown below in map and transverse views.

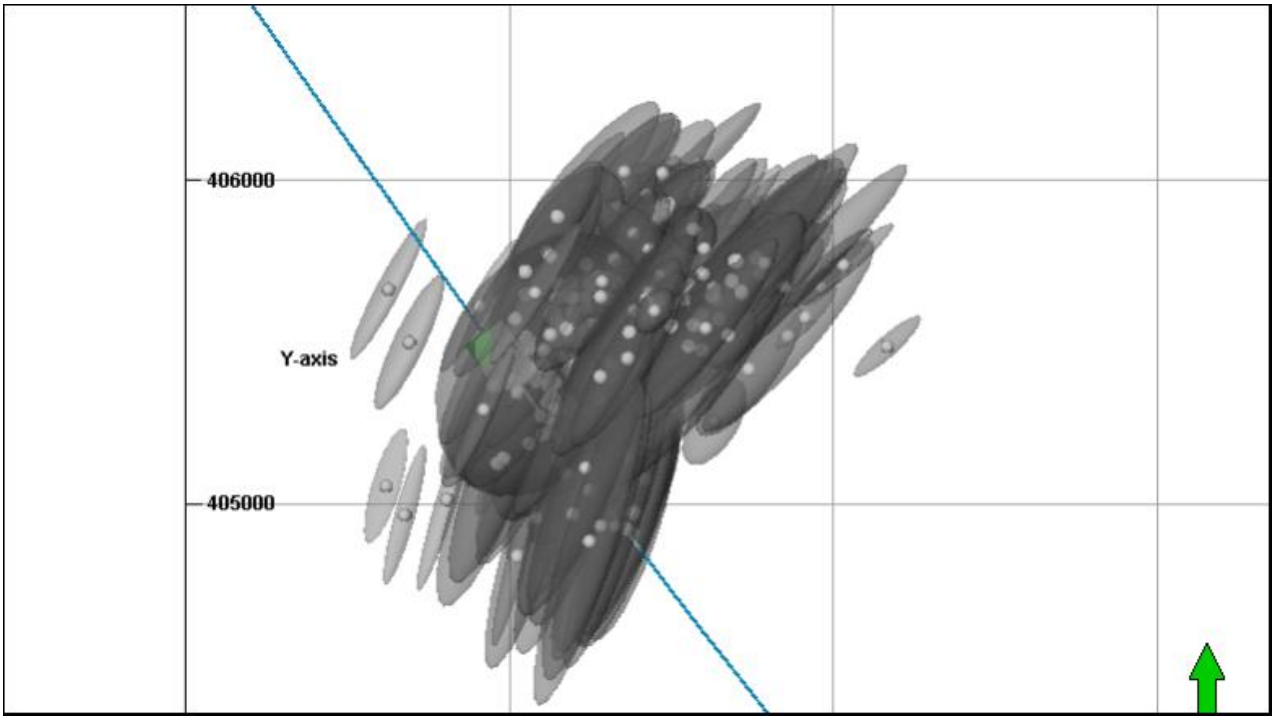



**Figure 5-4 - MIP 3H Stage 7 event location uncertainty ellipsoids – map view**

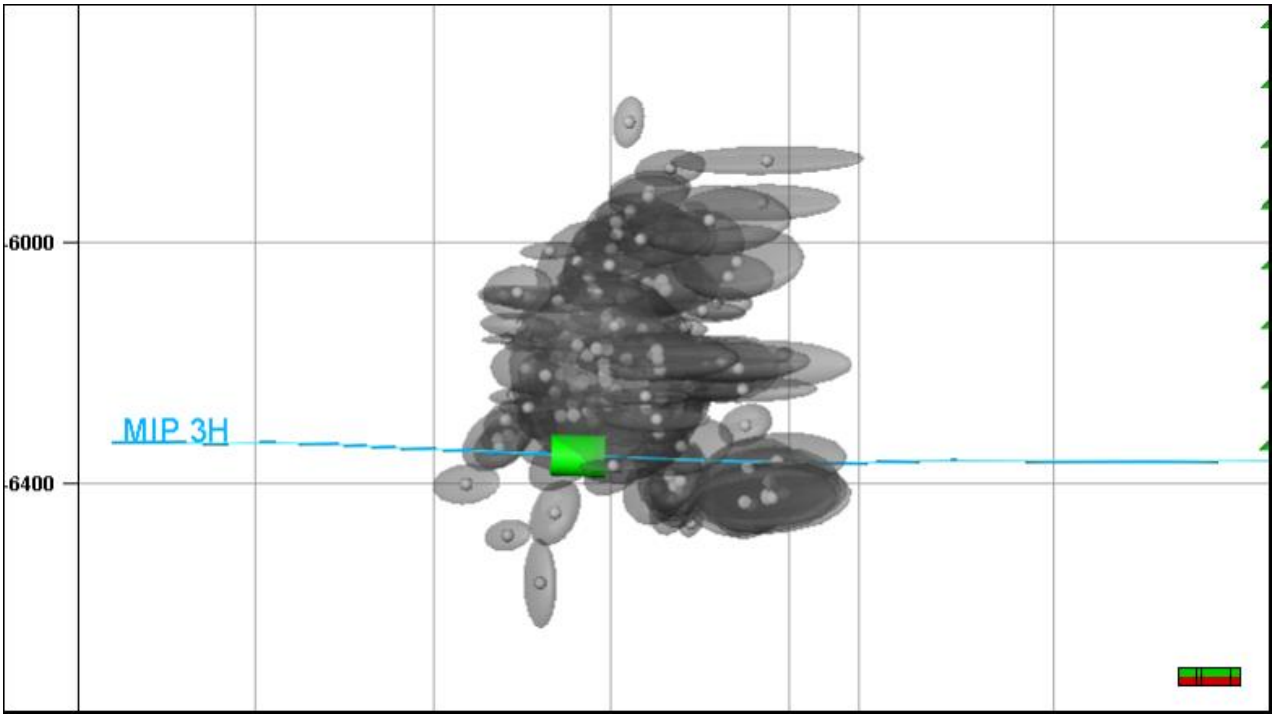



**Figure 5-5 - MIP 3H Stage 7 event location uncertainty ellipsoids – side view**

### 5.1.1 MIP 3H Stage 7 On-Site Notes and Observations

## 5.2 MIP 3H Stage 8

The MIP 3H Stage 8 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

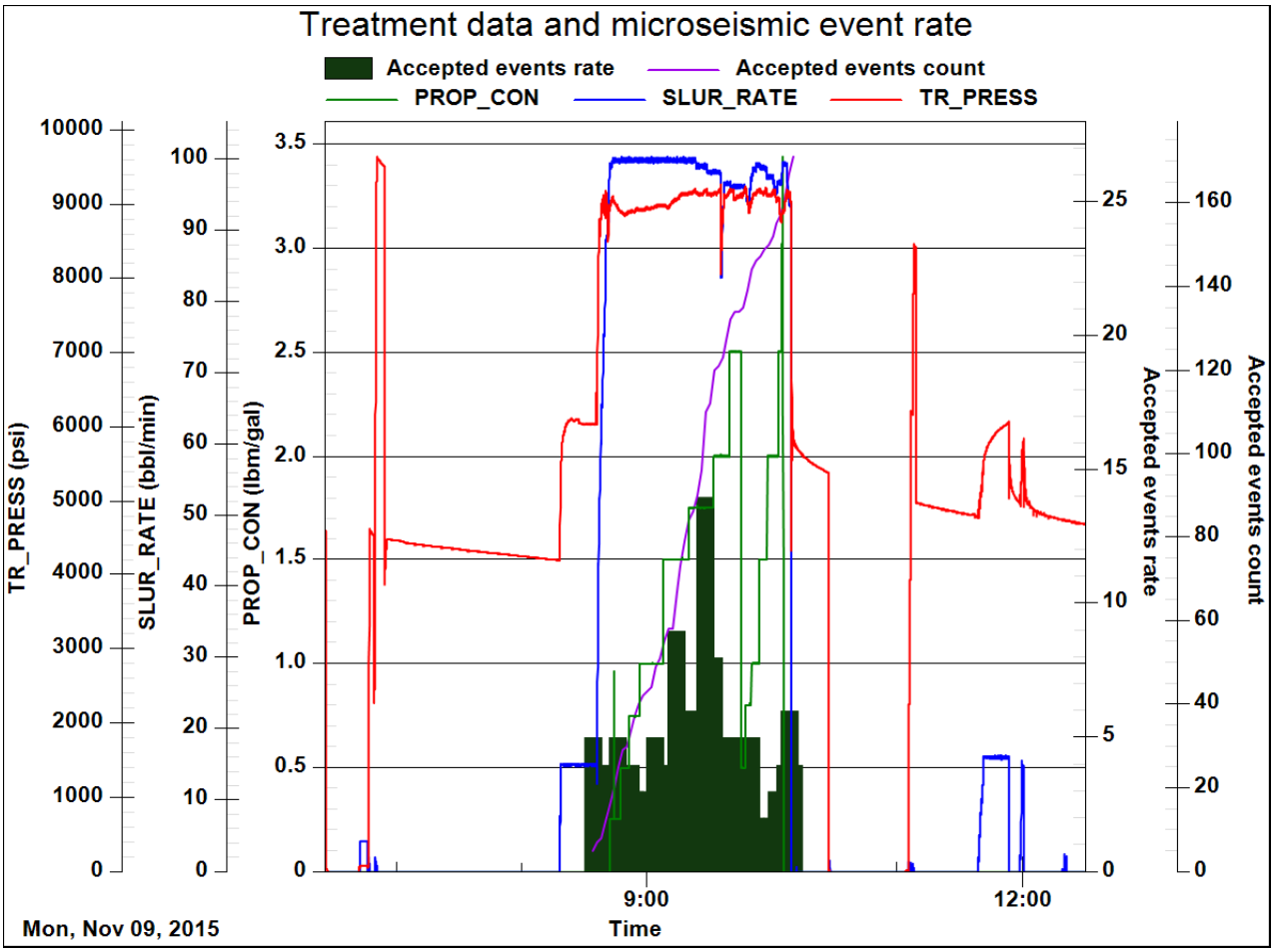



**Figure 5-6 - MIP 3H Stage 8 treatment data and microseismic event rate**

**Table 5.4 - MIP 3H Stage 8 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 343743 | 365478 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 346743 | 368478 |
| 100 Mesh (lbm) | 330000 | 330340 |
| 40/70 White (lbm) | 110000 | 110160 |
| Total proppants (lbm) | 440000 | 440500 |

**Table 5.5 - MIP 3H Stage 8 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 95 |
| Average pressure (psi) | 8951 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5992 |
| Maximum PPA (lbm/gal) | 3.44 |

**Table 5.6 - MIP 3H Stage 8 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 91 |
| MS length (ft) | 1097 |
| MS height (ft) | 403 |
| MS volume (million ft3) | 32.6 |

The microseismic data from MIP 3H Stage 8 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

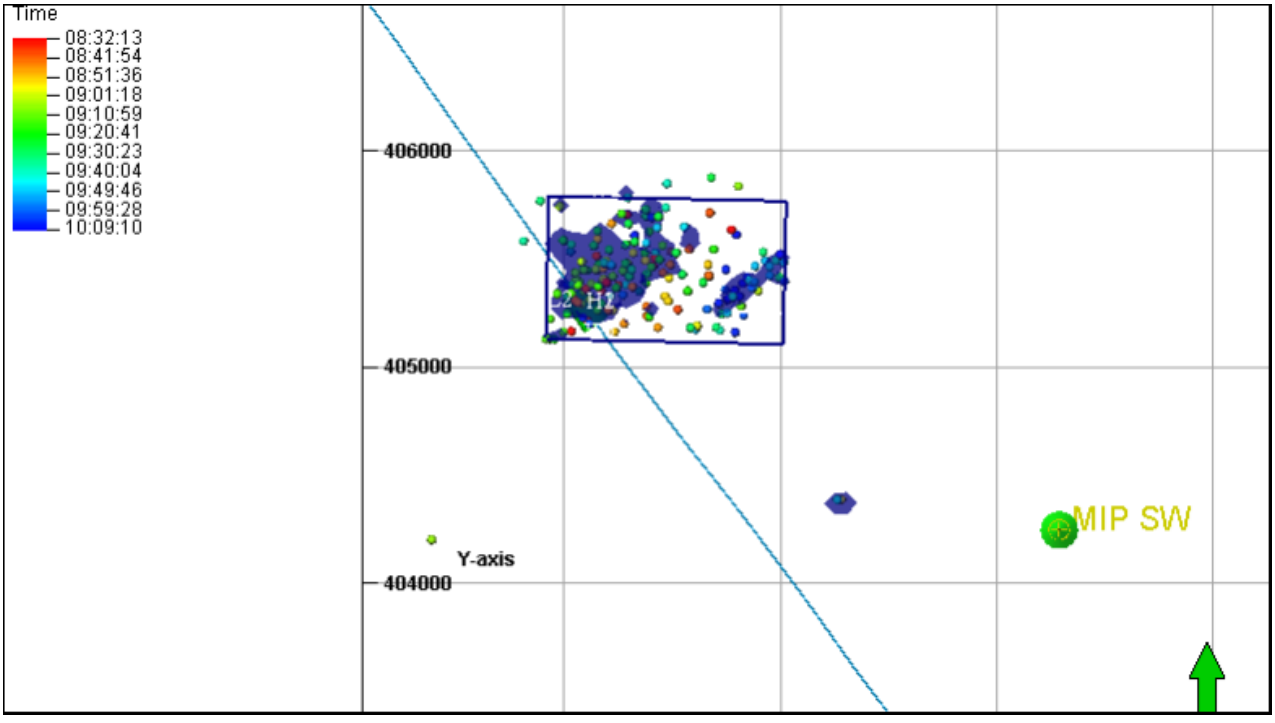



**Figure 5-7 - MIP 3H Stage 8 map view (length and width)**

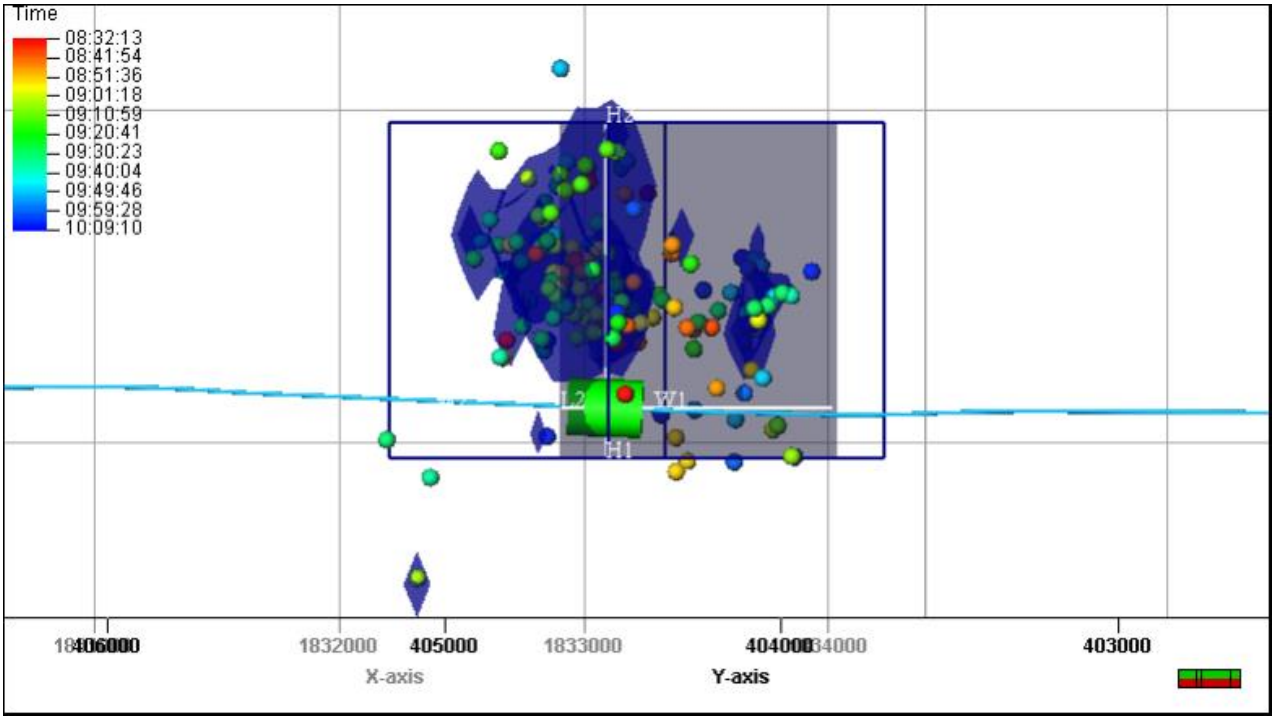



**Figure 5-8 - MIP 3H Stage 8 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 8 are shown below in map and transverse views.

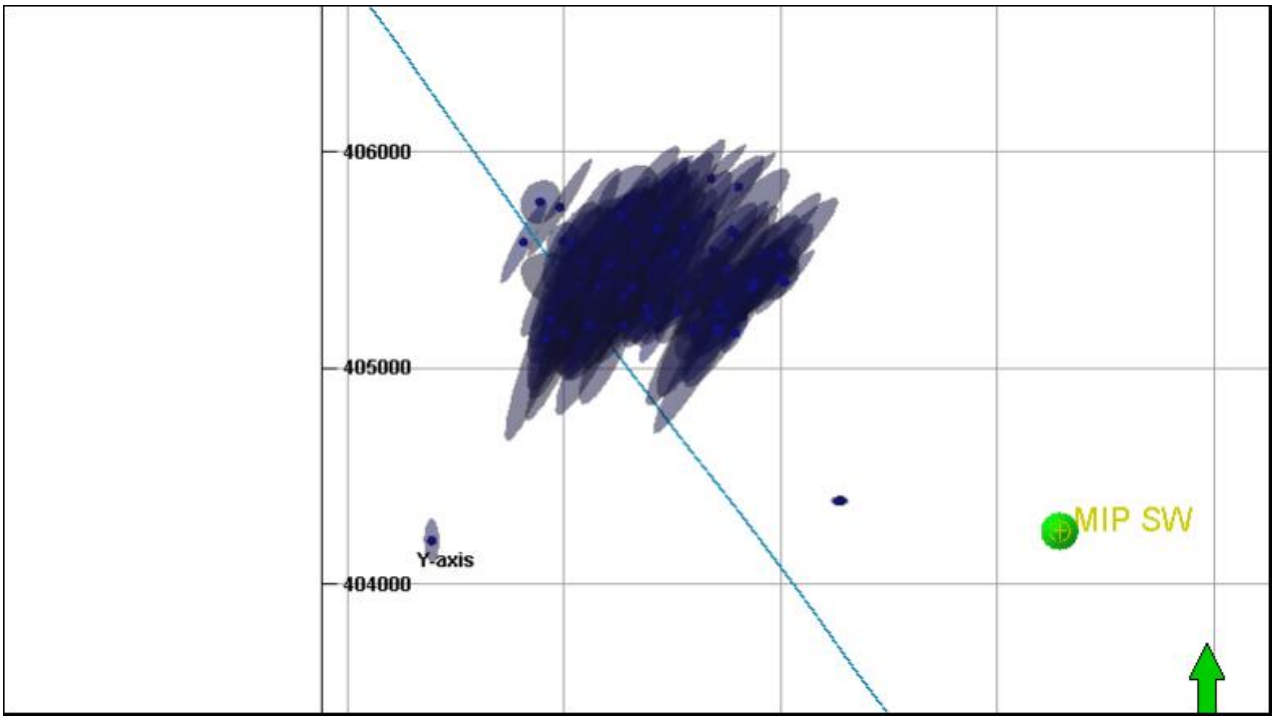



**Figure 5-9 - MIP 3H Stage 8 event location uncertainty ellipsoids – map view**

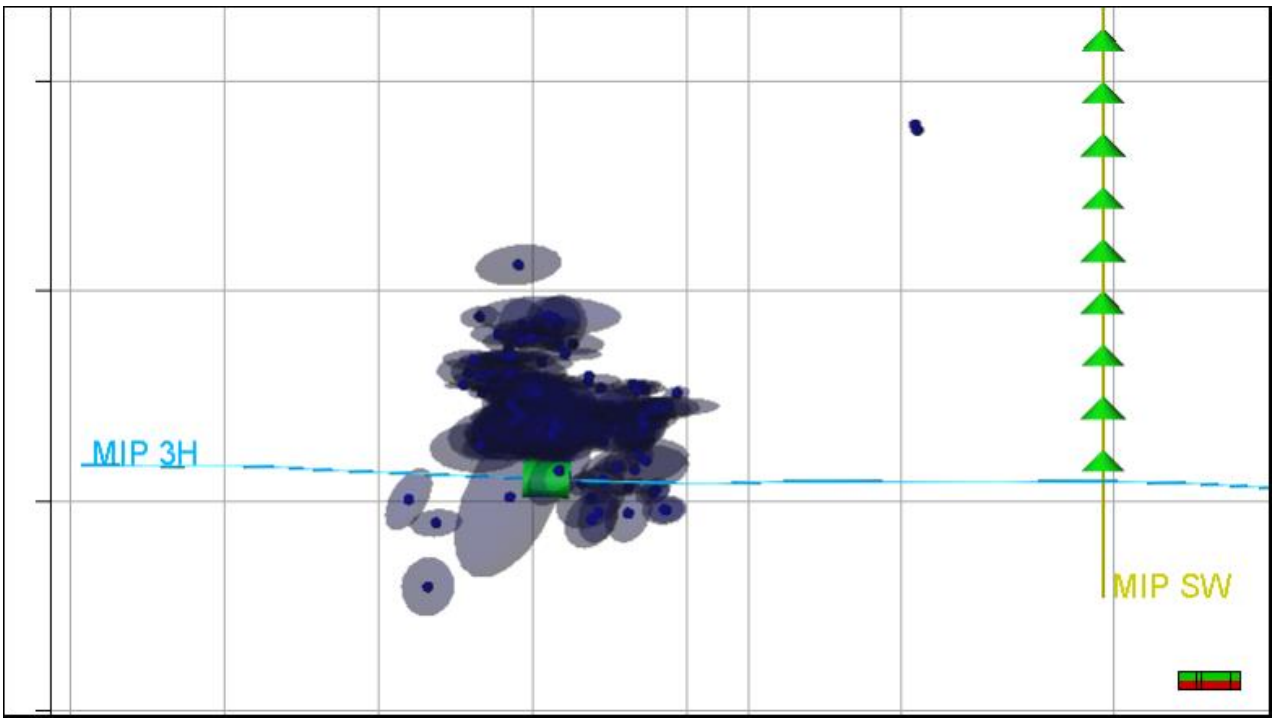



**Figure 5-10 - MIP 3H Stage 8 event location uncertainty ellipsoids – side view**

### 5.2.1 MIP 3H Stage 8 On-Site Notes and Observations

### 5.3 MIP 3H Stage 9

The MIP 3H Stage 9 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

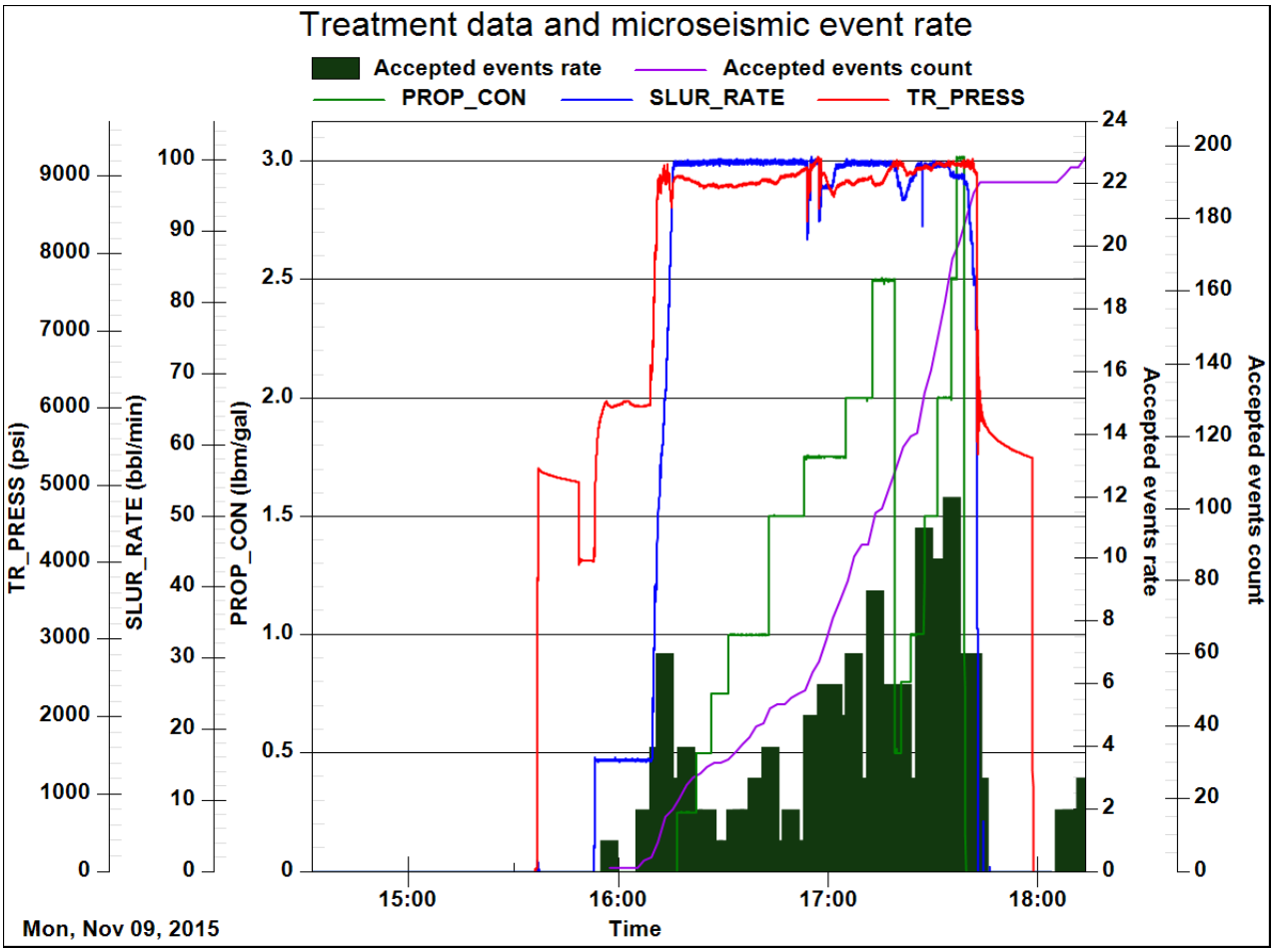



**Figure 5-11 - MIP 3H Stage 9 treatment data and microseismic event rate**

**Table 5.7 - MIP 3H Stage 9 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 343743 | 362292 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 346743 | 365292 |
| 100 Mesh (lbm) | 330000 | 330200 |
| 40/70 White (lbm) | 110000 | 110760 |
| Total proppants (lbm) | 440000 | 440960 |

**Table 5.8 - MIP 3H Stage 9 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 98.6 |
| Average pressure (psi) | 8991 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6210 |
| Maximum PPA (lbm/gal) | 3.017 |

**Table 5.9 - MIP 3H Stage 9 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 66 |
| MS length (ft) | 1156 |
| MS height (ft) | 561 |
| MS volume (million ft3) | 59.6 |

The microseismic data from MIP 3H Stage 9 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

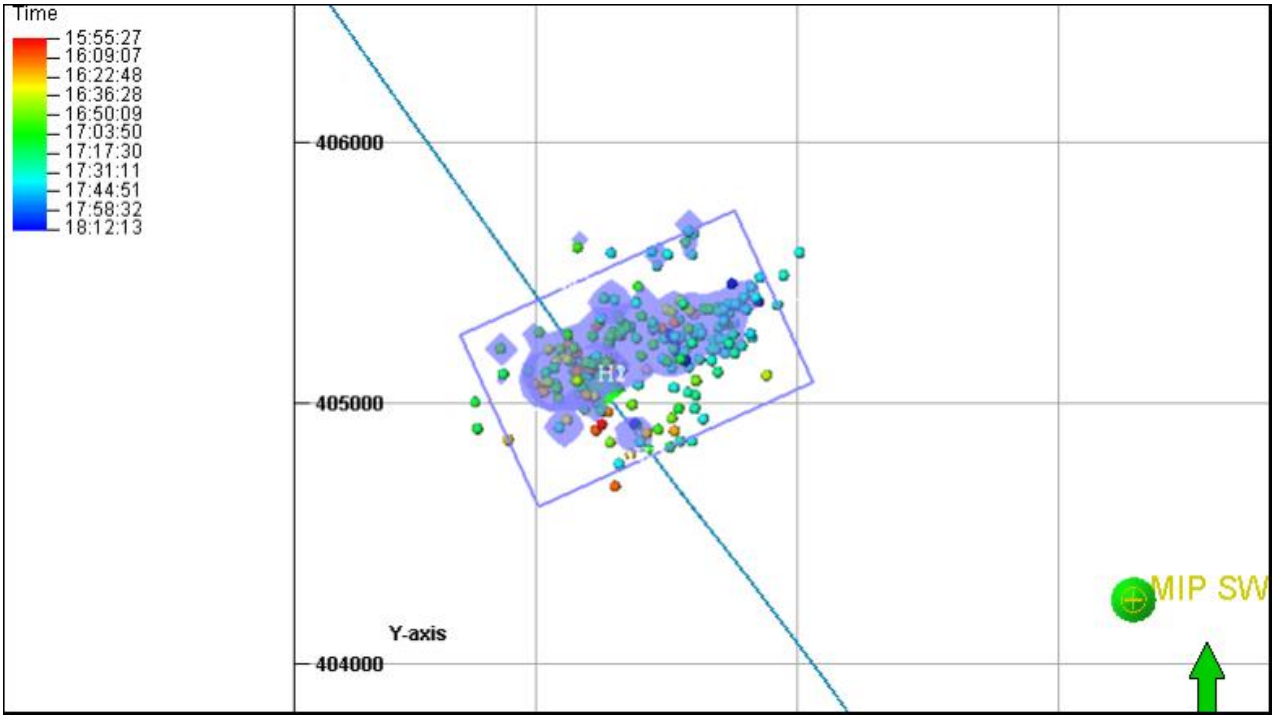



**Figure 5-12 - MIP 3H Stage 9 map view (length and width)**

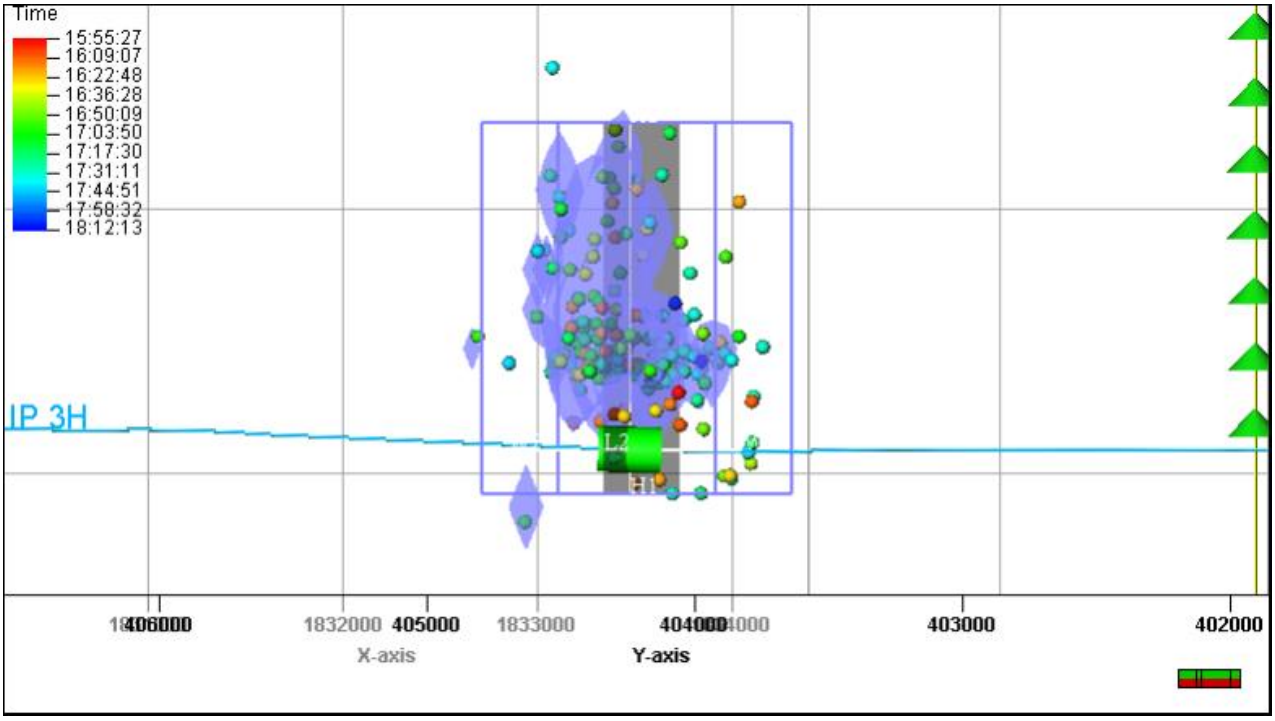



**Figure 5-13 - MIP 3H Stage 9 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 9 are shown below in map and transverse views.

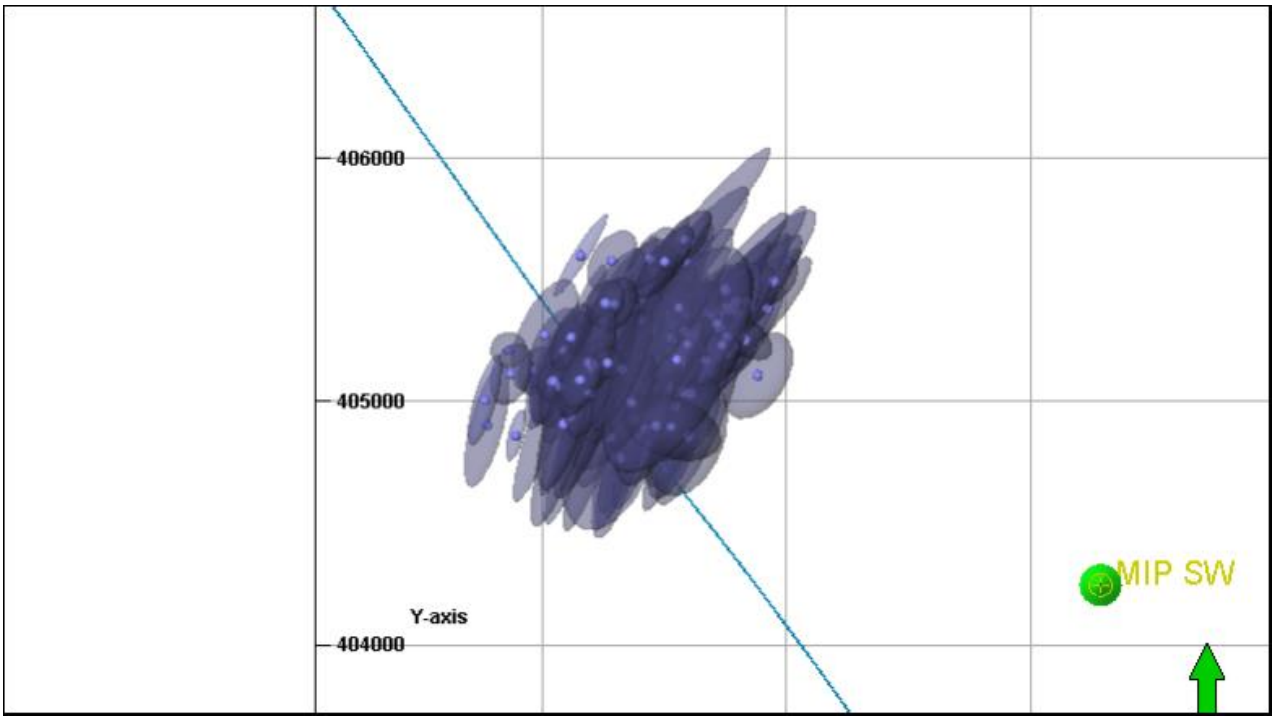



**Figure 5-14 - MIP 3H Stage 9 event location uncertainty ellipsoids – map view**

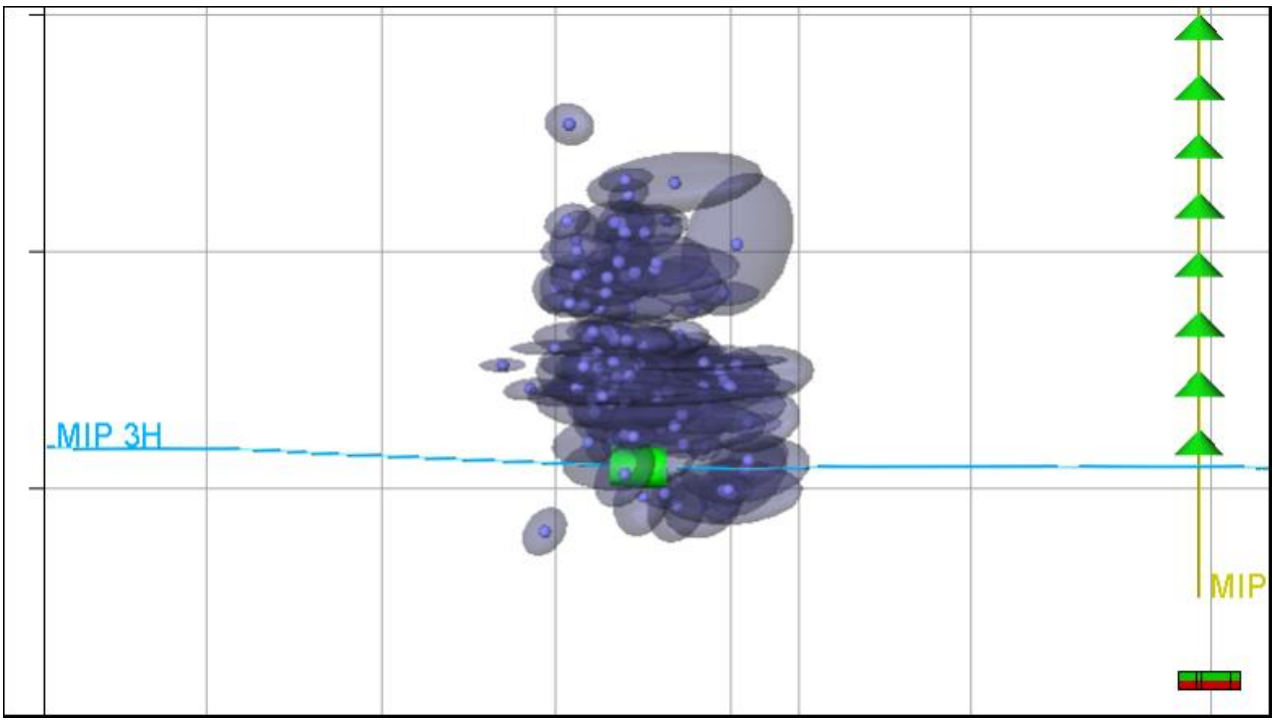



**Figure 5-15 - MIP 3H Stage 9 event location uncertainty ellipsoids – side view**

### 5.3.1 MIP 3H Stage 9 On-Site Notes and Observations

### 5.4 MIP 3H Stage 10

The MIP 3H Stage 10 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

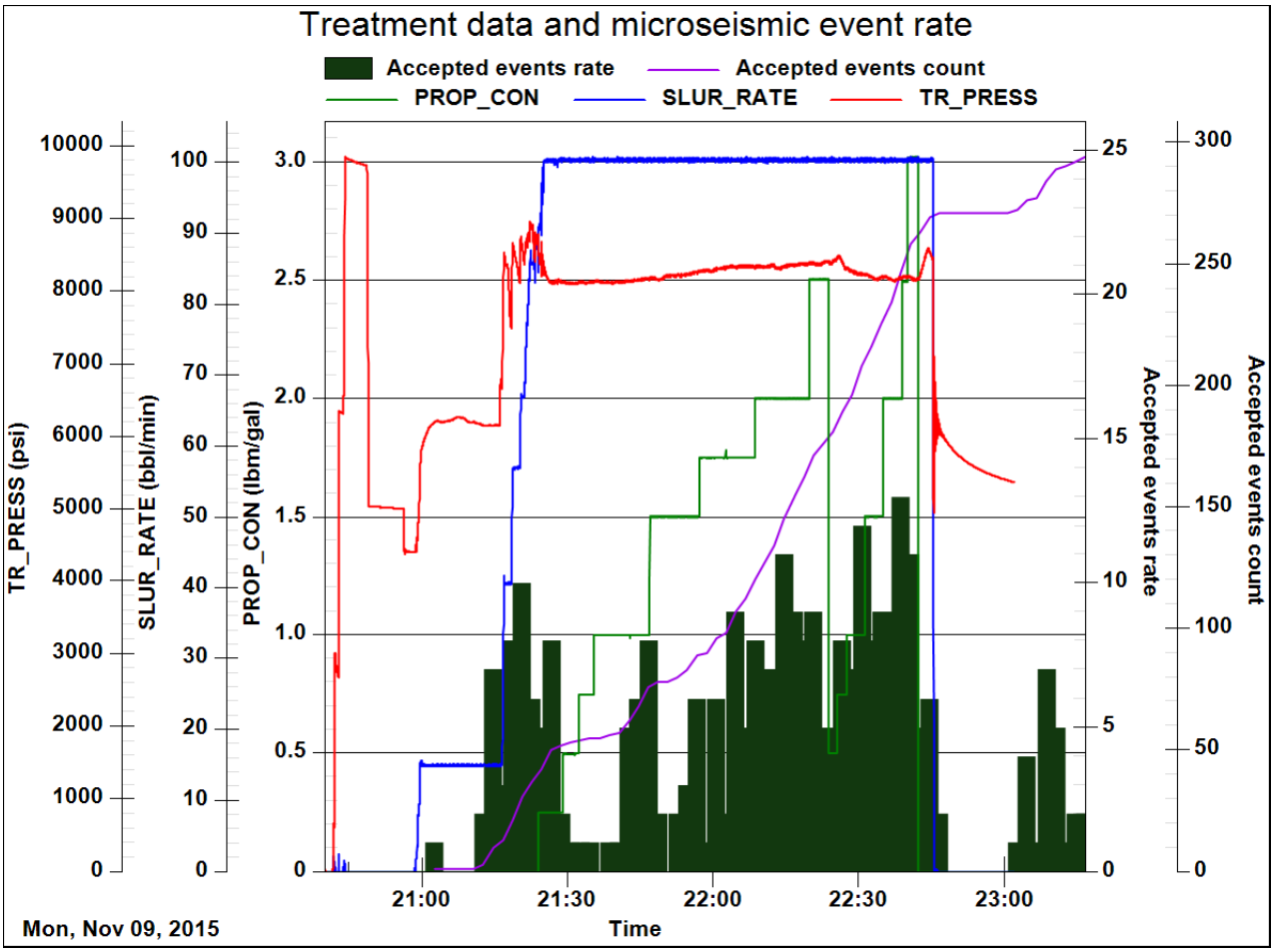



**Figure 5-16 - MIP 3H Stage 10 treatment data and microseismic event rate**

**Table 5.10 - MIP 3H Stage 10 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 343743 | 350116 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 346743 | 353116 |
| 100 Mesh (lbm) | 330000 | 329940 |
| 40/70 White (lbm) | 110000 | 110080 |
| Total proppants (lbm) | 440000 | 440020 |

**Table 5.11 - MIP 3H Stage 10 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 100 |
| Average pressure (psi) | 8253 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6241 |
| Maximum PPA (lbm/gal) | 3.021 |

**Table 5.12 - MIP 3H Stage 10 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 78 |
| MS length (ft) | 1250 |
| MS height (ft) | 335 |
| MS volume (million ft3) | 67.4 |

The microseismic data from MIP 3H Stage 10 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

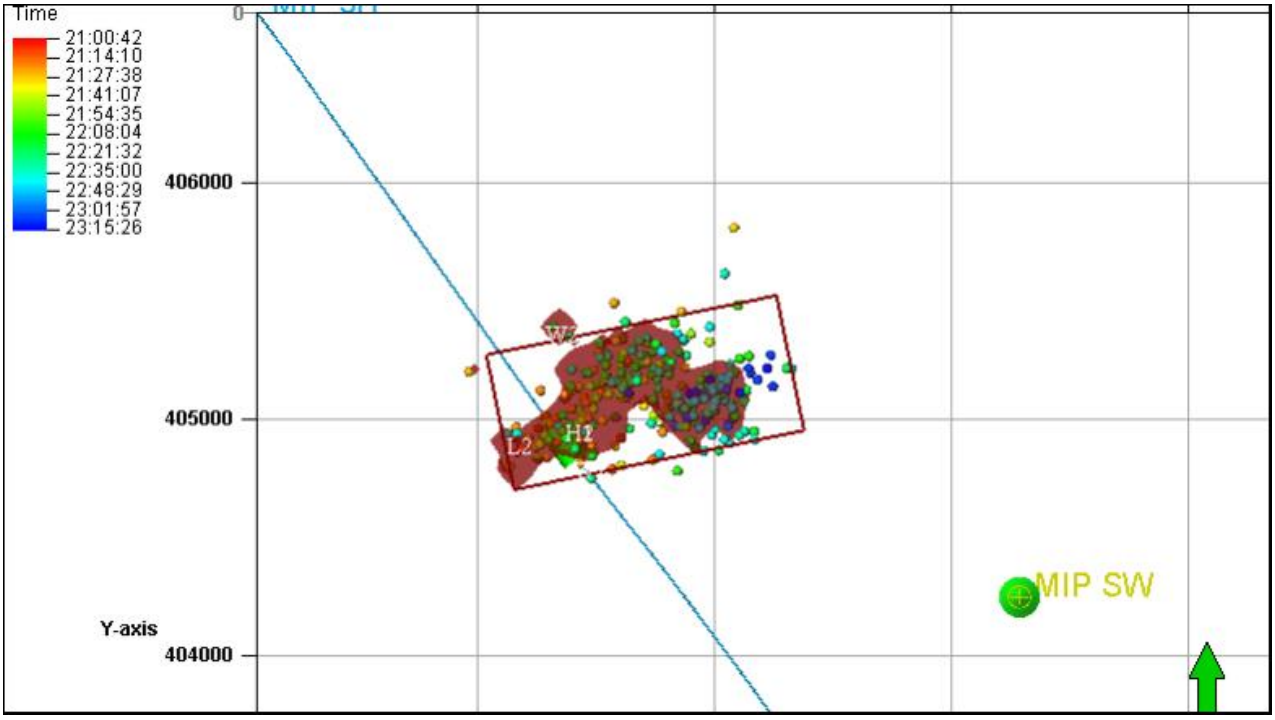



**Figure 5-17 - MIP 3H Stage 10 map view (length and width)**

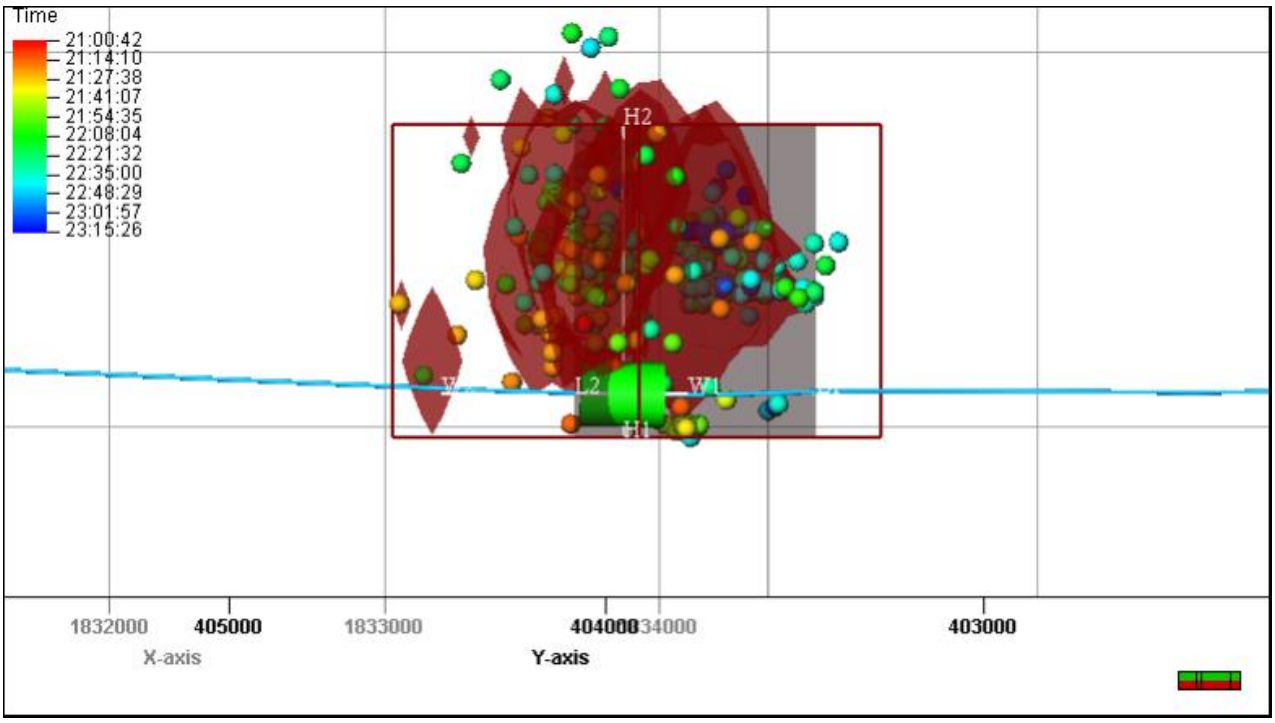



**Figure 5-18 - MIP 3H Stage 10 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 10 are shown below in map and transverse views.

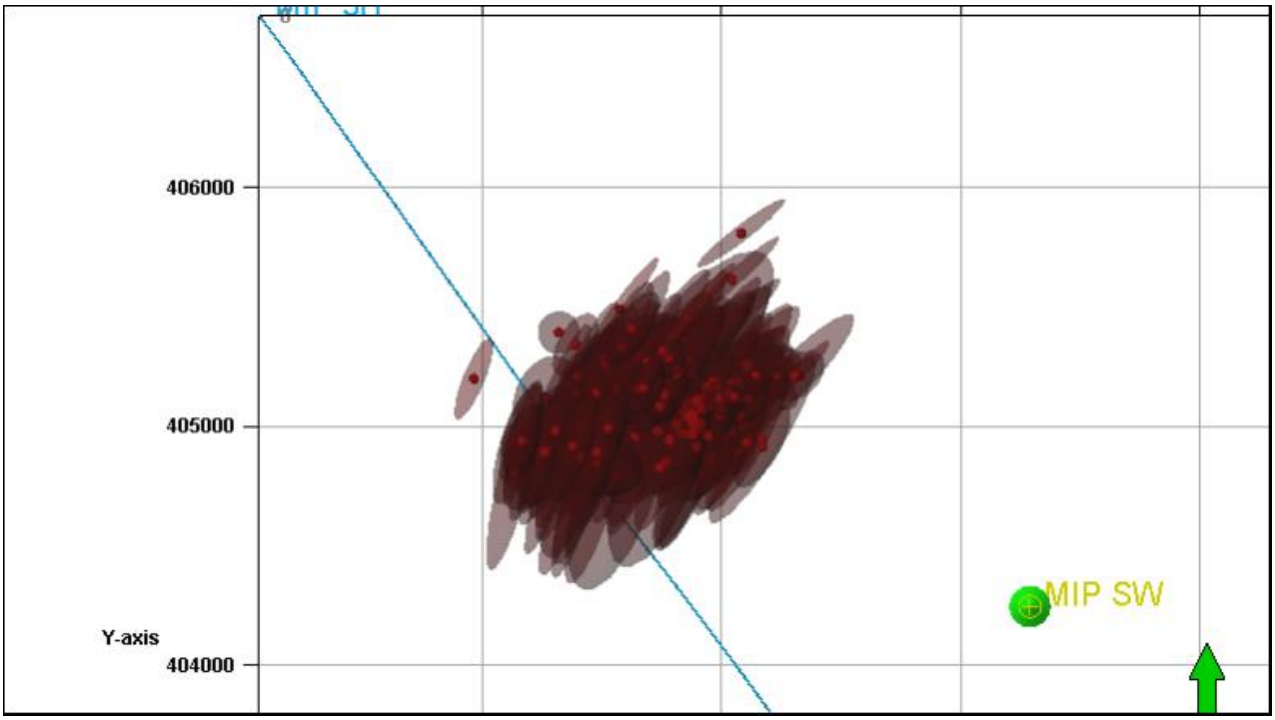



**Figure 5-19 - MIP 3H Stage 10 event location uncertainty ellipsoids – map view**

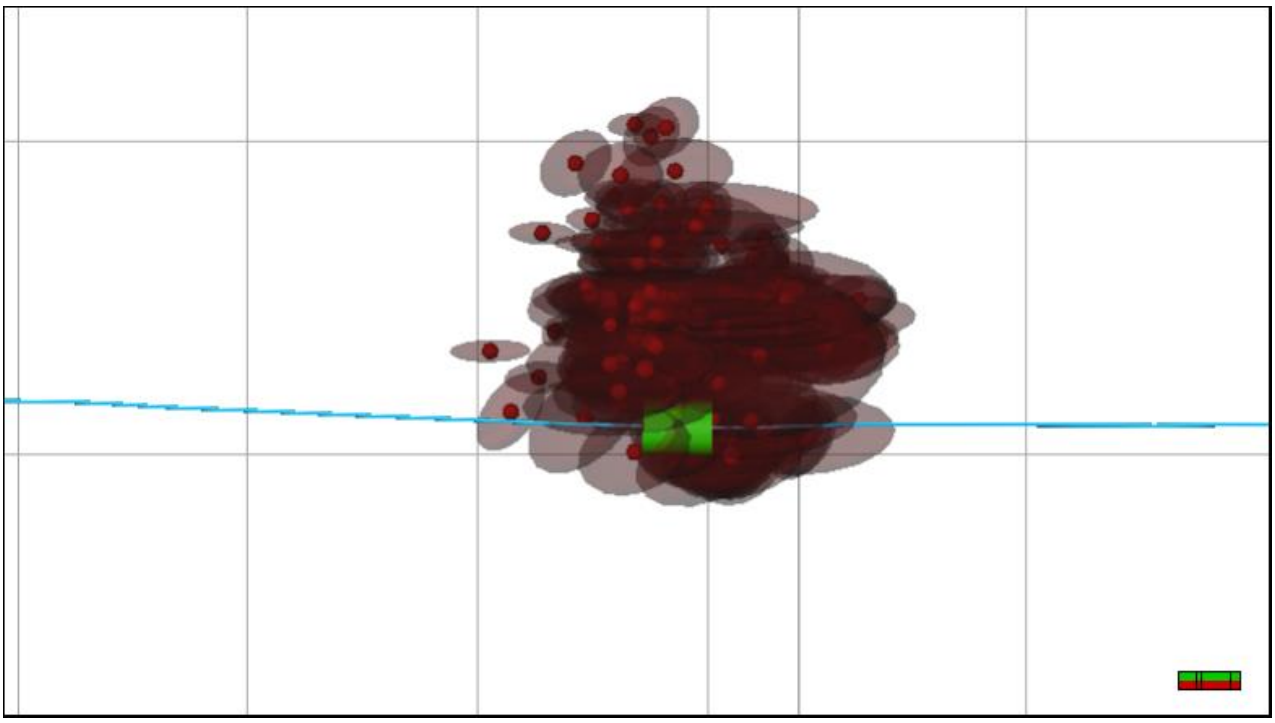


**Figure 5-20 - MIP 3H Stage 10 event location uncertainty ellipsoids – side view**

### 5.4.1 MIP 3H Stage 10 On-Site Notes and Observations

## 5.5 MIP 3H Stage 11

The MIP 3H Stage 11 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

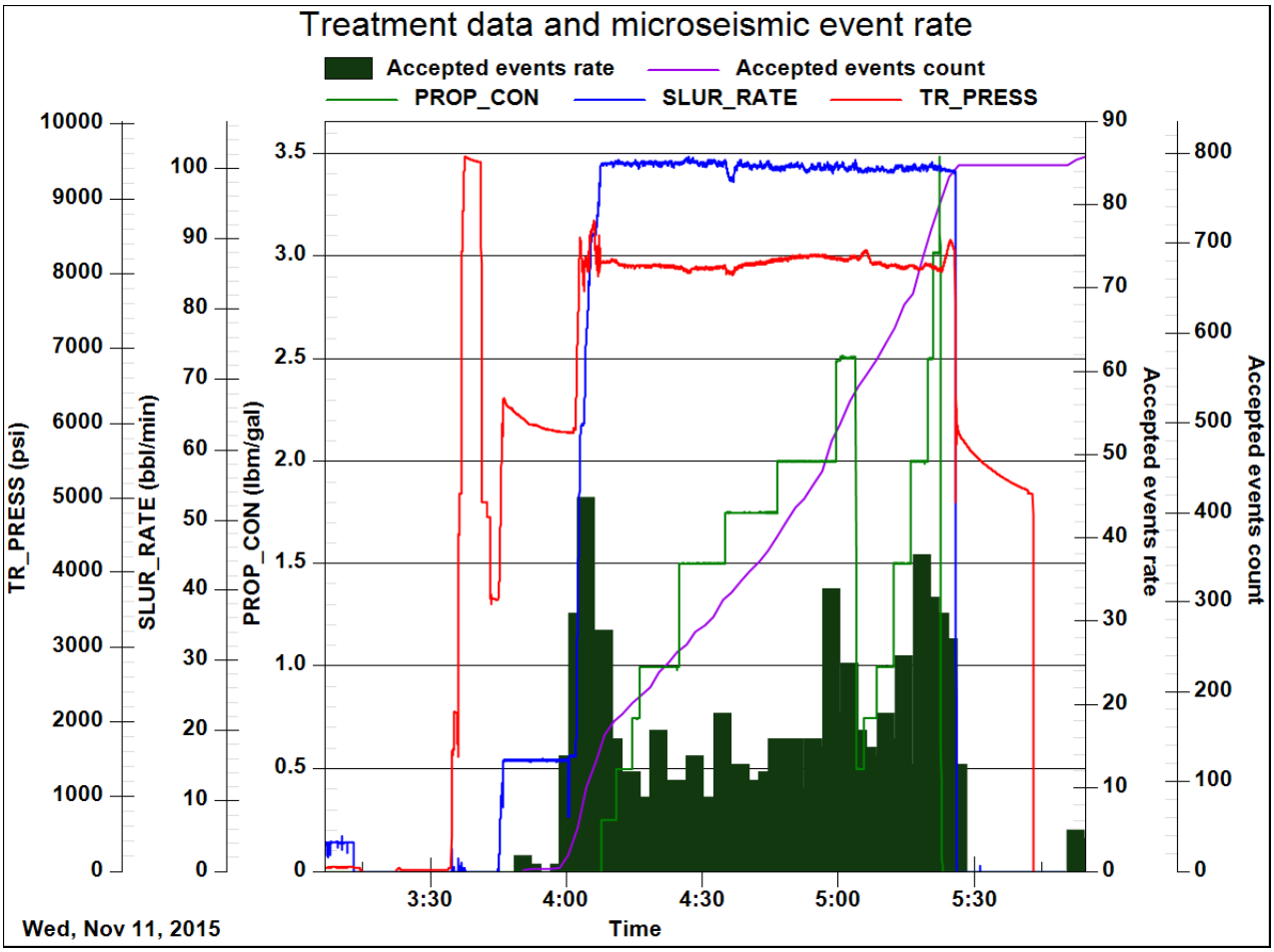



**Figure 5-21 - MIP 3H Stage 11 treatment data and microseismic event rate**

**Table 5.13 - MIP 3H Stage 11 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 343743 | 335169 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 346743 | 338169 |
| 100 Mesh (lbm) | 330000 | 330560 |
| 40/70 White (lbm) | 110000 | 109960 |
| Total proppants (lbm) | 440000 | 440520 |

**Table 5.14 - MIP 3H Stage 11 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.9 |
| Average pressure (psi) | 8135 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6022 |
| Maximum PPA (lbm/gal) | 3.484 |

**Table 5.15 - MIP 3H Stage 11 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 57 |
| MS length (ft) | 1233 |
| MS height (ft) | 536 |
| MS volume (million ft3) | 86.2 |

The microseismic data from MIP 3H Stage 11 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

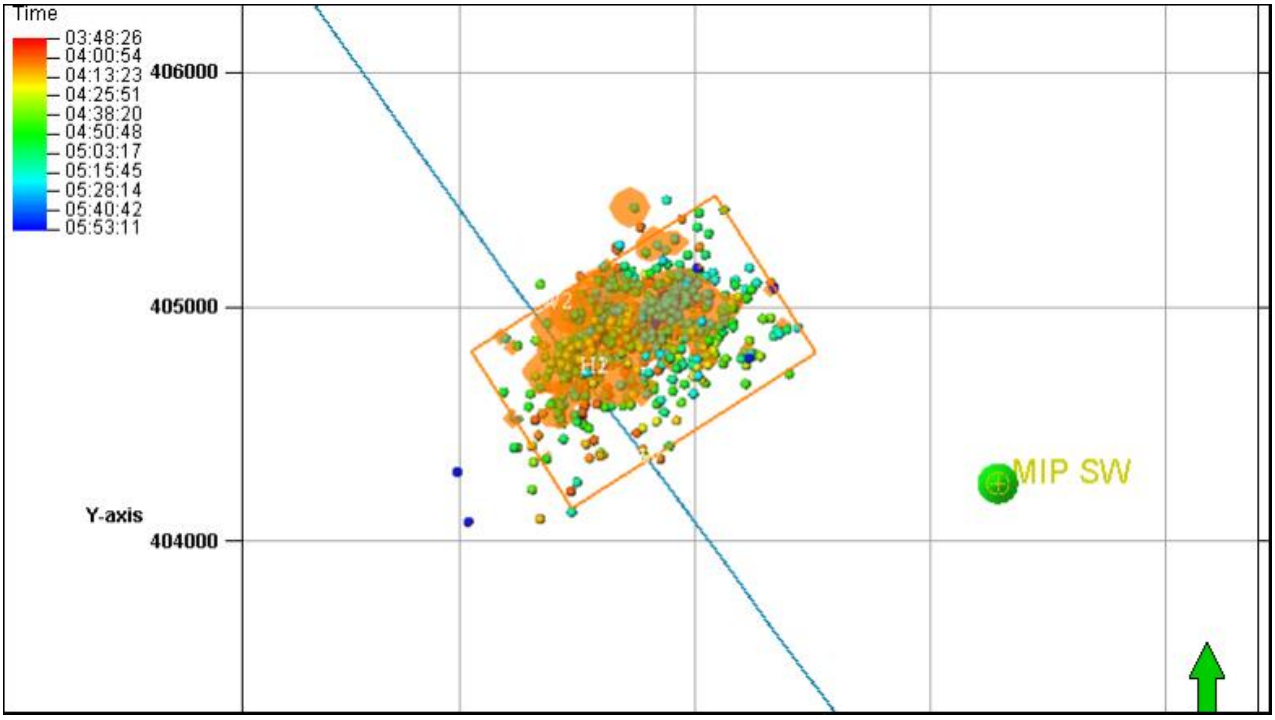



**Figure 5-22 - MIP 3H Stage 11 map view (length and width)**

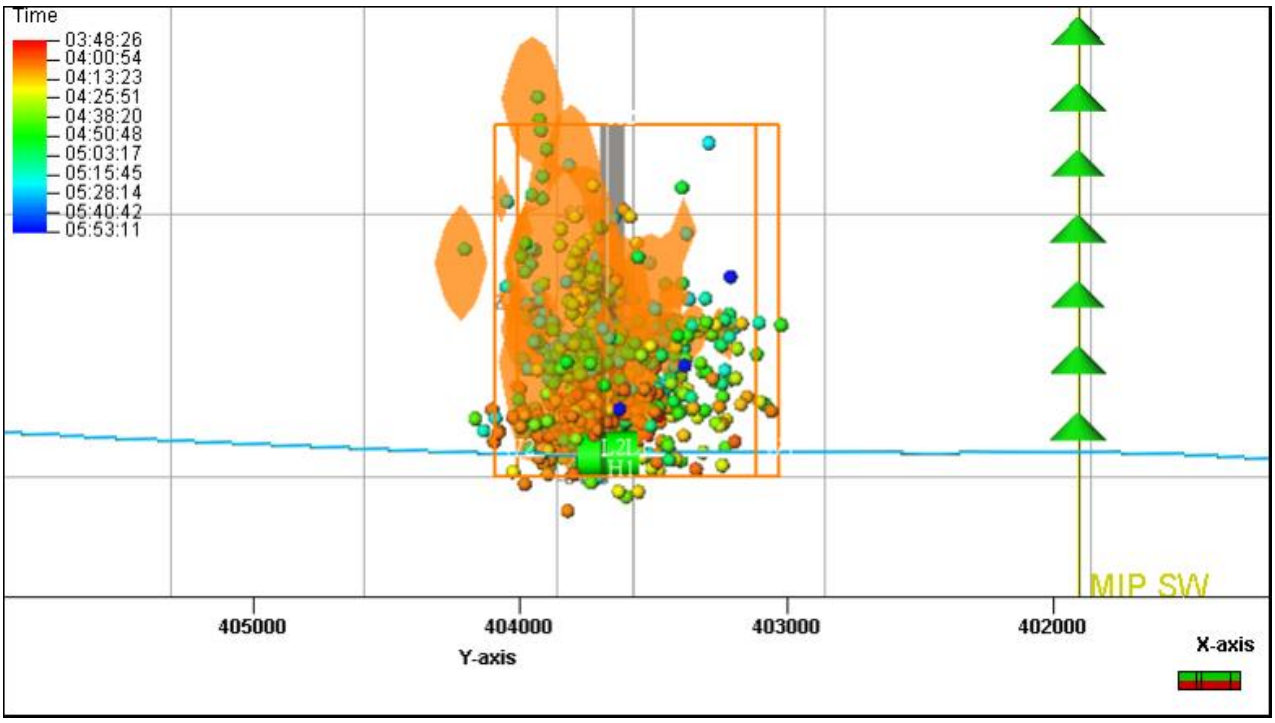



**Figure 5-23 - MIP 3H Stage 11 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 11 are shown below in map and transverse views.

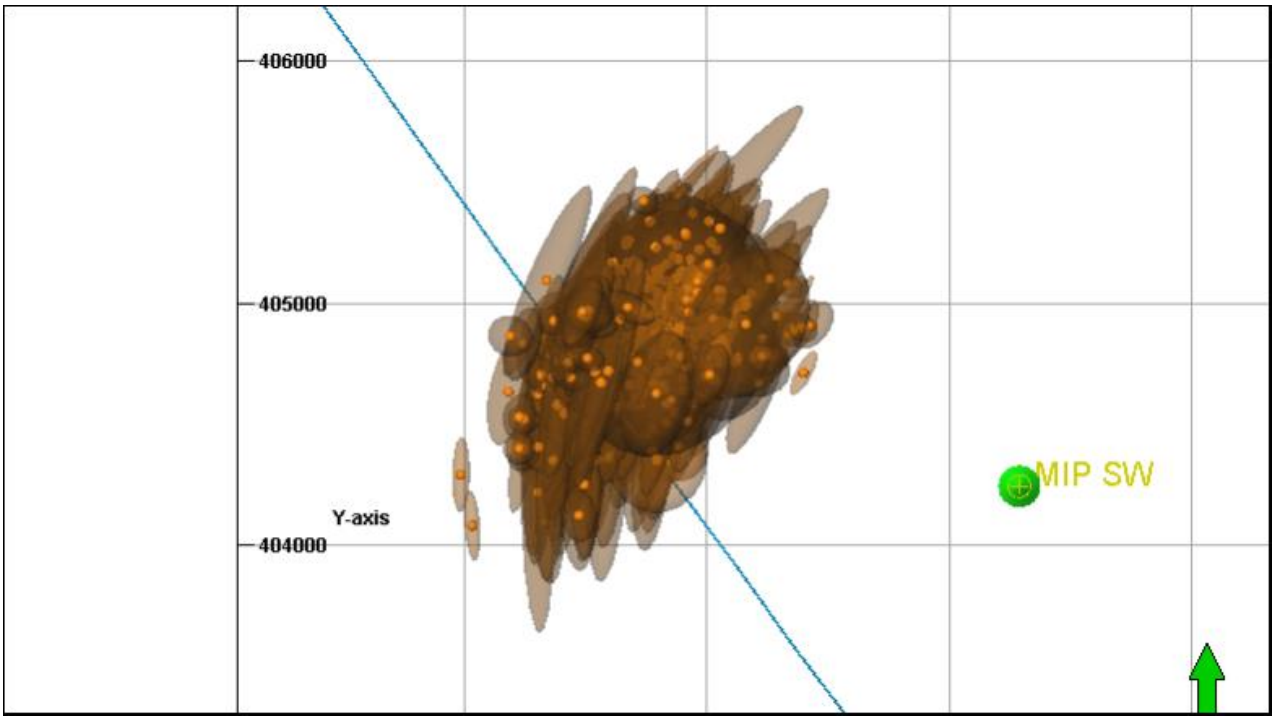



**Figure 5-24 - MIP 3H Stage 11 event location uncertainty ellipsoids – map view**

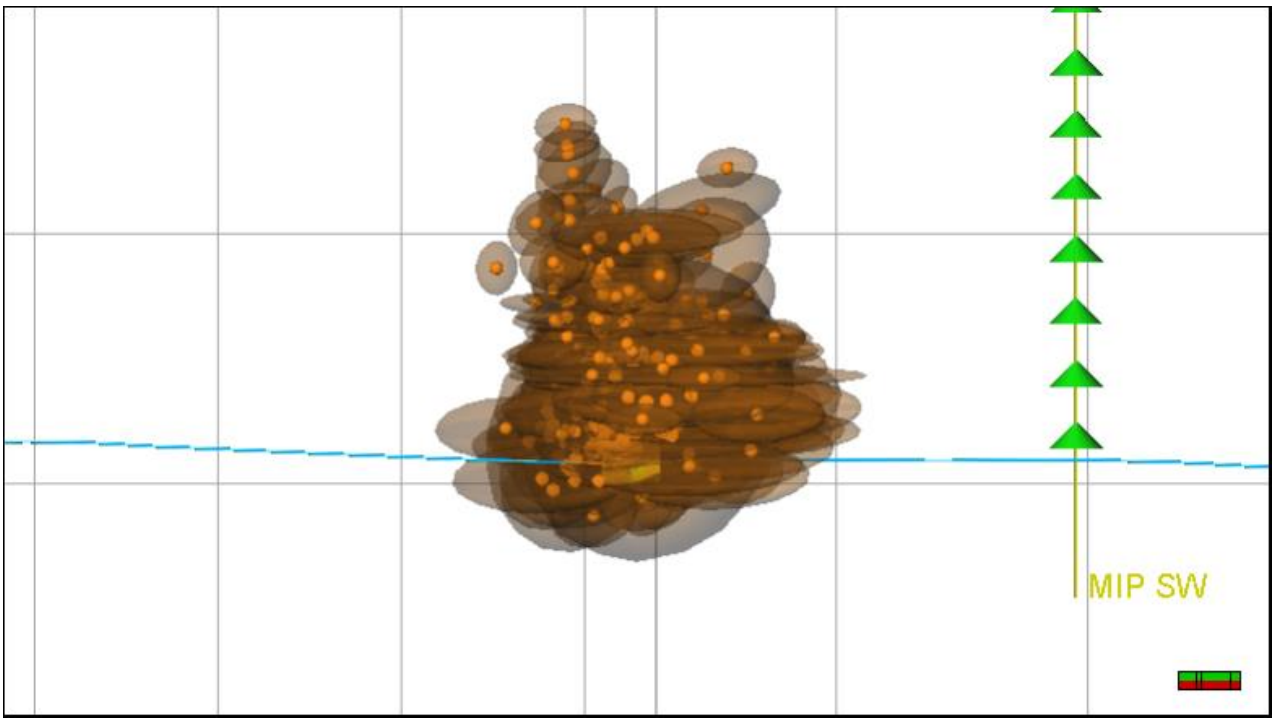



**Figure 5-25 - MIP 3H Stage 11 event location uncertainty ellipsoids – side view**

### 5.5.1 MIP 3H Stage 11 On-Site Notes and Observations

### 5.6 MIP 3H Stage 12

The MIP 3H Stage 12 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

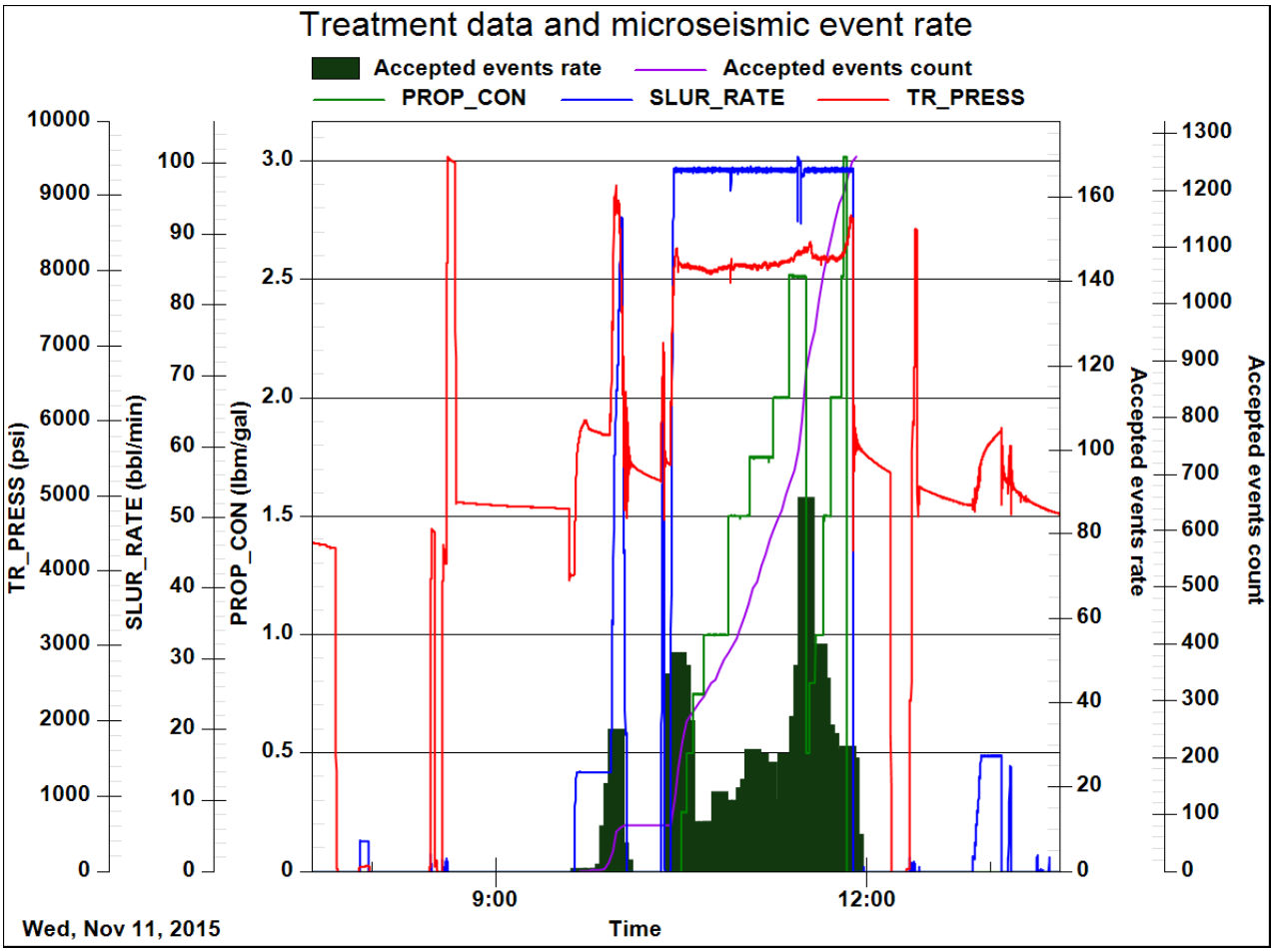



**Figure 5-26 - MIP 3H Stage 12 treatment data and microseismic event rate**

**Table 5.16 - MIP 3H Stage 12 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 343743 | 374309 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 346743 | 377309 |
| 100 Mesh (lbm) | 330000 | 330320 |
| 40/70 White (lbm) | 110000 | 110360 |
| Total proppants (lbm) | 440000 | 440680 |

**Table 5.17 - MIP 3H Stage 12 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.2 |
| Average pressure (psi) | 8201 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5898 |
| Maximum PPA (lbm/gal) | 3.017 |

**Table 5.18 - MIP 3H Stage 12 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 74 |
| MS length (ft) | 1453 |
| MS height (ft) | 558 |
| MS volume (million ft3) | 193.2 |

The microseismic data from MIP 3H Stage 12 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

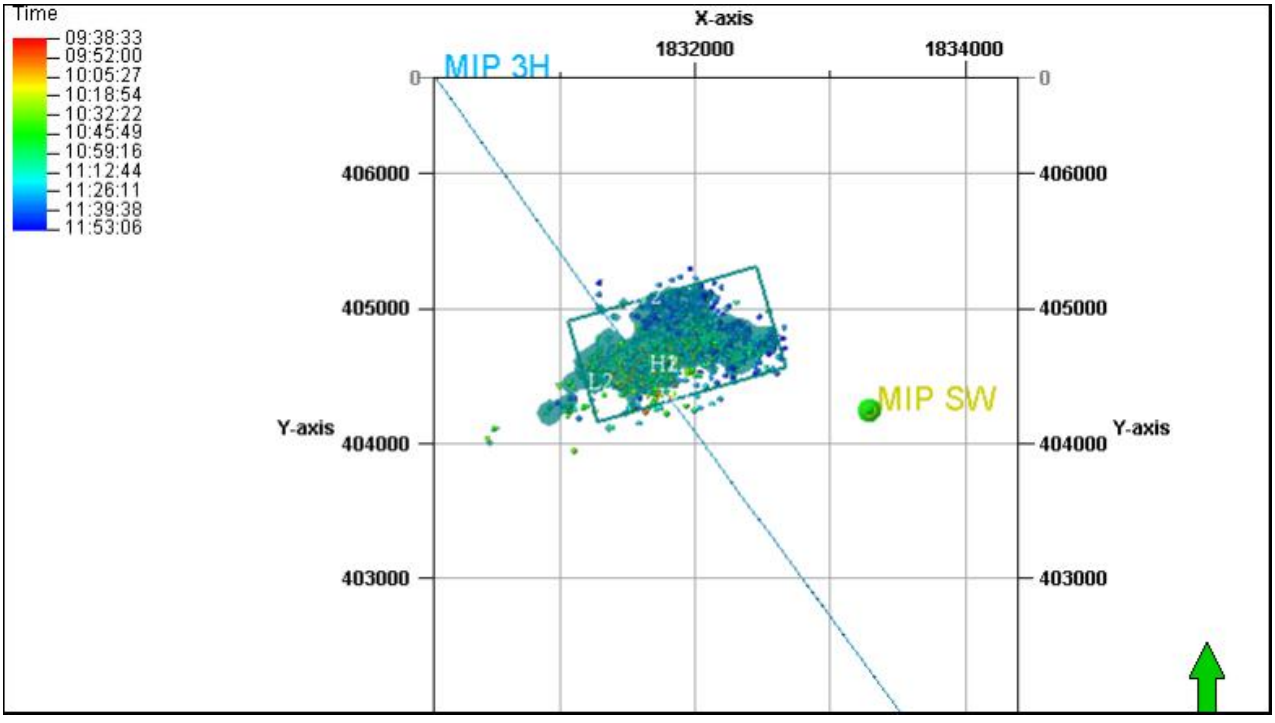



**Figure 5-27 - MIP 3H Stage 12 map view (length and width)**

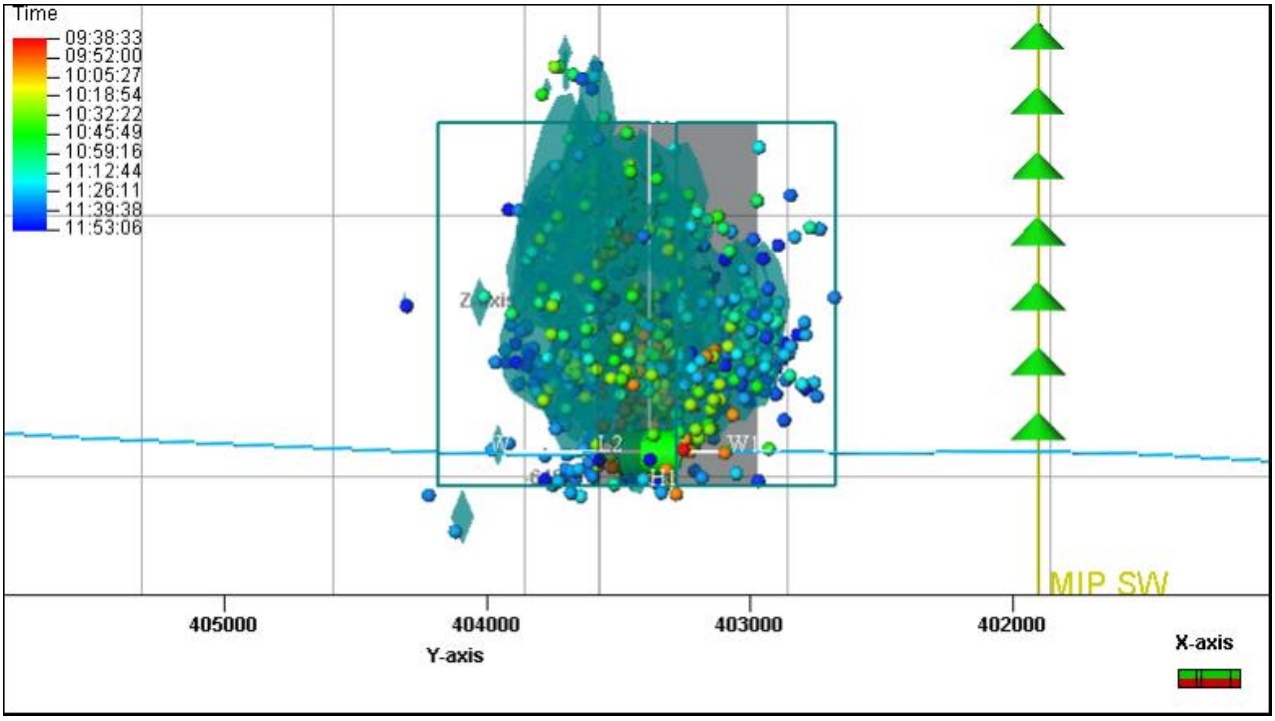



**Figure 5-28 - MIP 3H Stage 12 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 12 are shown below in map and transverse views.

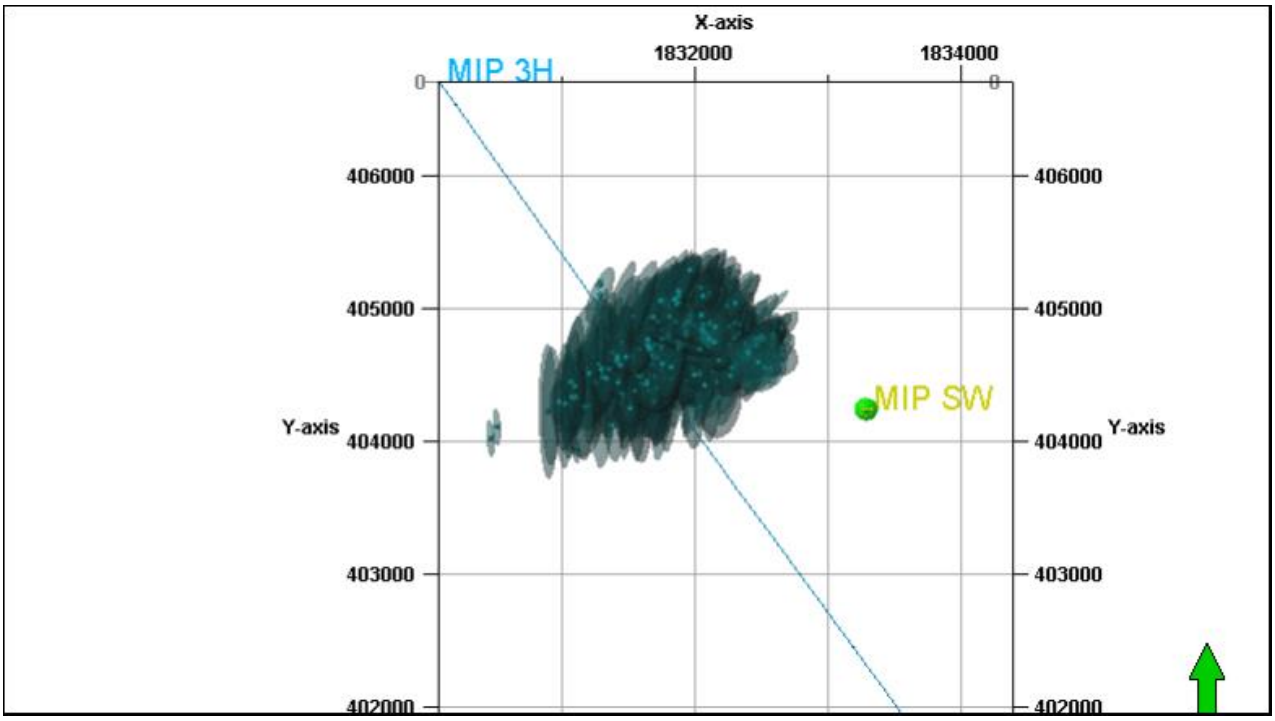



**Figure 5-29 - MIP 3H Stage 12 event location uncertainty ellipsoids – map view**

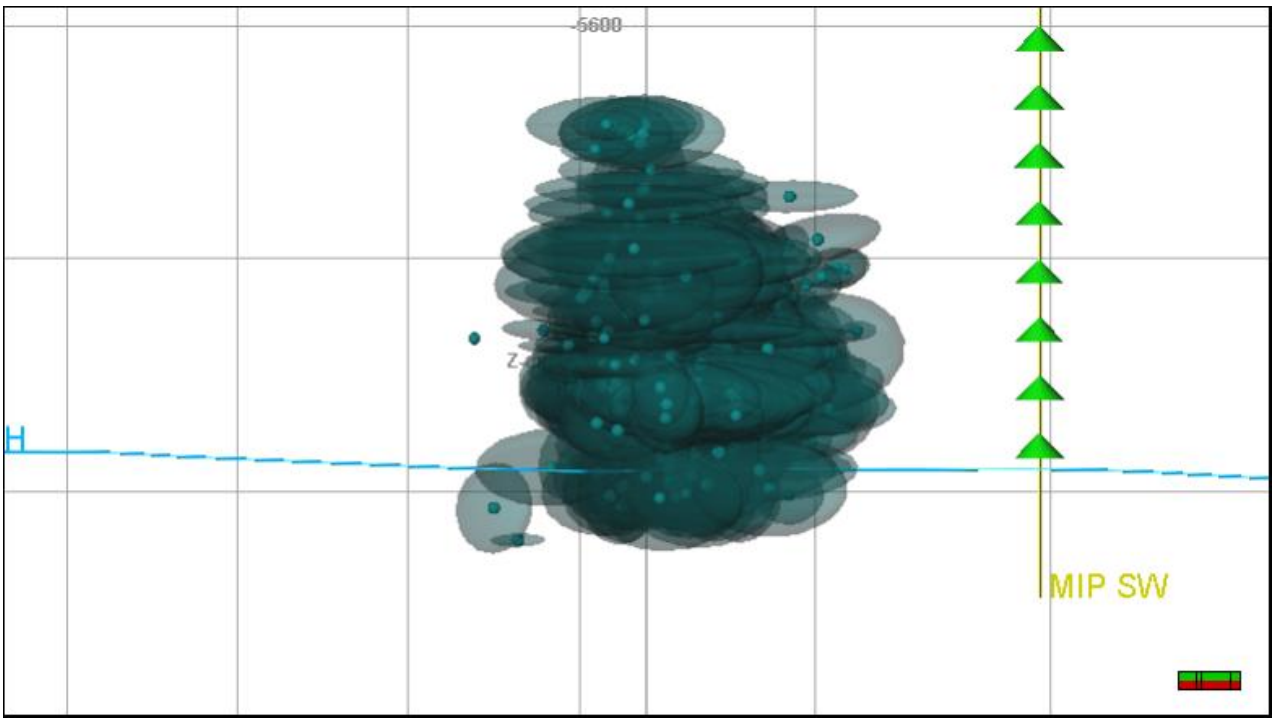



**Figure 5-30 - MIP 3H Stage 12 event location uncertainty ellipsoids – side view**

### 5.6.1 MIP 3H Stage 12 On-Site Notes and Observations

## 5.7 MIP 3H Stage 13

The MIP 3H Stage 13 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

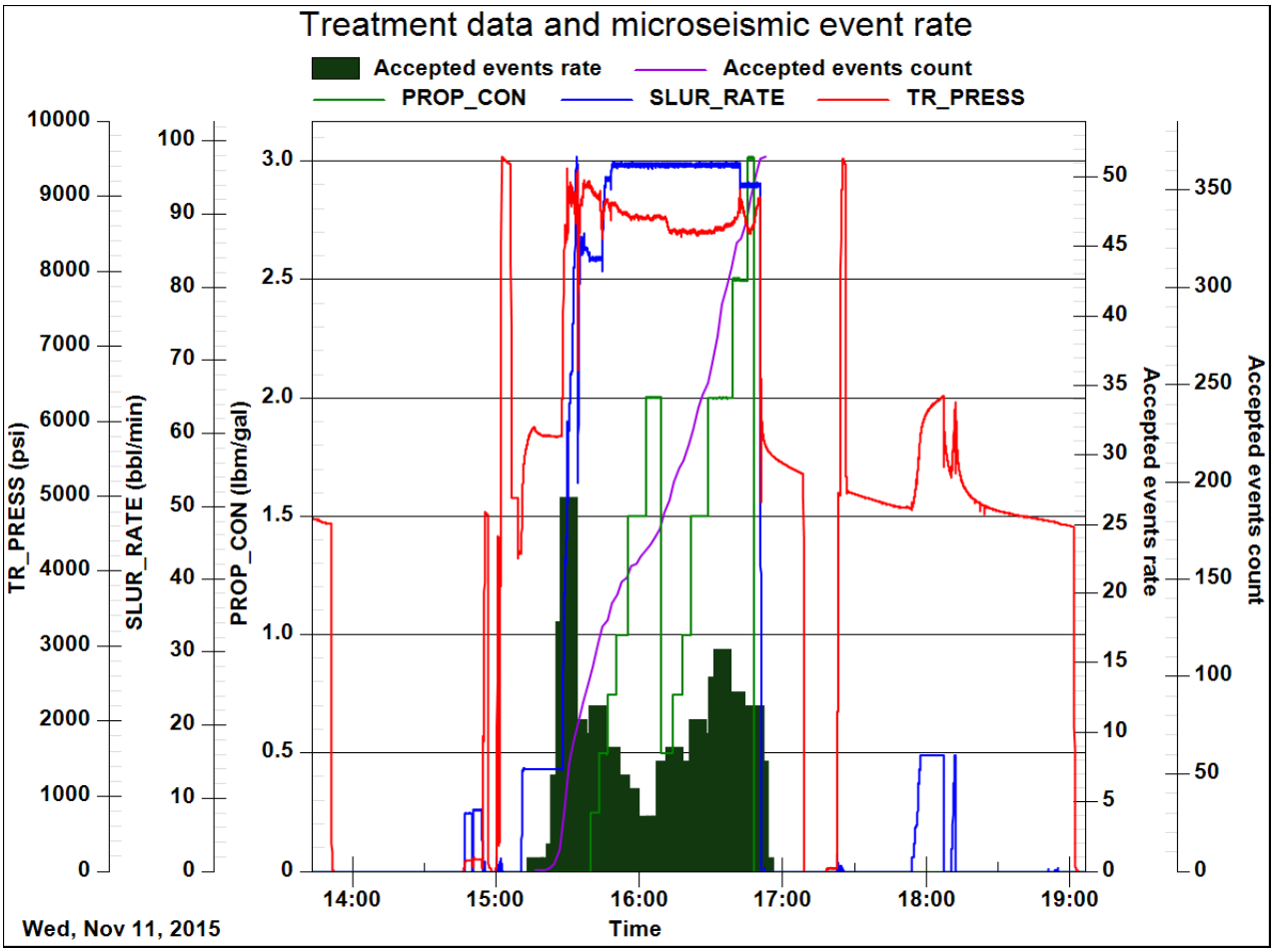



**Figure 5-31 - MIP 3H Stage 13 treatment data and microseismic event rate**

**Table 5.19 - MIP 3H Stage 13 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 310567 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 2999 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 369060 | 313566 |
| 100 Mesh (lbm) | 155200 | 127500 |
| 40/70 White (lbm) | 284800 | 232780 |
| Total proppants (lbm) | 440000 | 360280 |

**Table 5.20 - MIP 3H Stage 13 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 95.1 |
| Average pressure (psi) | 8696 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6015 |
| Maximum PPA (lbm/gal) | 3.018 |

**Table 5.21 - MIP 3H Stage 13 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 80 |
| MS length (ft) | 1924 |
| MS height (ft) | 561 |
| MS volume (million ft3) | 47.7 |

The microseismic data from MIP 3H Stage 13 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

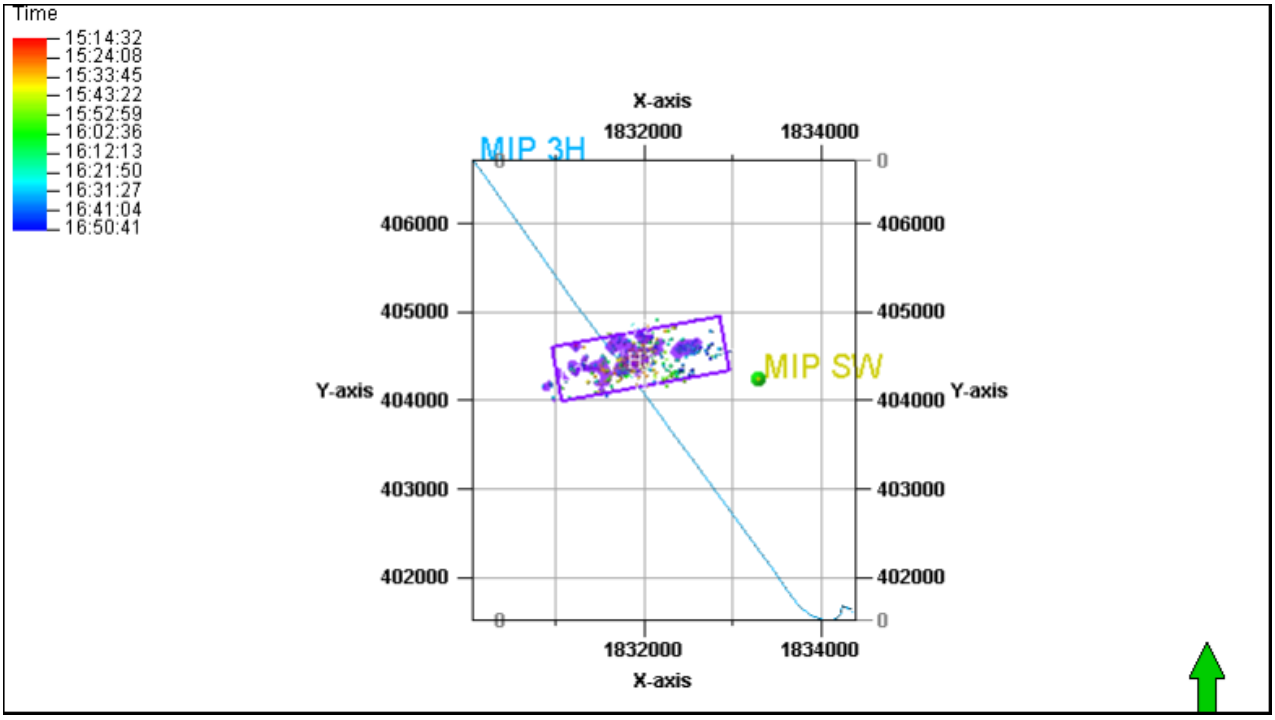



**Figure 5-32 - MIP 3H Stage 13 map view (length and width)**

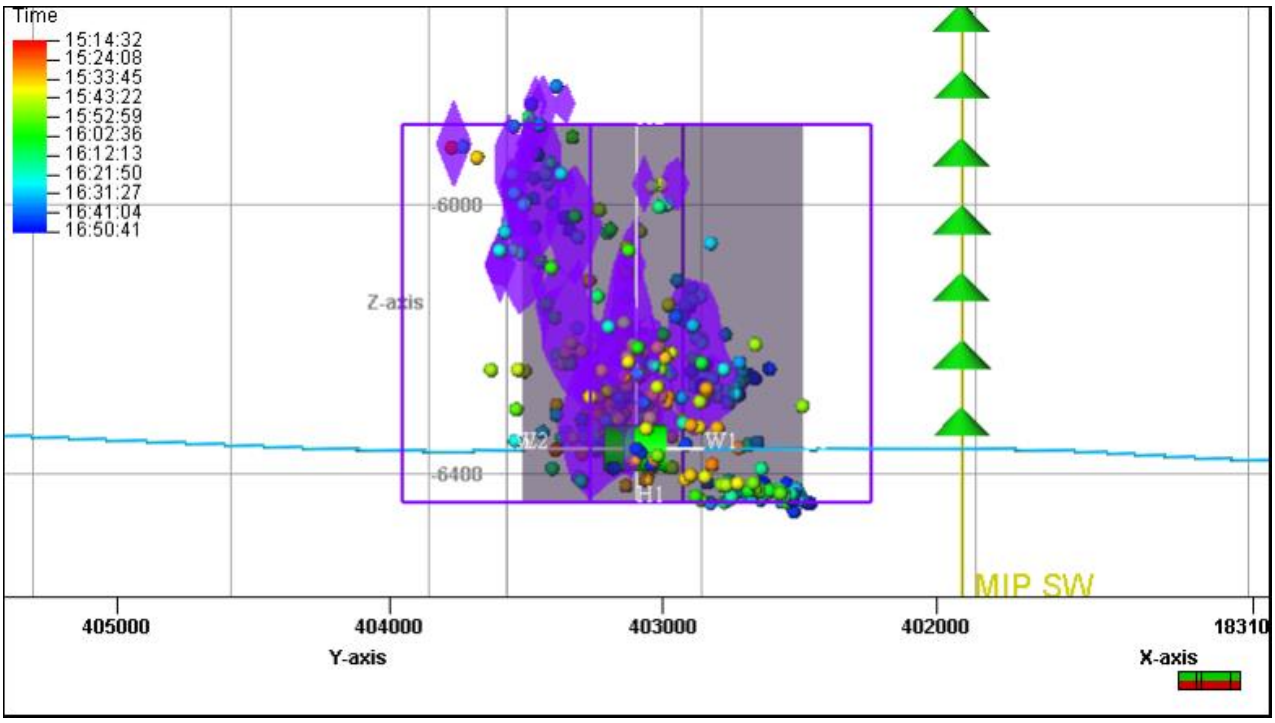



**Figure 5-33 - MIP 3H Stage 13 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 13 are shown below in map and transverse views.

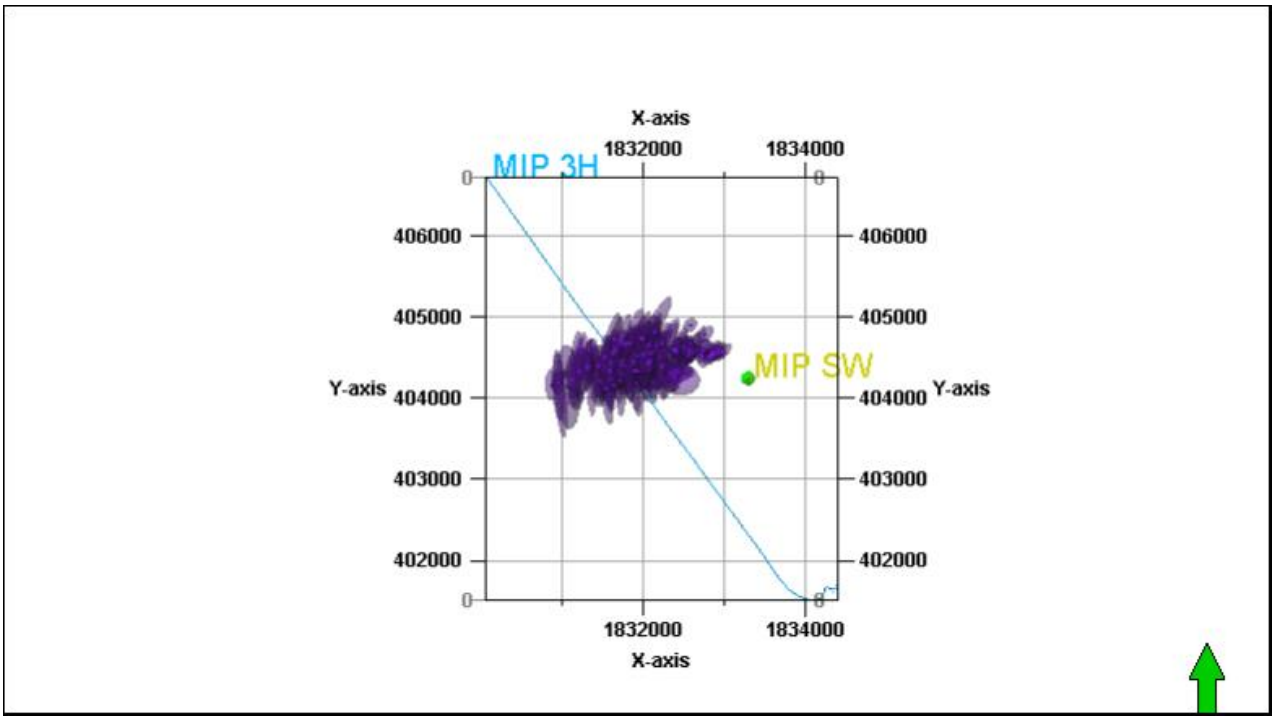



**Figure 5-34 - MIP 3H Stage 13 event location uncertainty ellipsoids – map view**

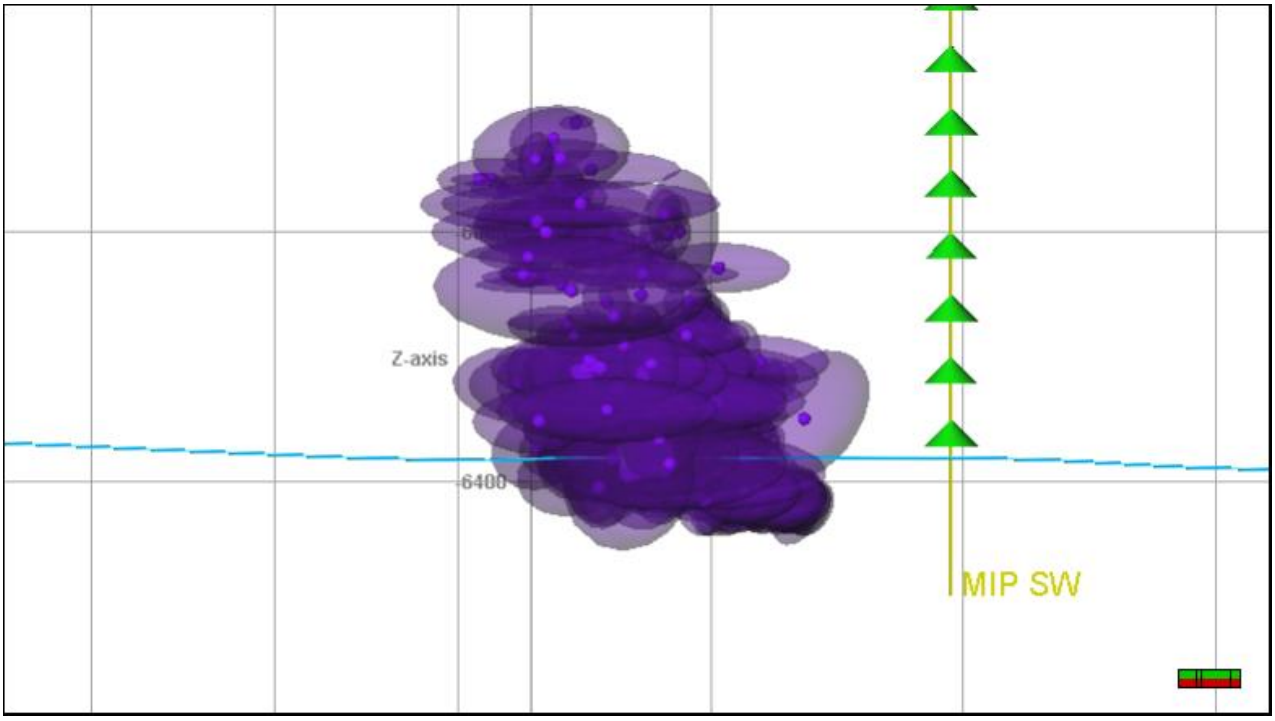



**Figure 5-35 - MIP 3H Stage 13 event location uncertainty ellipsoids – side view**

### 5.7.1 MIP 3H Stage 13 On-Site Notes and Observations

### 5.8 MIP 3H Stage 14

The MIP 3H Stage 14 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

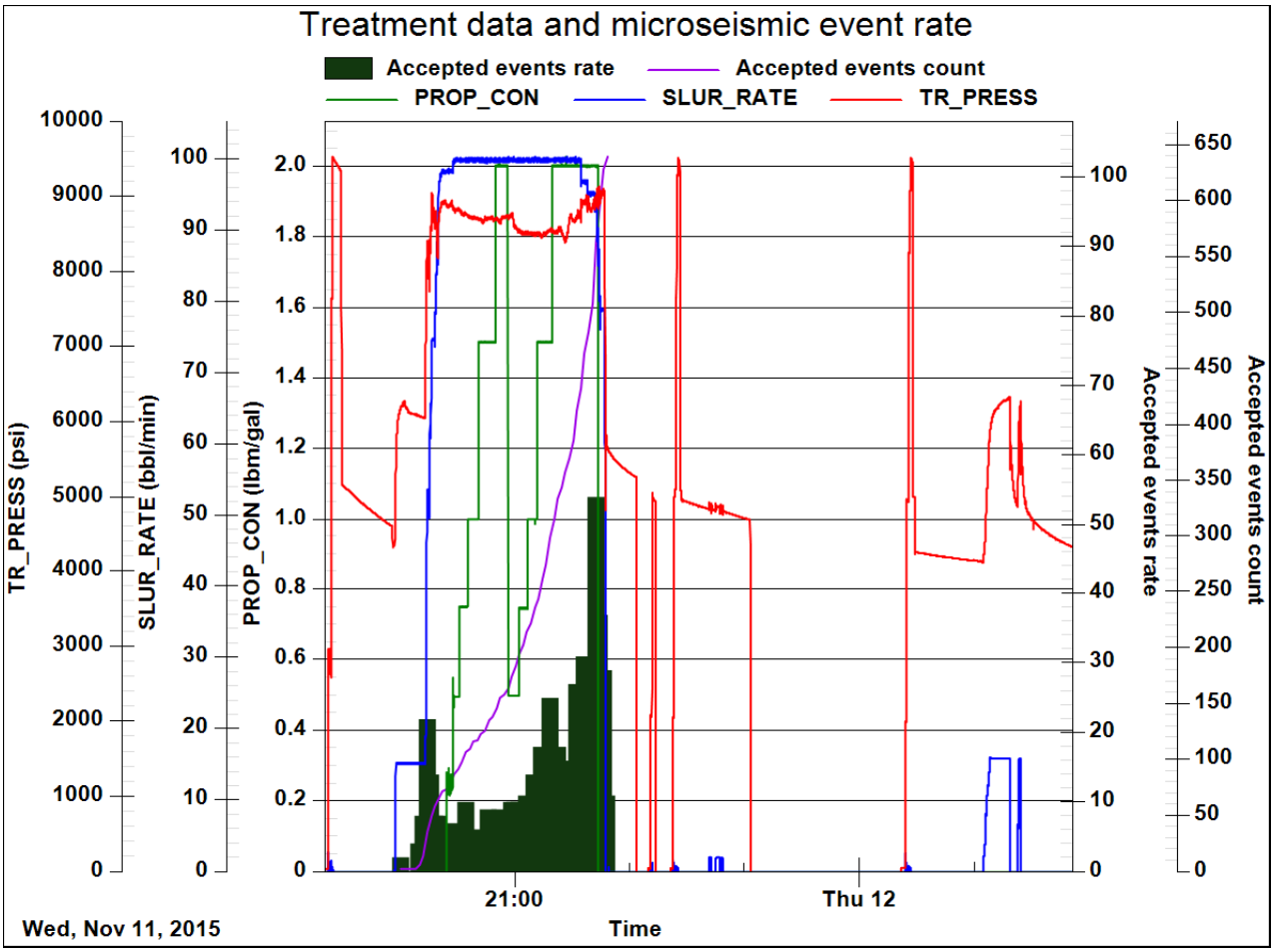



**Figure 5-36 - MIP 3H Stage 14 treatment data and microseismic event rate**

**Table 5.22 - MIP 3H Stage 14 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 366422 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 369060 | 369422 |
| 100 Mesh (lbm) | 155200 | 155380 |
| 40/70 White (lbm) | 284800 | 281680 |
| Total proppants (lbm) | 440000 | 437060 |

**Table 5.23 - MIP 3H Stage 14 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 98.3 |
| Average pressure (psi) | 8694 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5867 |
| Maximum PPA (lbm/gal) | 2.026 |

**Table 5.24 - MIP 3H Stage 14 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 88 |
| MS length (ft) | 1576 |
| MS height (ft) | 556 |
| MS volume (million ft3) | 67.2 |

The microseismic data from MIP 3H Stage 14 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

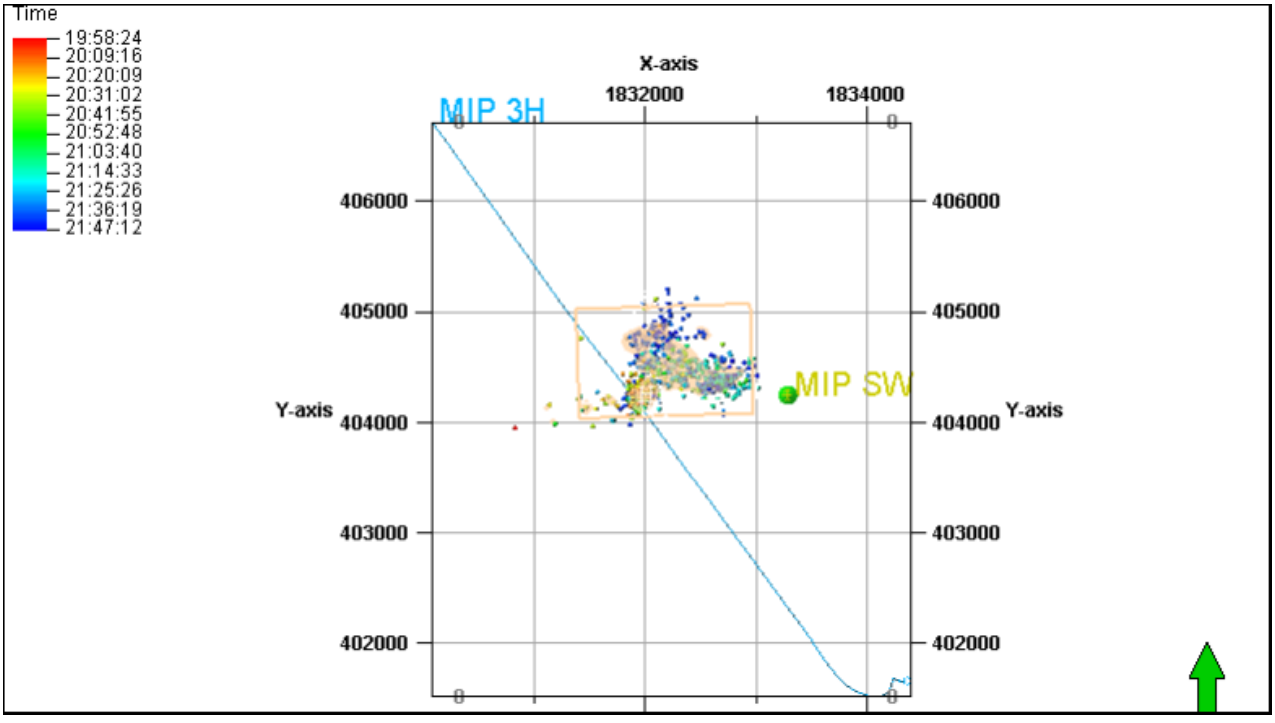



**Figure 5-37 - MIP 3H Stage 14 map view (length and width)**

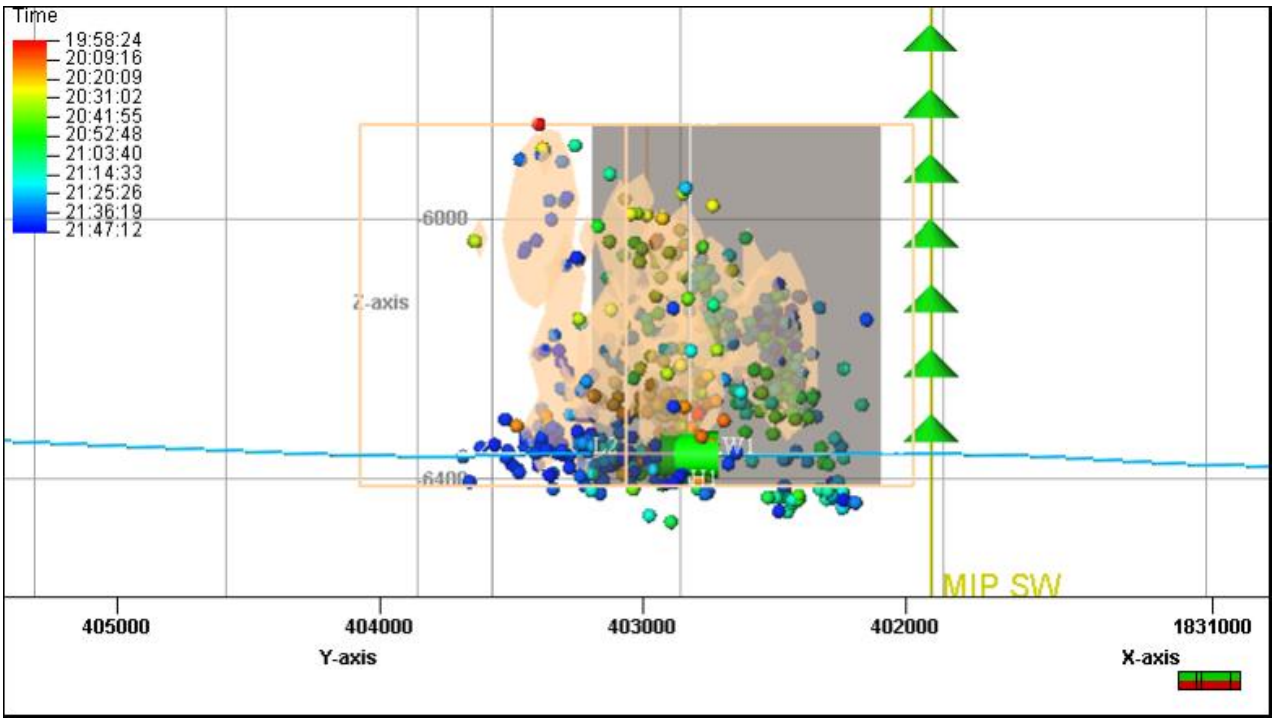



**Figure 5-38 - MIP 3H Stage 14 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 14 are shown below in map and transverse views.

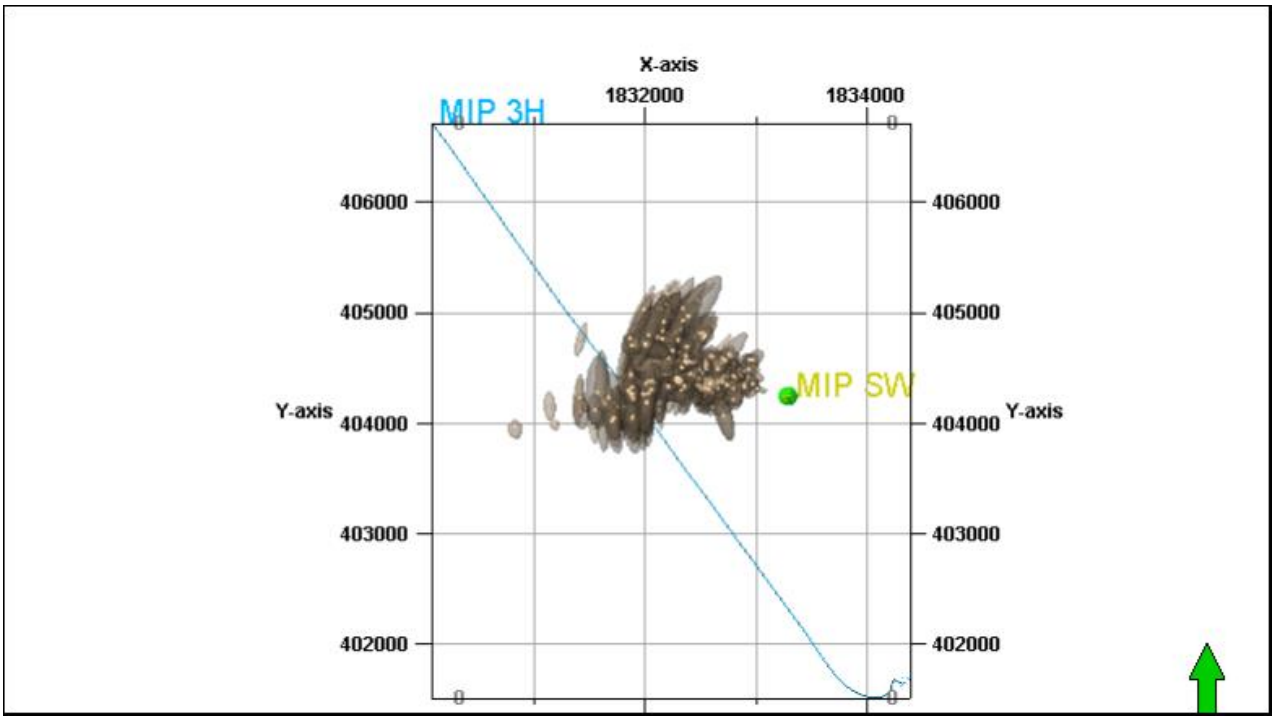



**Figure 5-39 - MIP 3H Stage 14 event location uncertainty ellipsoids – map view**

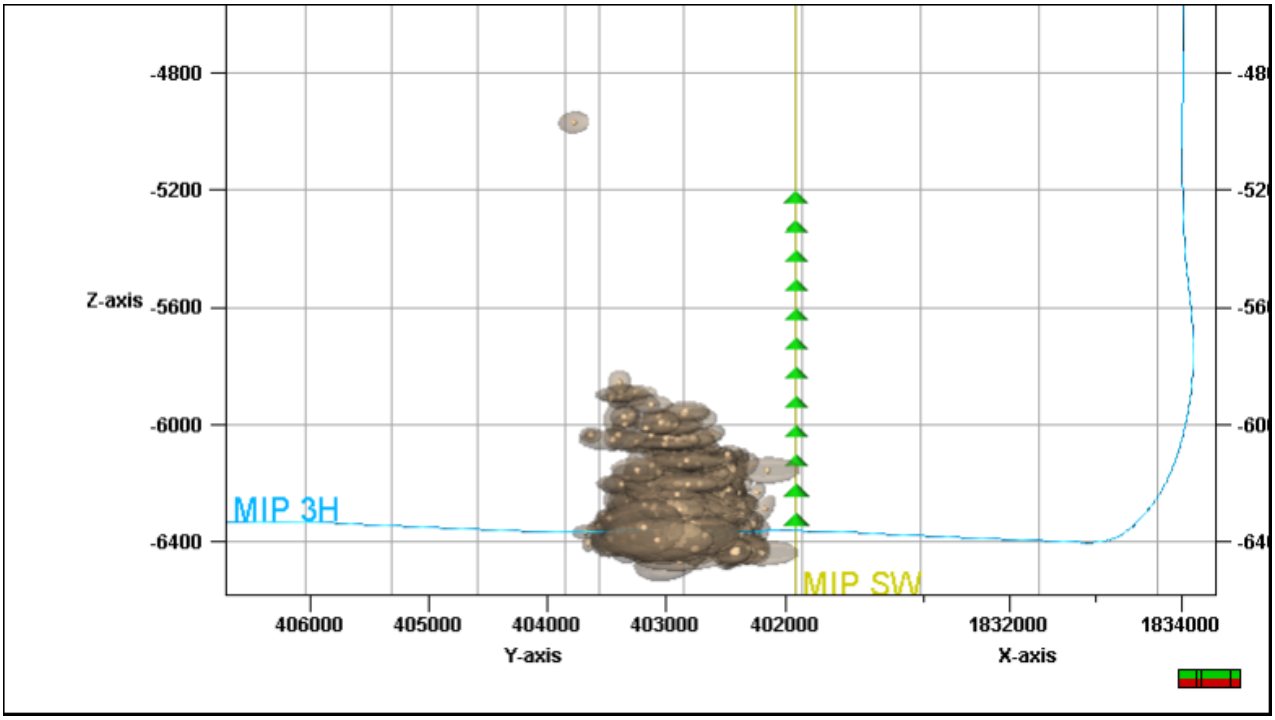



**Figure 5-40 - MIP 3H Stage 14 event location uncertainty ellipsoids – side view**

### 5.8.1 MIP 3H Stage 14 On-Site Notes and Observations

### 5.9 MIP 3H Stage 15

The MIP 3H Stage 15 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

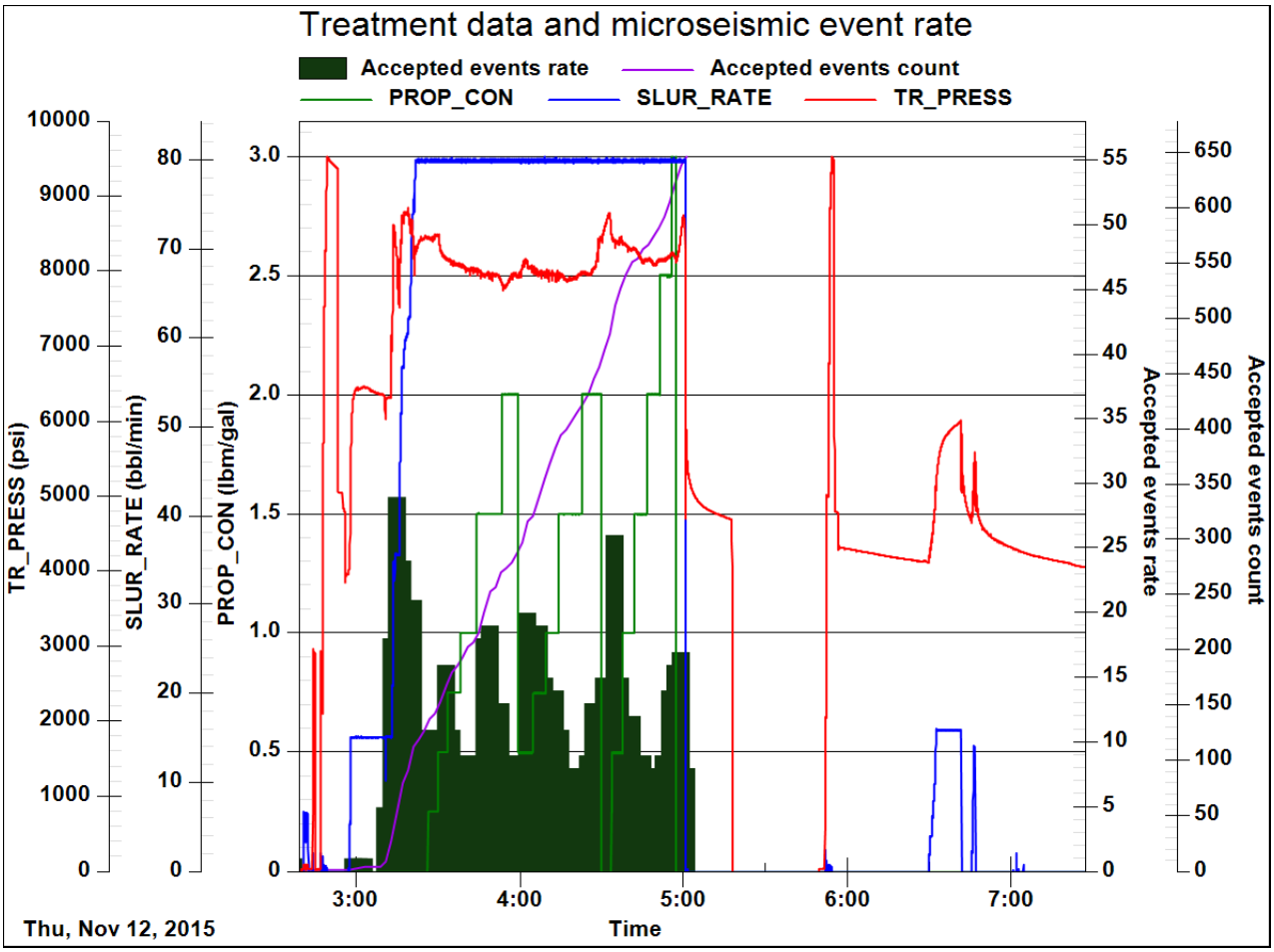



**Figure 5-41 - MIP 3H Stage 15 treatment data and microseismic event rate**

**Table 5.25 - MIP 3H Stage 15 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 341693 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 311790 | 344693 |
| 100 Mesh (lbm) | 127600 | 127300 |
| 40/70 White (lbm) | 232400 | 232660 |
| Total proppants (lbm) | 360000 | 359960 |

**Table 5.26 - MIP 3H Stage 15 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 79.9 |
| Average pressure (psi) | 8131 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5681 |
| Maximum PPA (lbm/gal) | 2.998 |

**Table 5.27 - MIP 3H Stage 15 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 78 |
| MS length (ft) | 1510 |
| MS height (ft) | 723 |
| MS volume (million ft3) | 68.3 |

The microseismic data from MIP 3H Stage 15 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

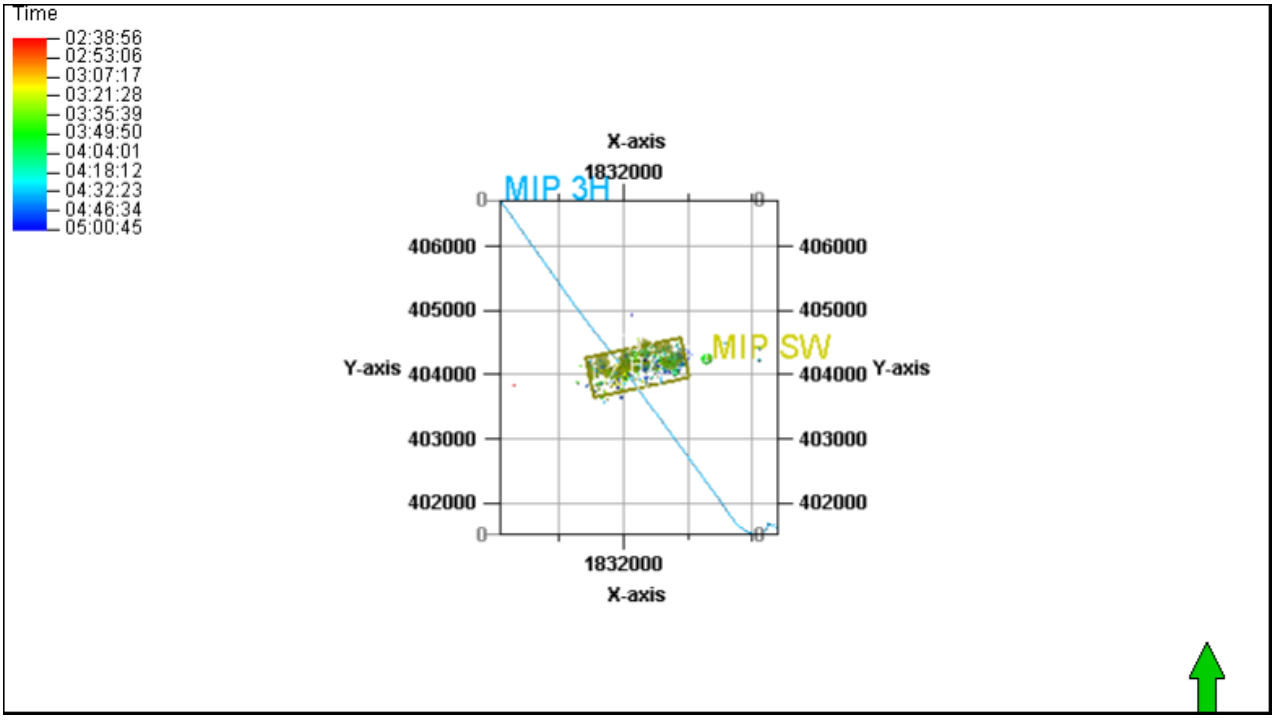



**Figure 5-42 - MIP 3H Stage 15 map view (length and width)**

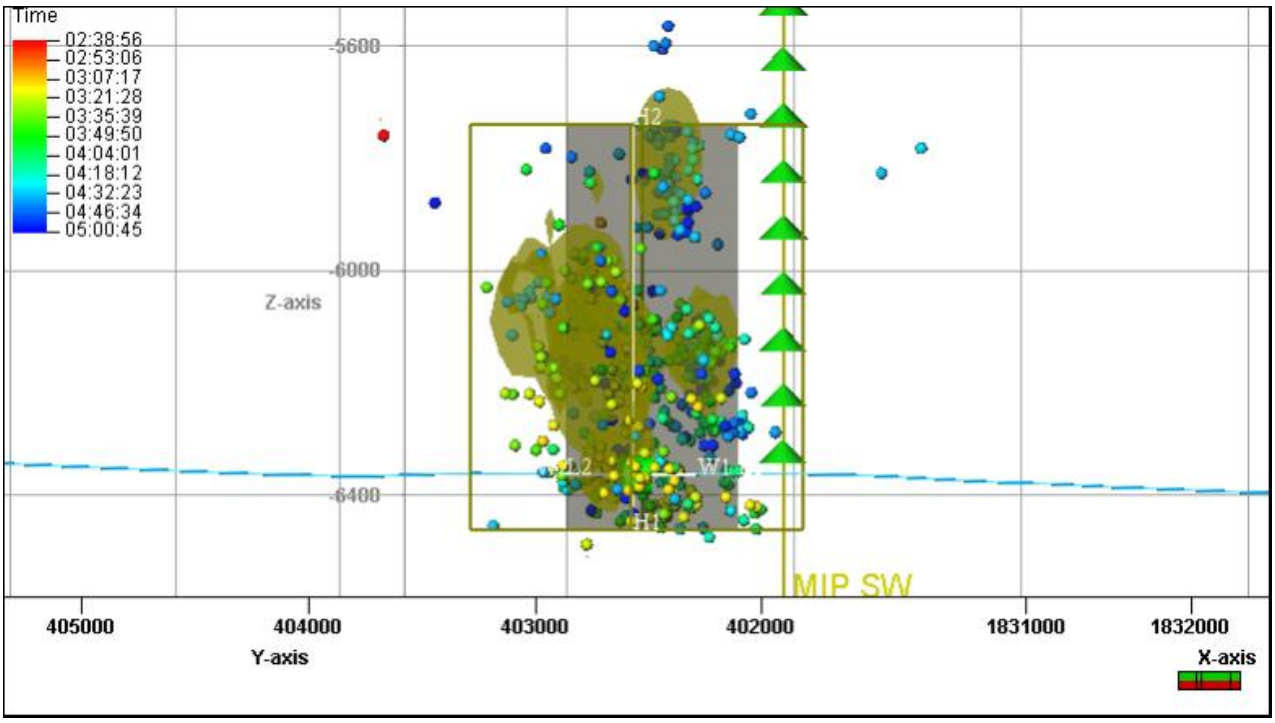



**Figure 5-43 - MIP 3H Stage 15 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 15 are shown below in map and transverse views.

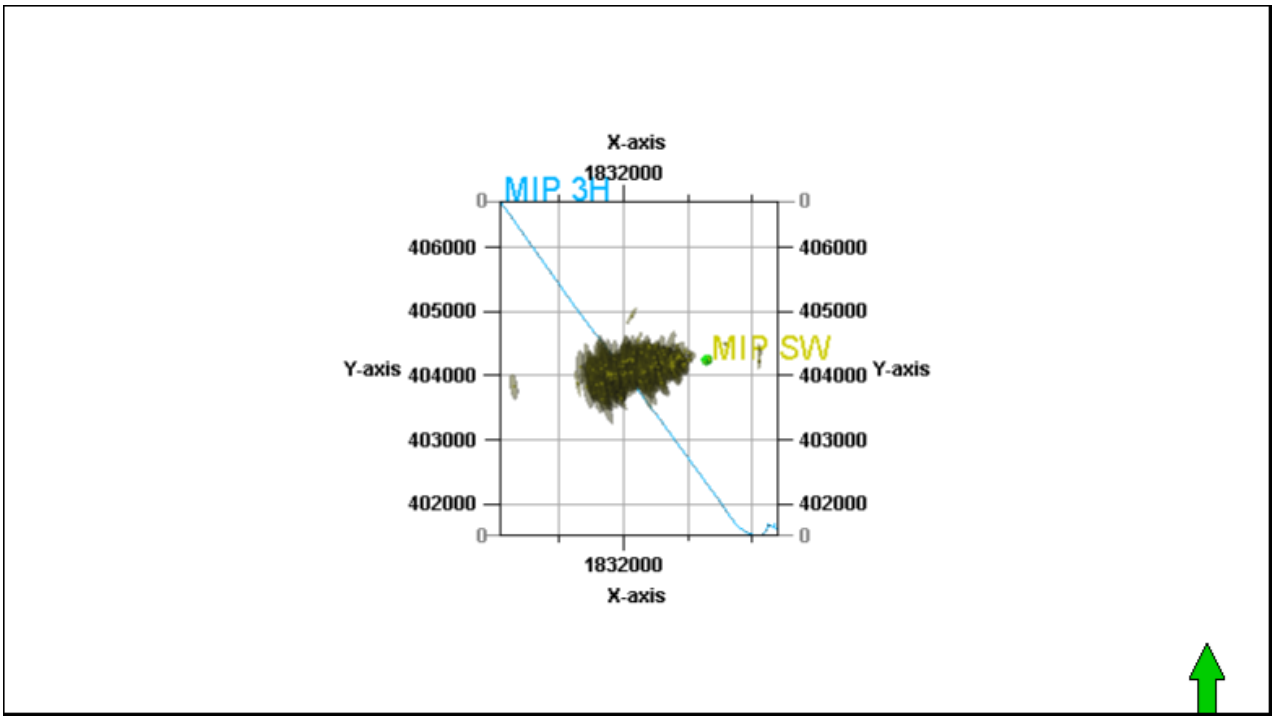



**Figure 5-44 - MIP 3H Stage 15 event location uncertainty ellipsoids – map view**

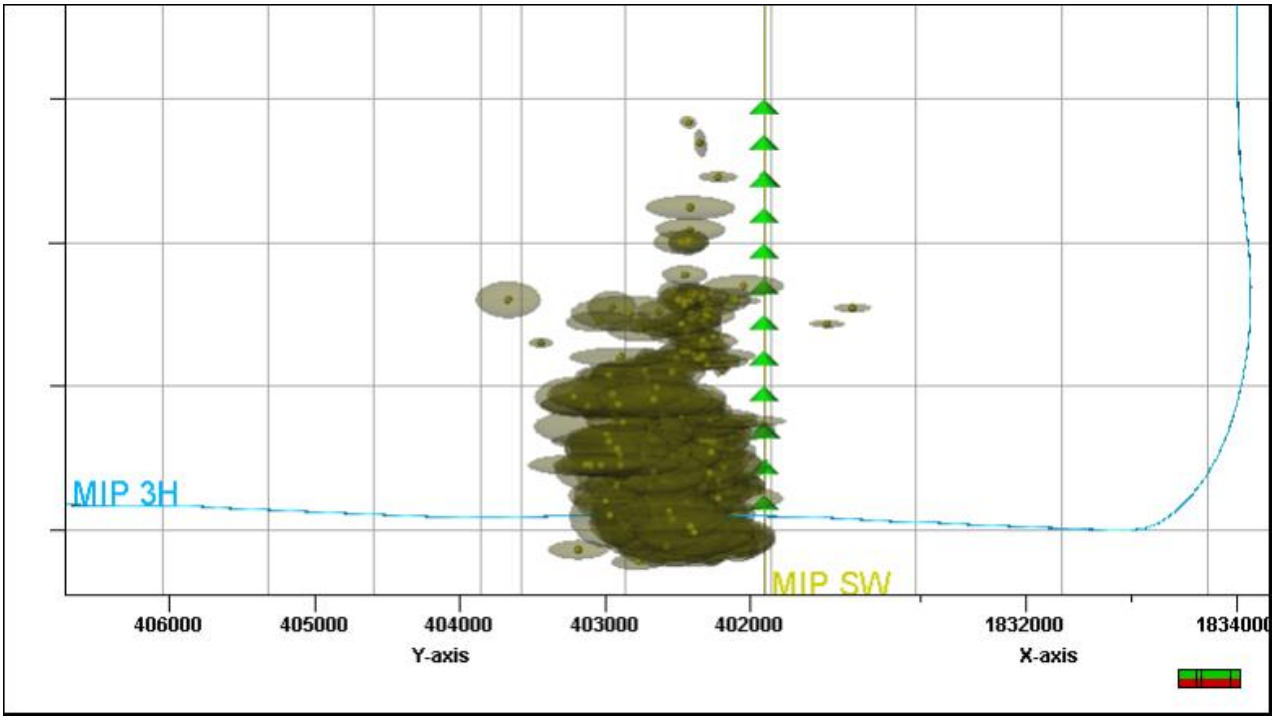



**Figure 5-45 - MIP 3H Stage 15 event location uncertainty ellipsoids – side view**

### 5.9.1 MIP 3H Stage 15 On-Site Notes and Observations

## 5.10 MIP 3H Stage 16

The MIP 3H Stage 16 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

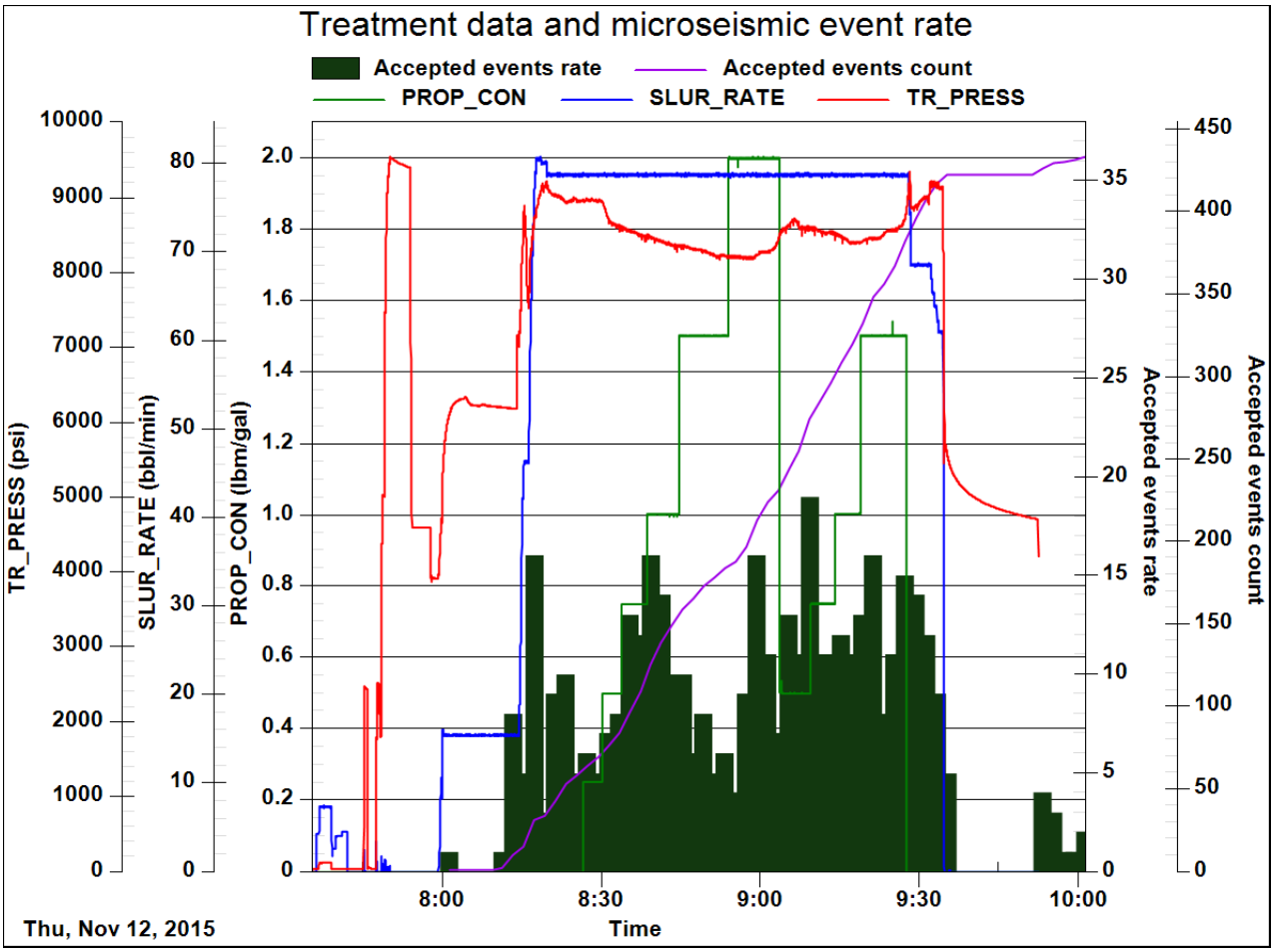



**Figure 5-46 - MIP 3H Stage 16 treatment data and microseismic event rate**

**Table 5.28 - MIP 3H Stage 16 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 254793 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 311790 | 257793 |
| 100 Mesh (lbm) | 127600 | 126840 |
| 40/70 White (lbm) | 232400 | 61620 |
| Total proppants (lbm) | 360000 | 188460 |

**Table 5.29 - MIP 3H Stage 16 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 77.8 |
| Average pressure (psi) | 8573 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5961 |
| Maximum PPA (lbm/gal) | 2.003 |

**Table 5.30 - MIP 3H Stage 16 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 76 |
| MS length (ft) | 1575 |
| MS height (ft) | 711 |
| MS volume (million ft3) | 40.8 |

The microseismic data from MIP 3H Stage 16 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

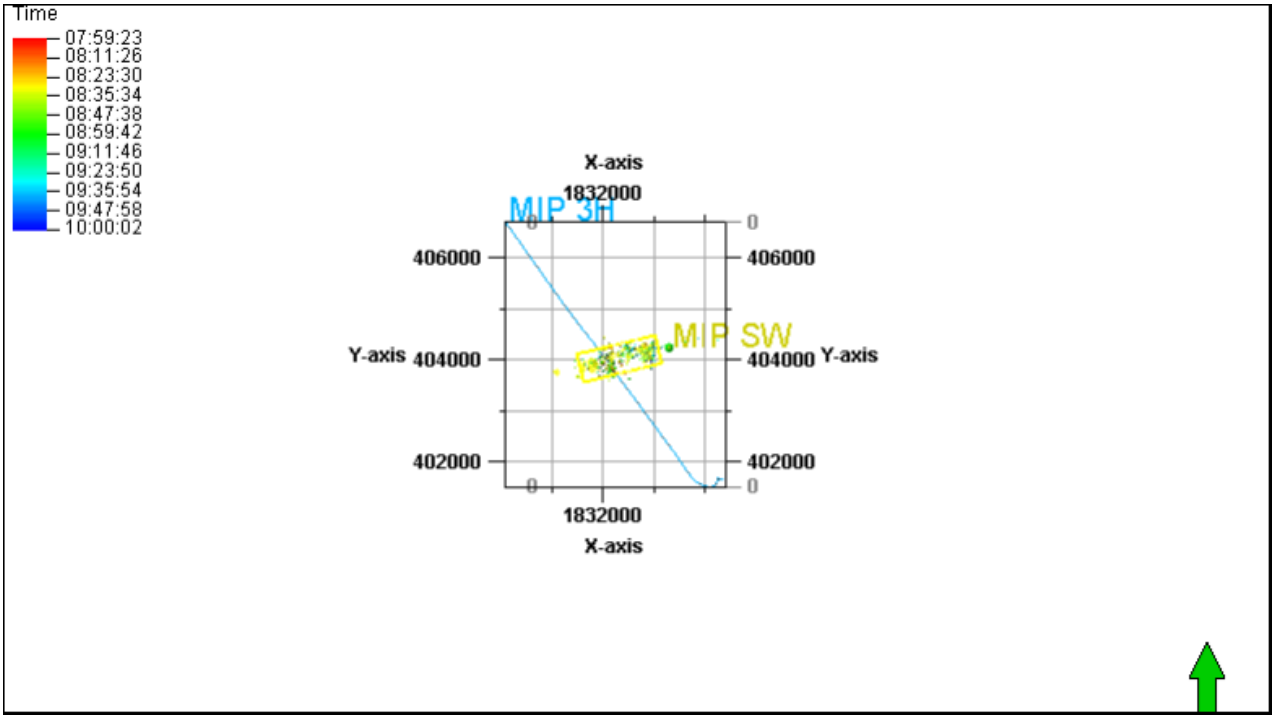



**Figure 5-47 - MIP 3H Stage 16 map view (length and width)**

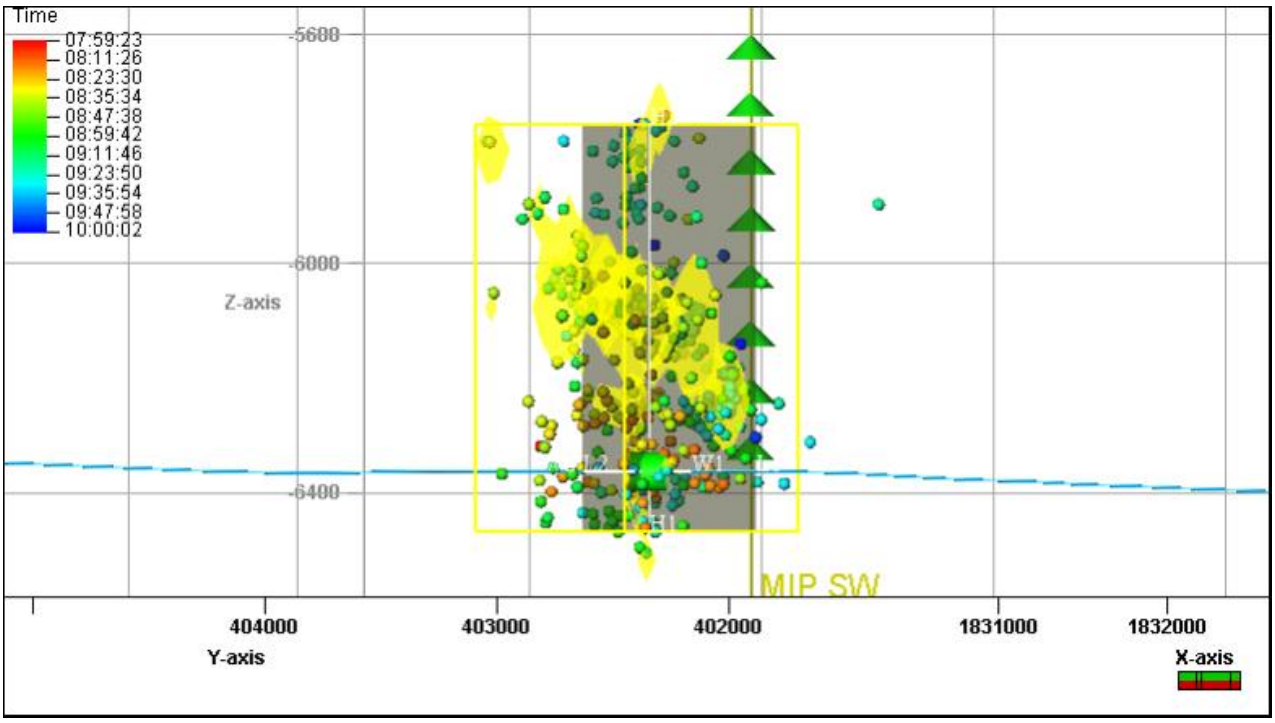



**Figure 5-48 - MIP 3H Stage 16 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 16 are shown below in map and transverse views.

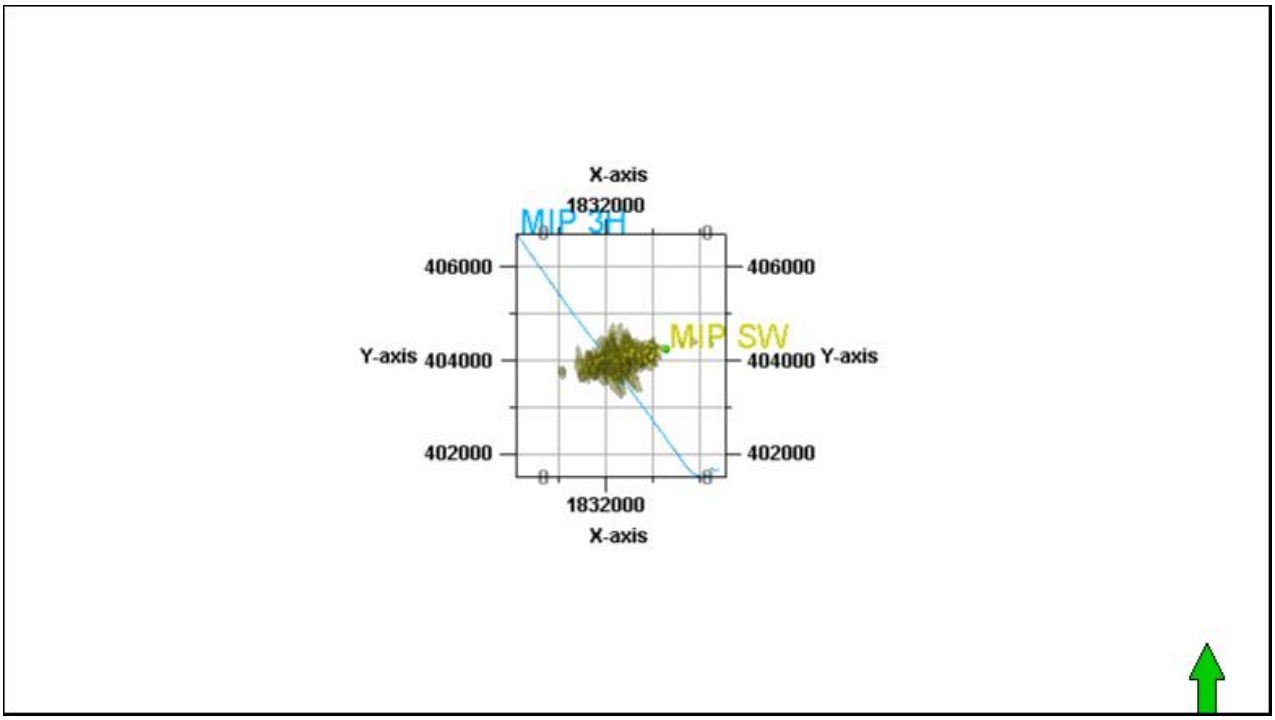



**Figure 5-49 - MIP 3H Stage 16 event location uncertainty ellipsoids – map view**

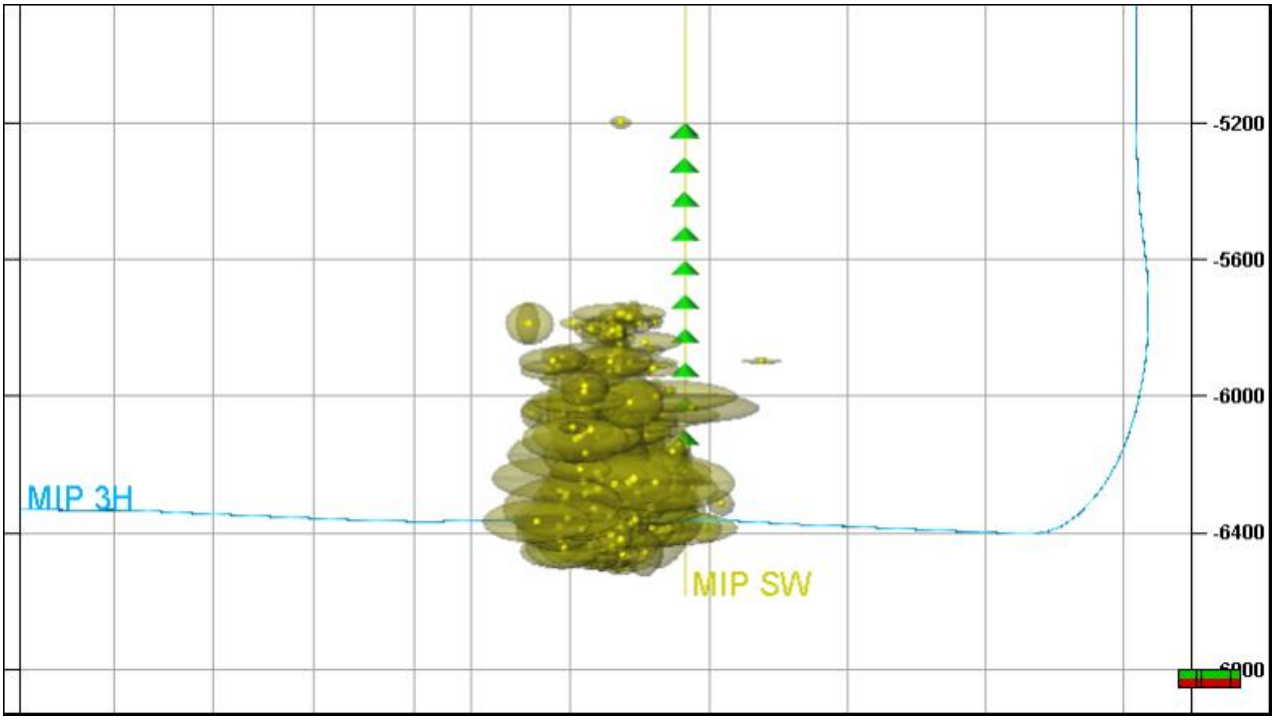



**Figure 5-50 - MIP 3H Stage 16 event location uncertainty ellipsoids – side view**

### 5.10.1 MIP 3H Stage 16 On-Site Notes and Observations

## 5.11 MIP 3H Stage 17

The MIP 3H Stage 17 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

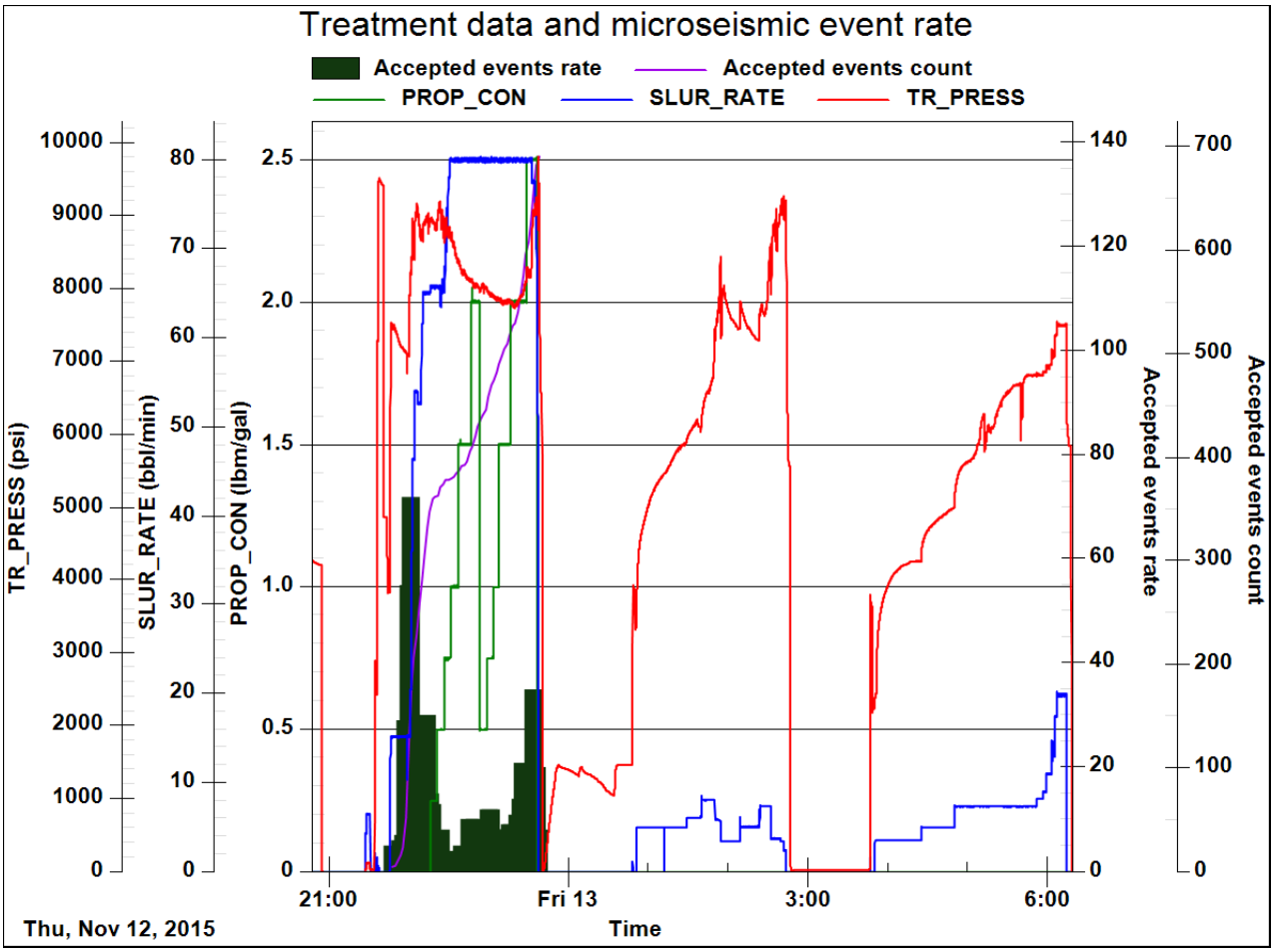



**Figure 5-51 - MIP 3H Stage 17 treatment data and microseismic event rate**

**Table 5.31 - MIP 3H Stage 17 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 290207 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 311790 | 293207 |
| 100 Mesh (lbm) | 127600 | 127920 |
| 40/70 White (lbm) | 232400 | 223200 |
| Total proppants (lbm) | 360000 | 351120 |

**Table 5.32 - MIP 3H Stage 17 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 79.4 |
| Average pressure (psi) | 8114 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 0 |
| Maximum PPA (lbm/gal) | 2.509 |

**Table 5.33 - MIP 3H Stage 17 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 70 |
| MS length (ft) | 1584 |
| MS height (ft) | 398 |
| MS volume (million ft3) | 22.5 |

The microseismic data from MIP 3H Stage 17 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

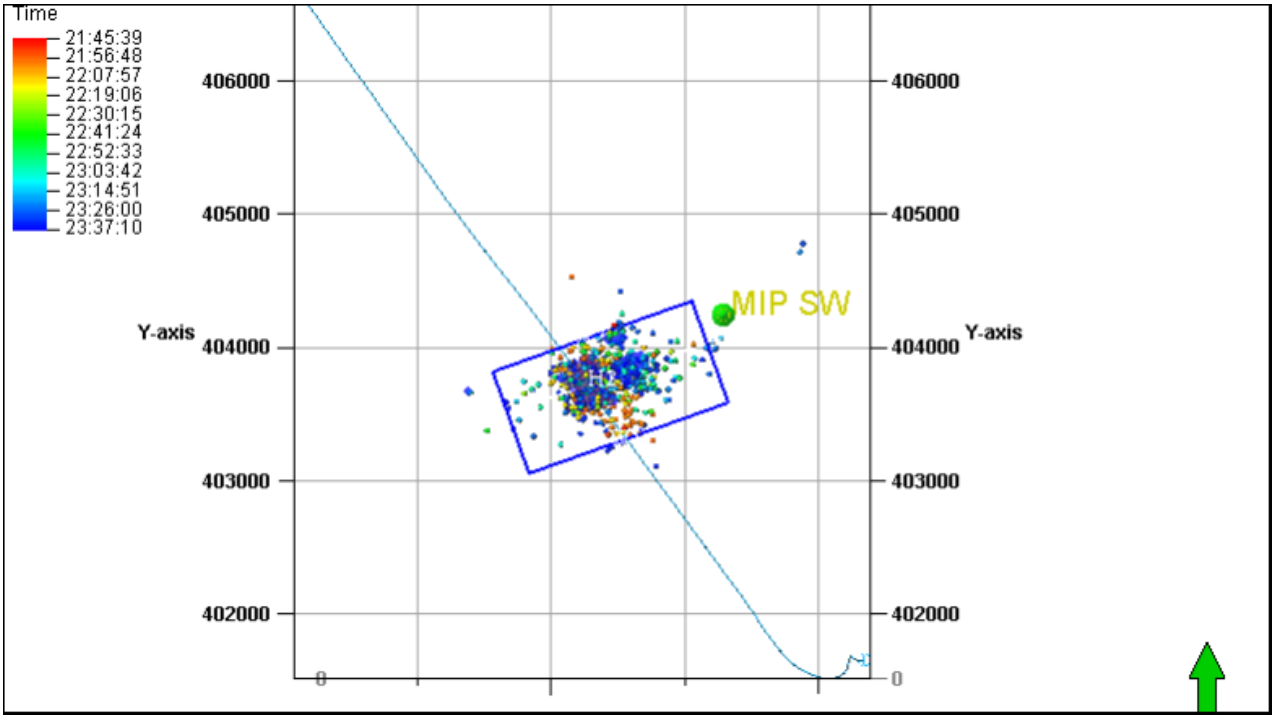



**Figure 5-52 - MIP 3H Stage 17 map view (length and width)**

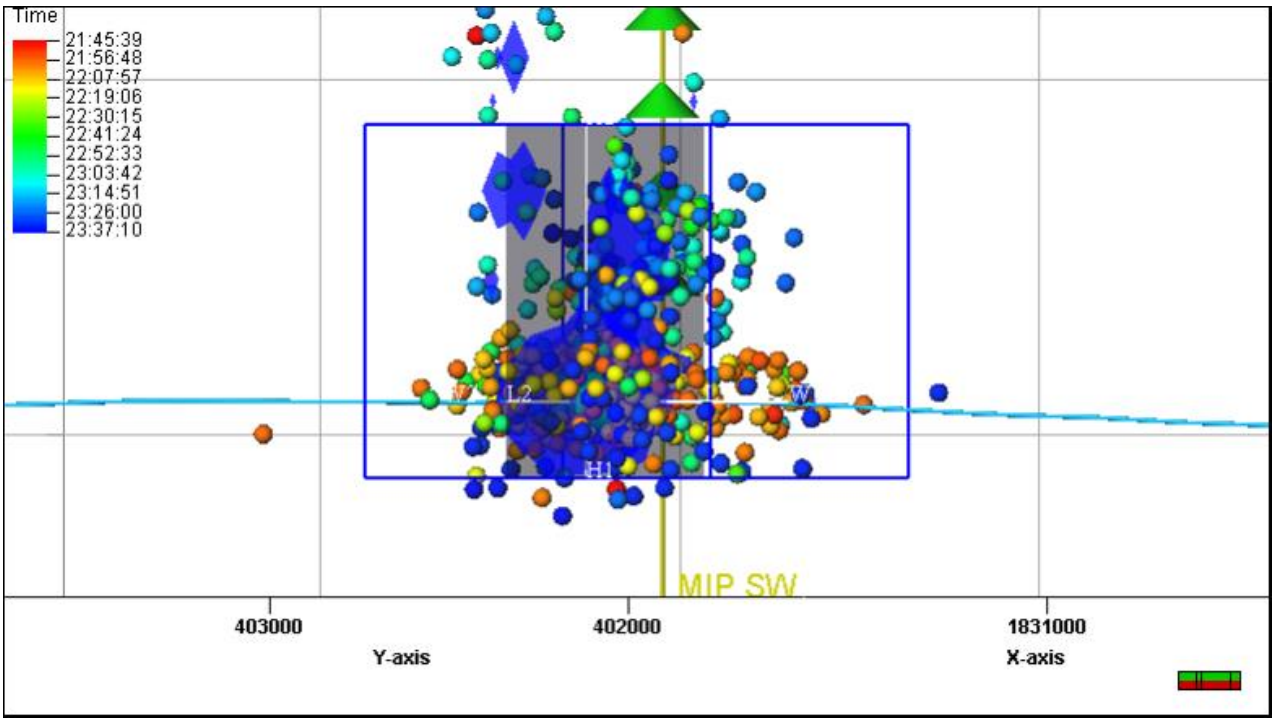



**Figure 5-53 - MIP 3H Stage 17 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 17 are shown below in map and transverse views.

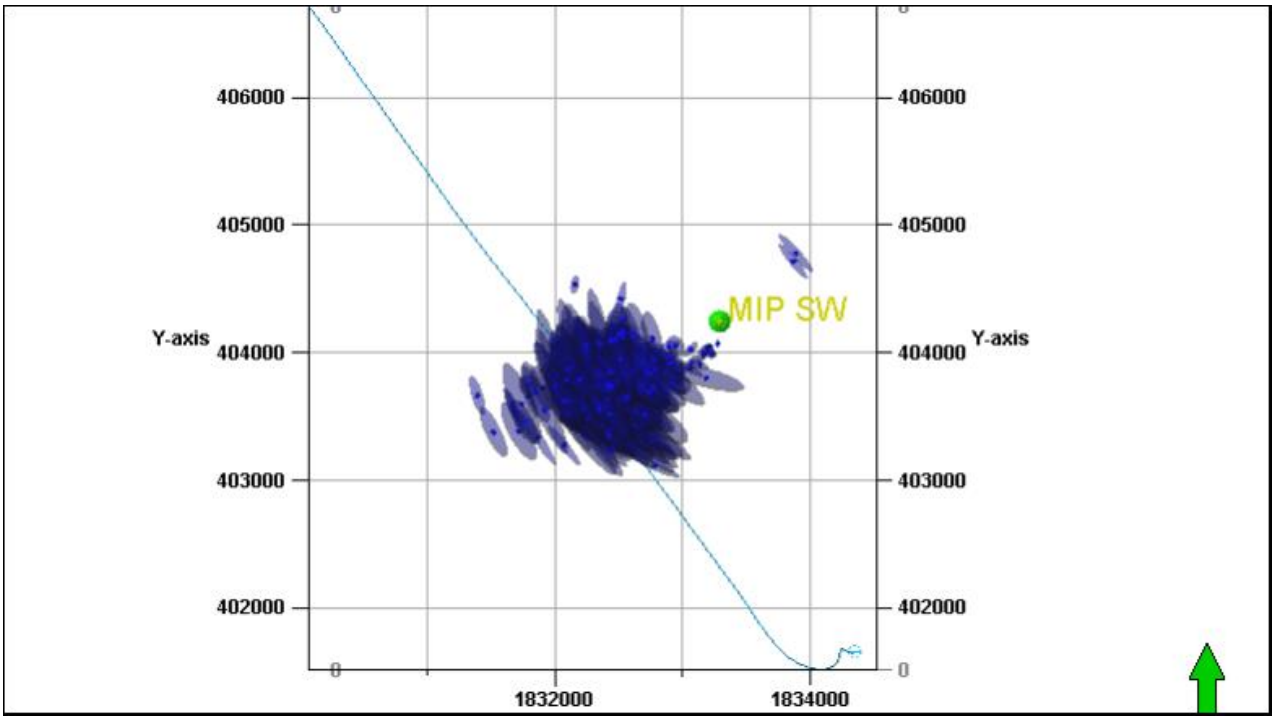



**Figure 5-54 - MIP 3H Stage 17 event location uncertainty ellipsoids – map view**

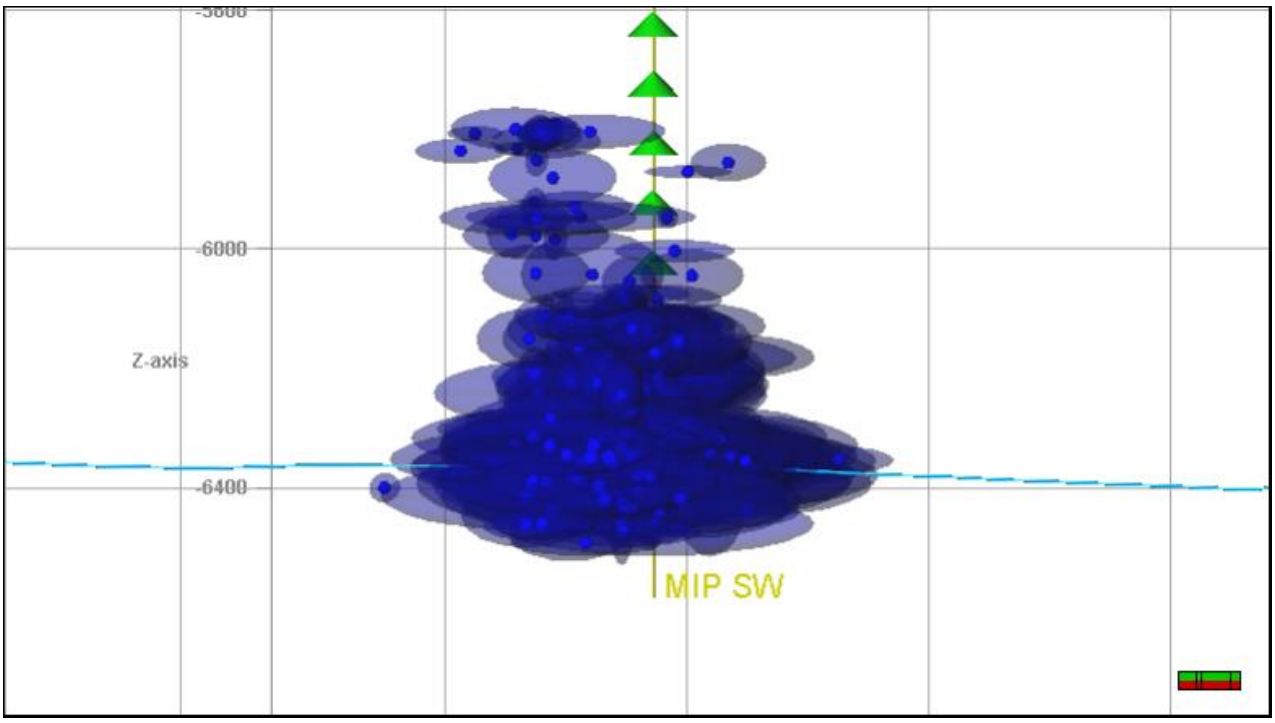



**Figure 5-55 - MIP 3H Stage 17 event location uncertainty ellipsoids – side view**

### 5.11.1 MIP 3H Stage 17 On-Site Notes and Observations

## 5.12 MIP 3H Stage 18

The MIP 3H Stage 18 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

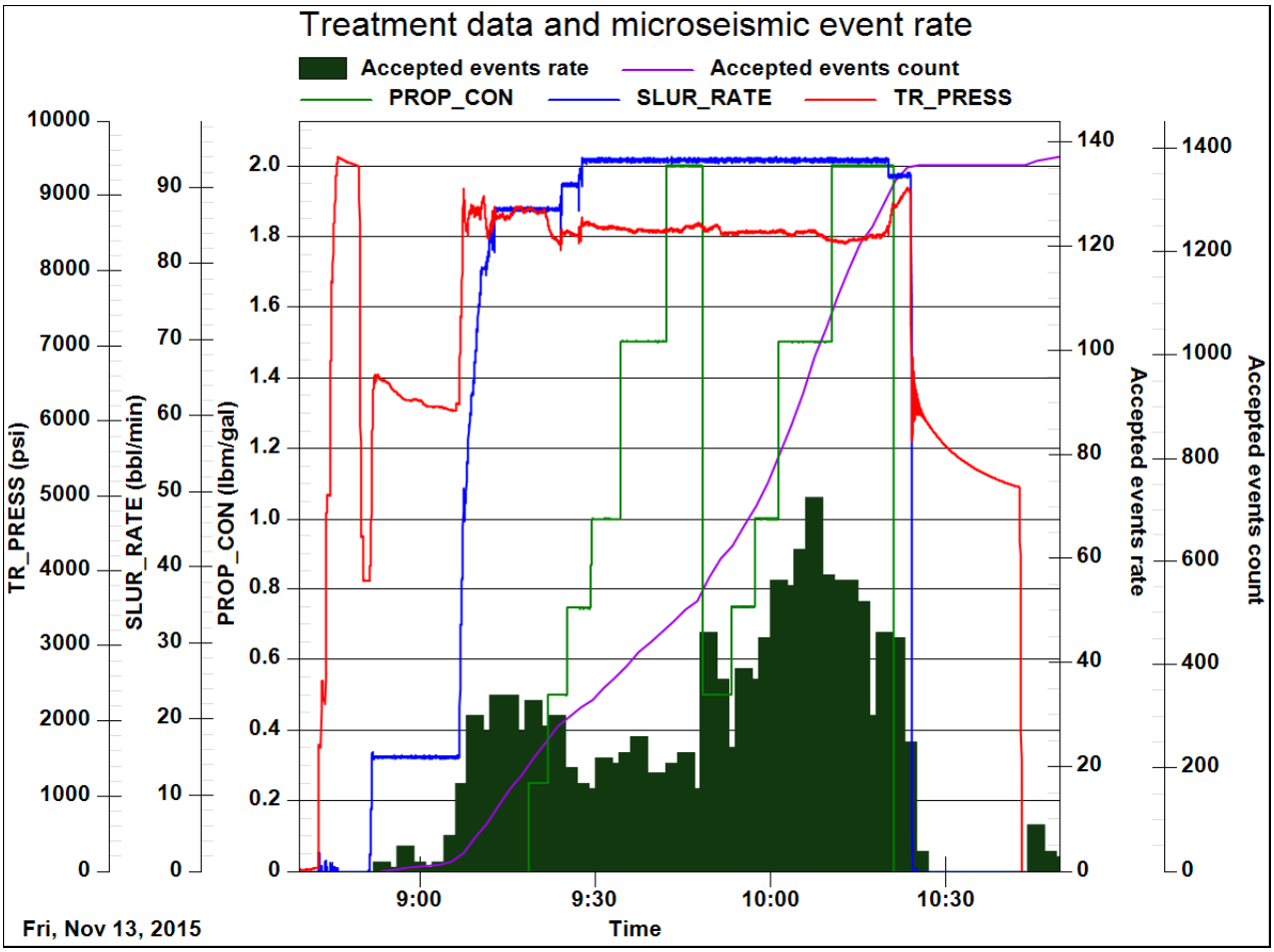



**Figure 5-56 - MIP 3H Stage 18 treatment data and microseismic event rate**

**Table 5.34 - MIP 3H Stage 18 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 286995 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 311790 | 289995 |
| 100 Mesh (lbm) | 127600 | 127280 |
| 40/70 White (lbm) | 232400 | 164580 |
| Total proppants (lbm) | 360000 | 291860 |

**Table 5.35 - MIP 3H Stage 18 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 92.4 |
| Average pressure (psi) | 8561 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6427 |
| Maximum PPA (lbm/gal) | 2.025 |

**Table 5.36 - MIP 3H Stage 18 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 70 |
| MS length (ft) | 1496 |
| MS height (ft) | 516 |
| MS volume (million ft3) | 79.5 |

The microseismic data from MIP 3H Stage 18 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

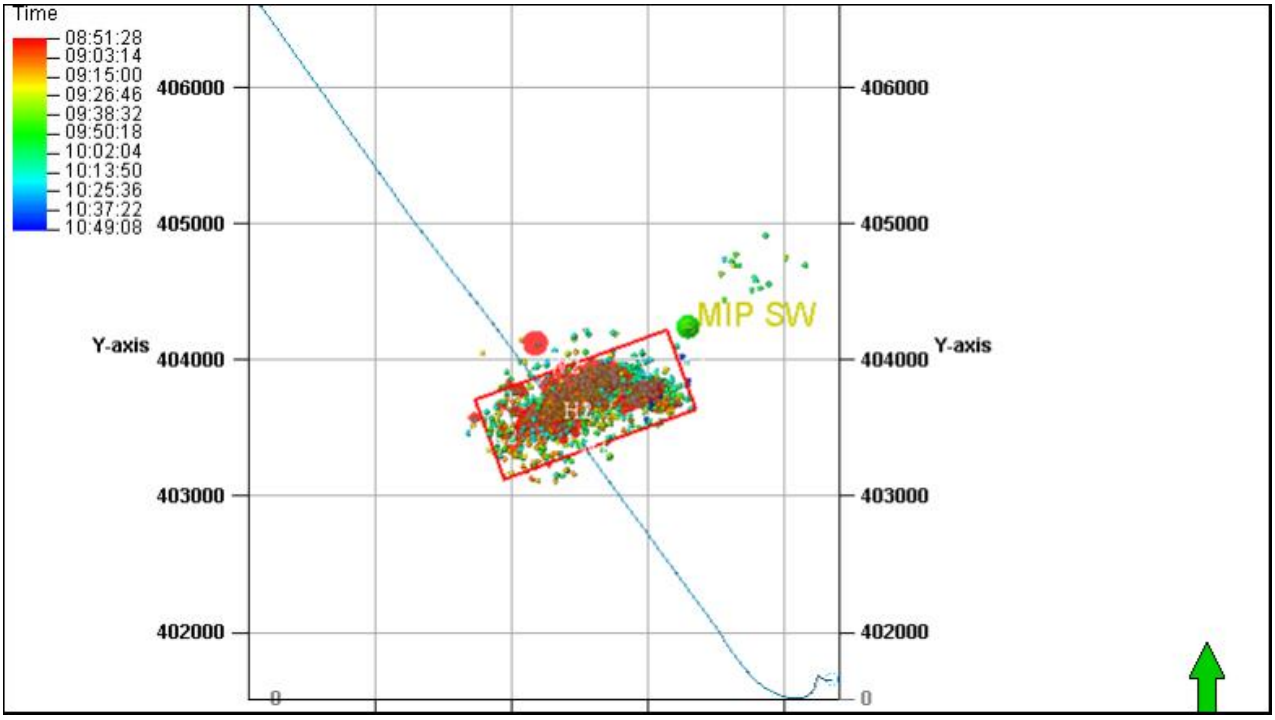



**Figure 5-57 - MIP 3H Stage 18 map view (length and width)**

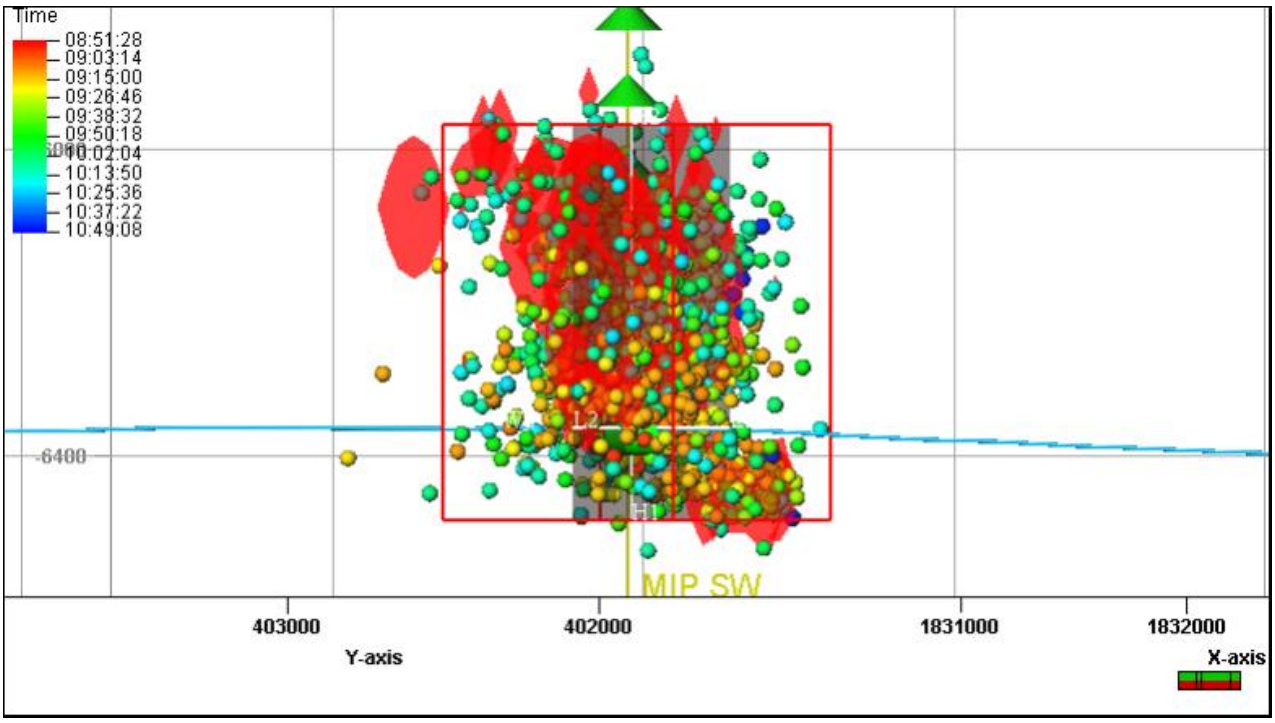



**Figure 5-58 - MIP 3H Stage 18 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 18 are shown below in map and transverse views.

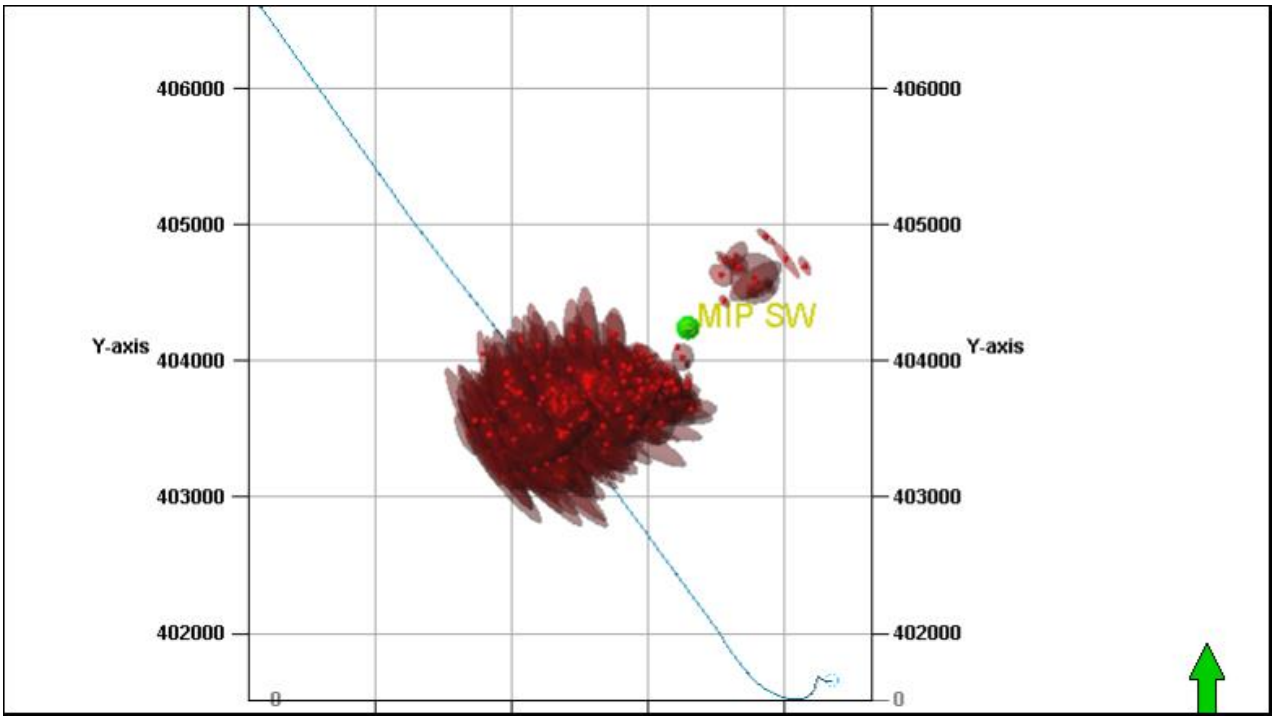



**Figure 5-59 - MIP 3H Stage 18 event location uncertainty ellipsoids – map view**

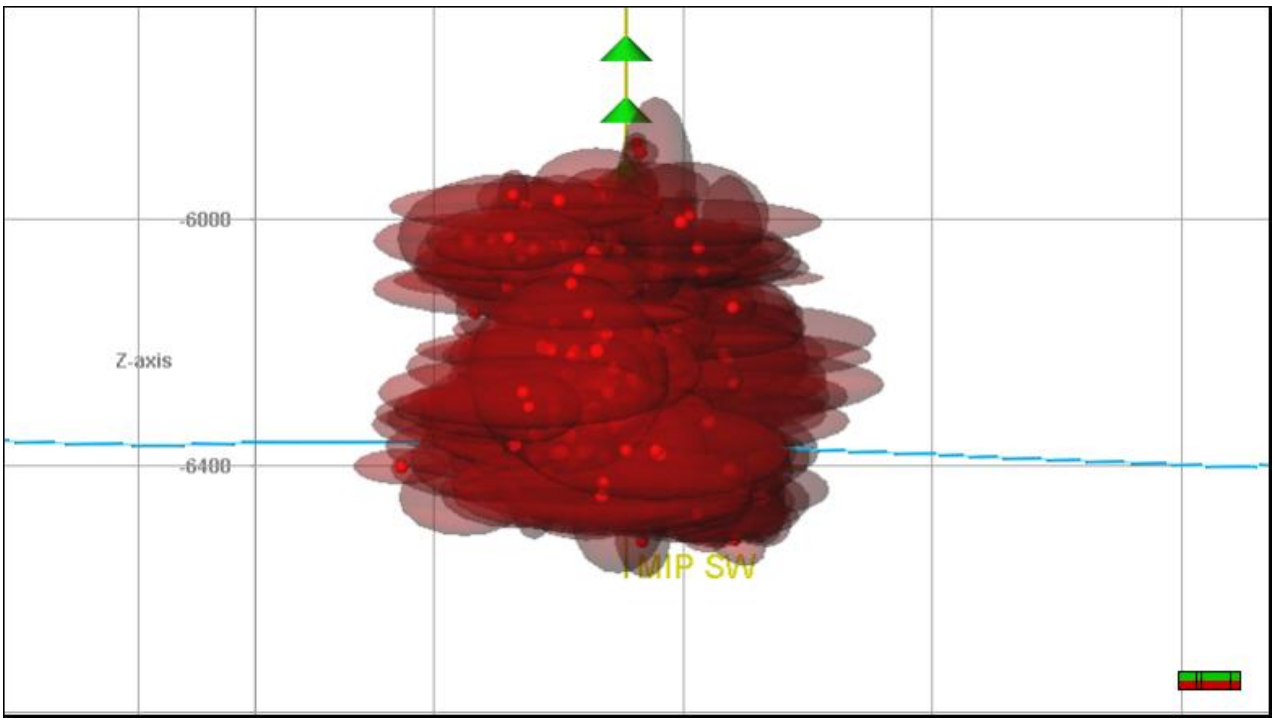



**Figure 5-60 - MIP 3H Stage 18 event location uncertainty ellipsoids – side view**

### 5.12.1 MIP 3H Stage 18 On-Site Notes and Observations

## 5.13 MIP 3H Stage 19

The MIP 3H Stage 19 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

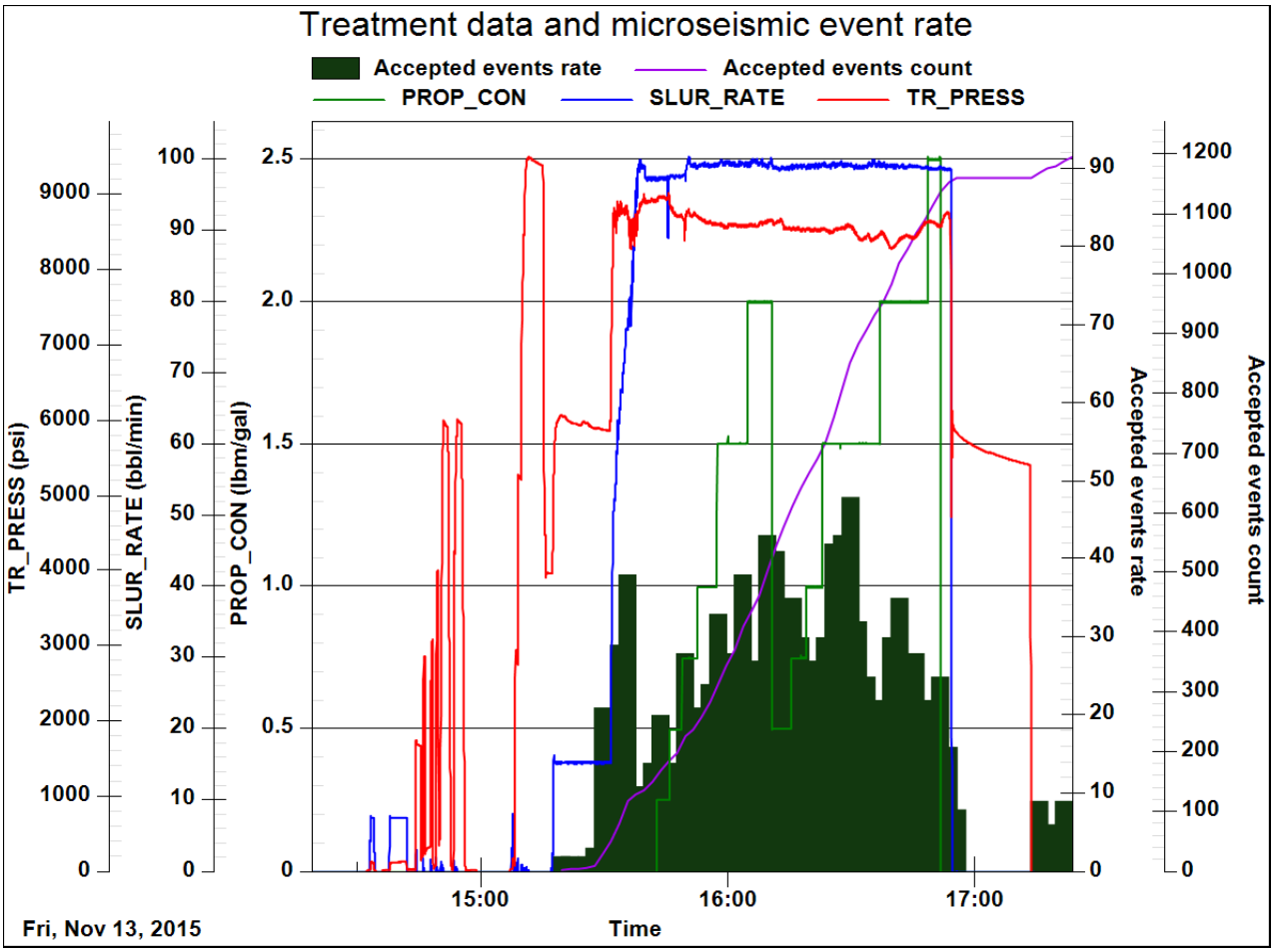



**Figure 5-61 - MIP 3H Stage 19 treatment data and microseismic event rate**

**Table 5.37 - MIP 3H Stage 19 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 324896 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 311790 | 327896 |
| 100 Mesh (lbm) | 127600 | 127660 |
| 40/70 White (lbm) | 232400 | 233030 |
| Total proppants (lbm) | 360000 | 360690 |

**Table 5.38 - MIP 3H Stage 19 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 98.8 |
| Average pressure (psi) | 8588 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5992 |
| Maximum PPA (lbm/gal) | 2.508 |

**Table 5.39 - MIP 3H Stage 19 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 80 |
| MS length (ft) | 1552 |
| MS height (ft) | 507 |
| MS volume (million ft3) | 78.7 |

The microseismic data from MIP 3H Stage 19 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

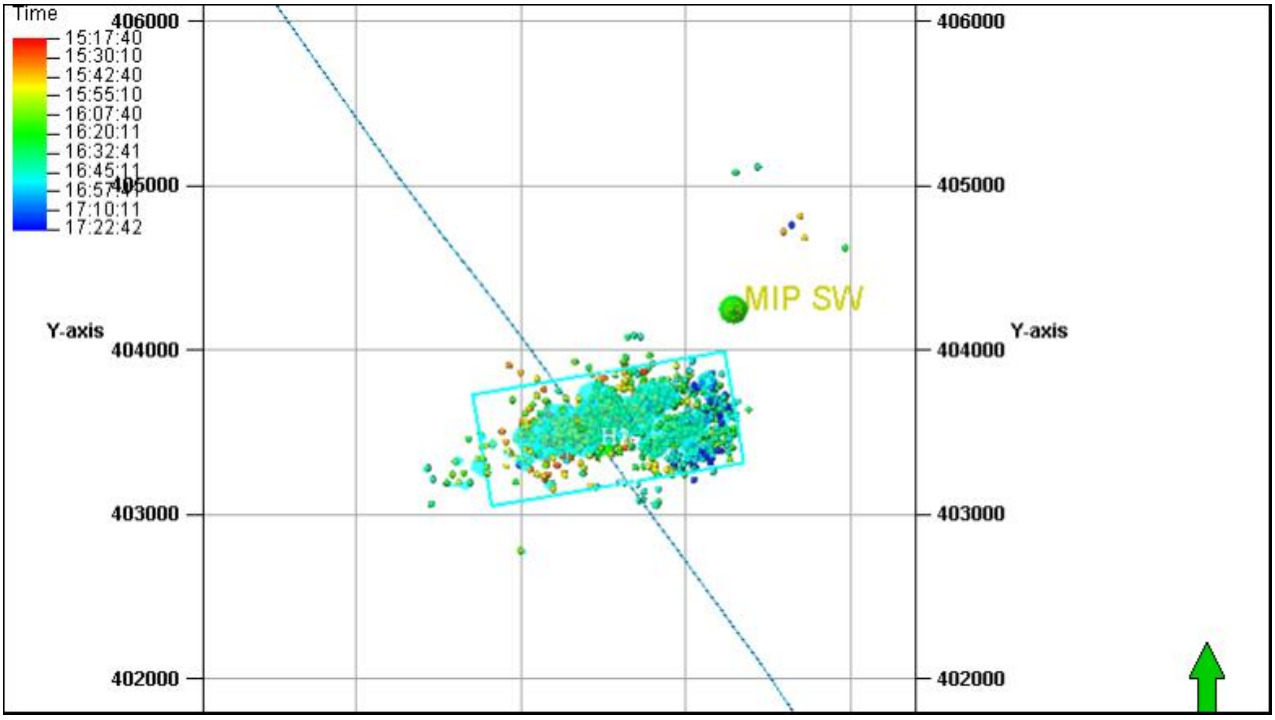



**Figure 5-62 - MIP 3H Stage 19 map view (length and width)**

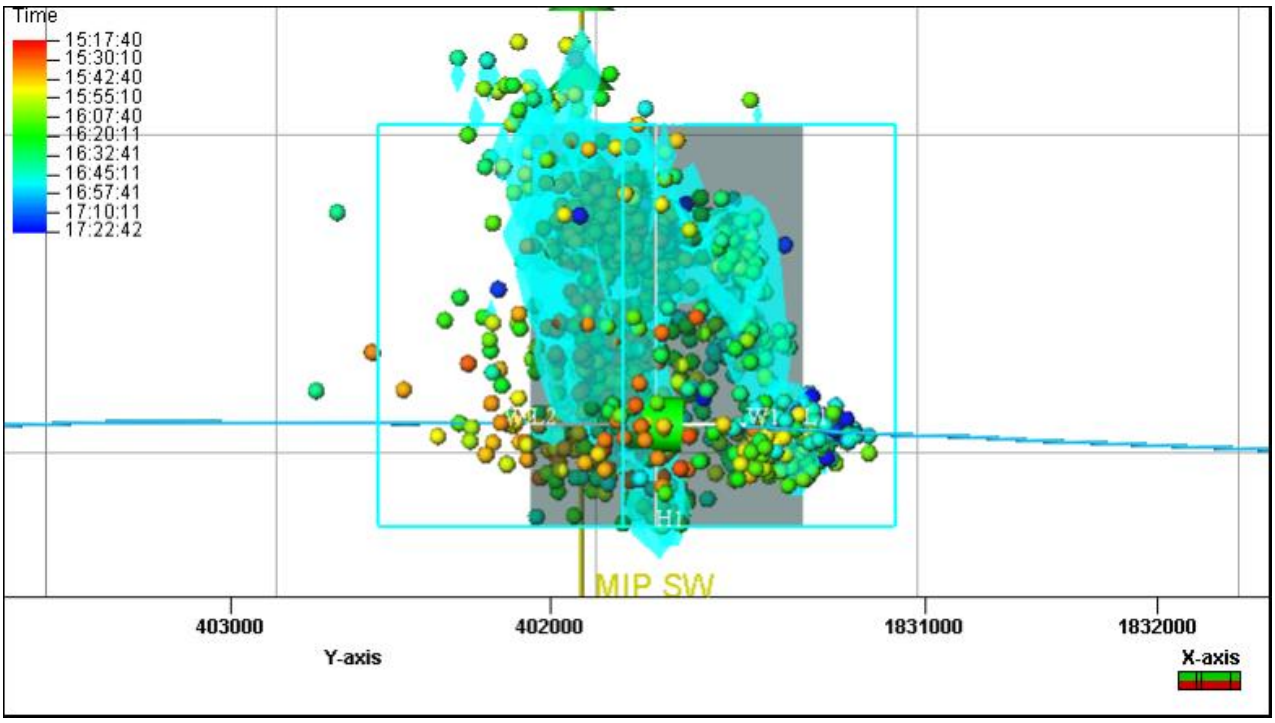



**Figure 5-63 - MIP 3H Stage 19 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 19 are shown below in map and transverse views.

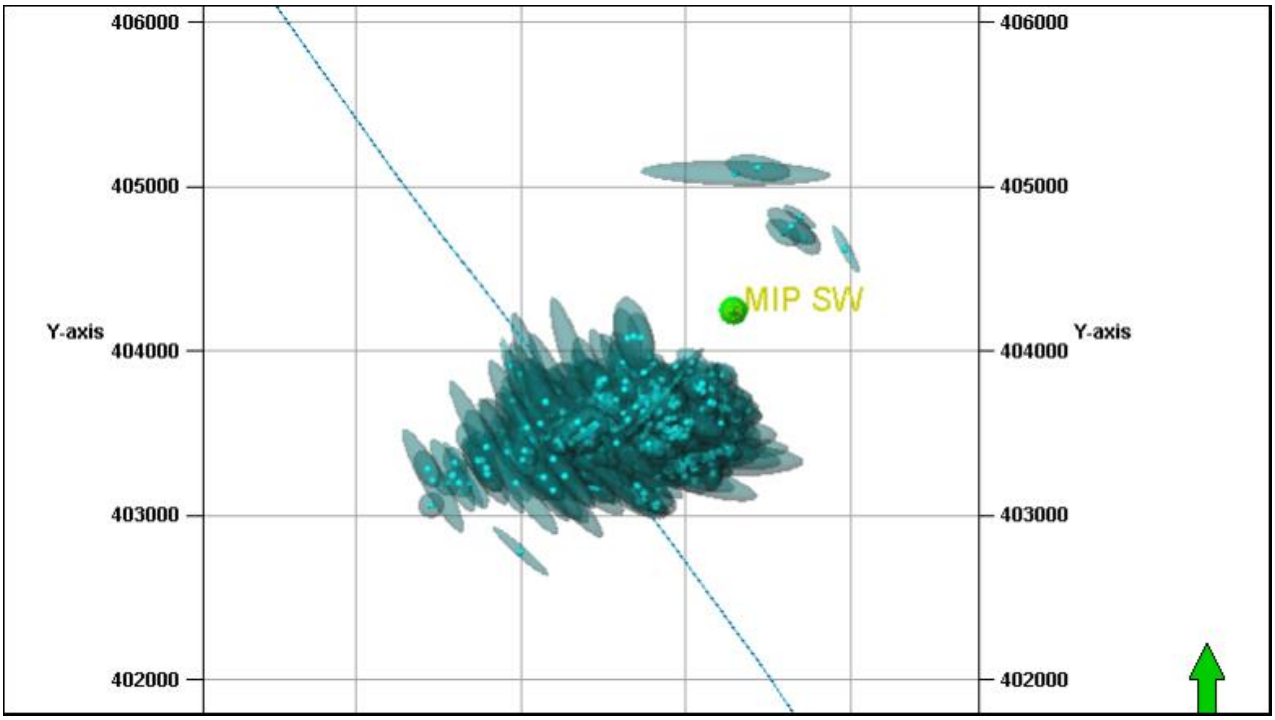



**Figure 5-64 - MIP 3H Stage 19 event location uncertainty ellipsoids – map view**

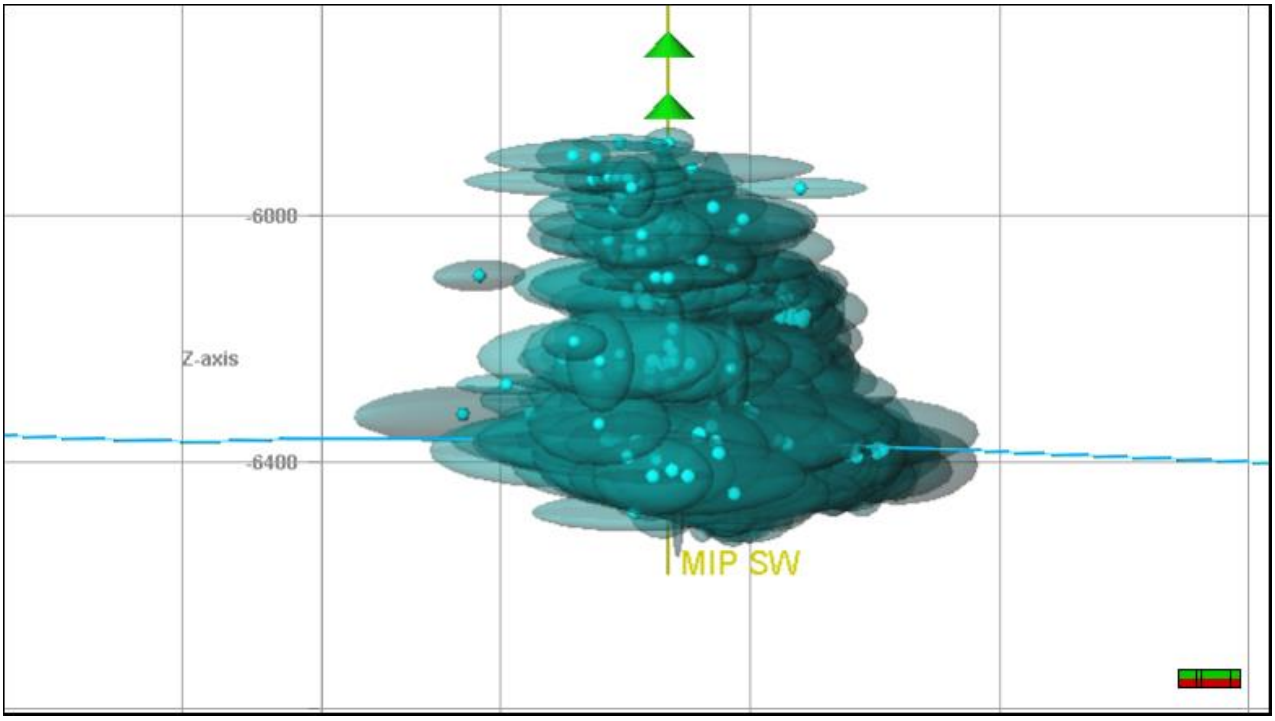



**Figure 5-65 - MIP 3H Stage 19 event location uncertainty ellipsoids – side view**

### 5.13.1 MIP 3H Stage 19 On-Site Notes and Observations

## 5.14 MIP 3H Stage 20

The MIP 3H Stage 20 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

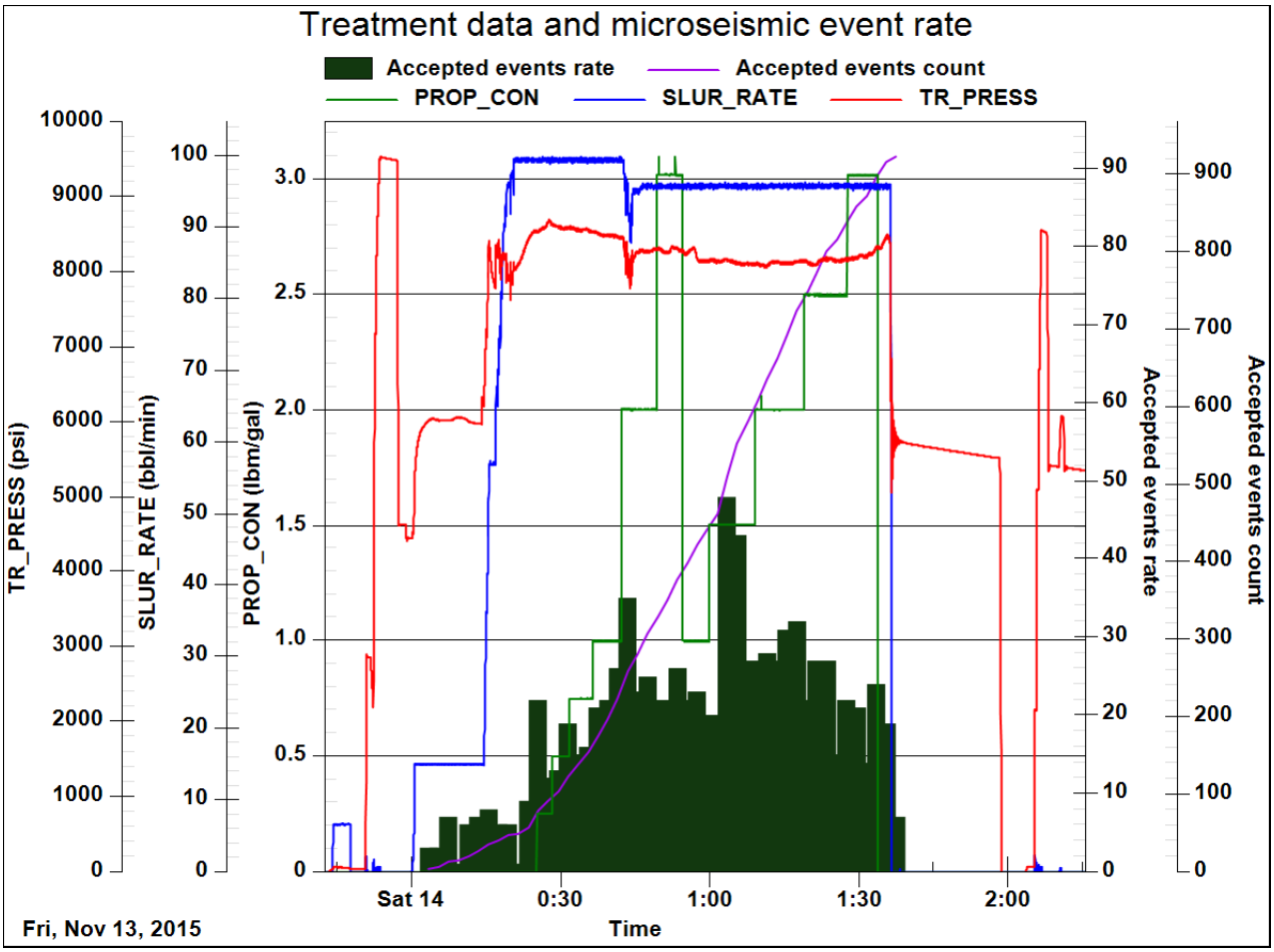



**Figure 5-66 - MIP 3H Stage 20 treatment data and microseismic event rate**

**Table 5.40 - MIP 3H Stage 20 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 254673 | 97220 |
| Sapphire (gal) | 168300 | 214564 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 424973 | 314784 |
| 100 Mesh (lbm) | 154000 | 153140 |
| 40/70 White (lbm) | 286000 | 286180 |
| Total proppants (lbm) | 440000 | 439320 |

**Table 5.41 - MIP 3H Stage 20 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 96.7 |
| Average pressure (psi) | 8270 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5867 |
| Maximum PPA (lbm/gal) | 3.094 |

**Table 5.42 - MIP 3H Stage 20 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 95 |
| MS length (ft) | 1855 |
| MS height (ft) | 498 |
| MS volume (million ft3) | 61.7 |

The microseismic data from MIP 3H Stage 20 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

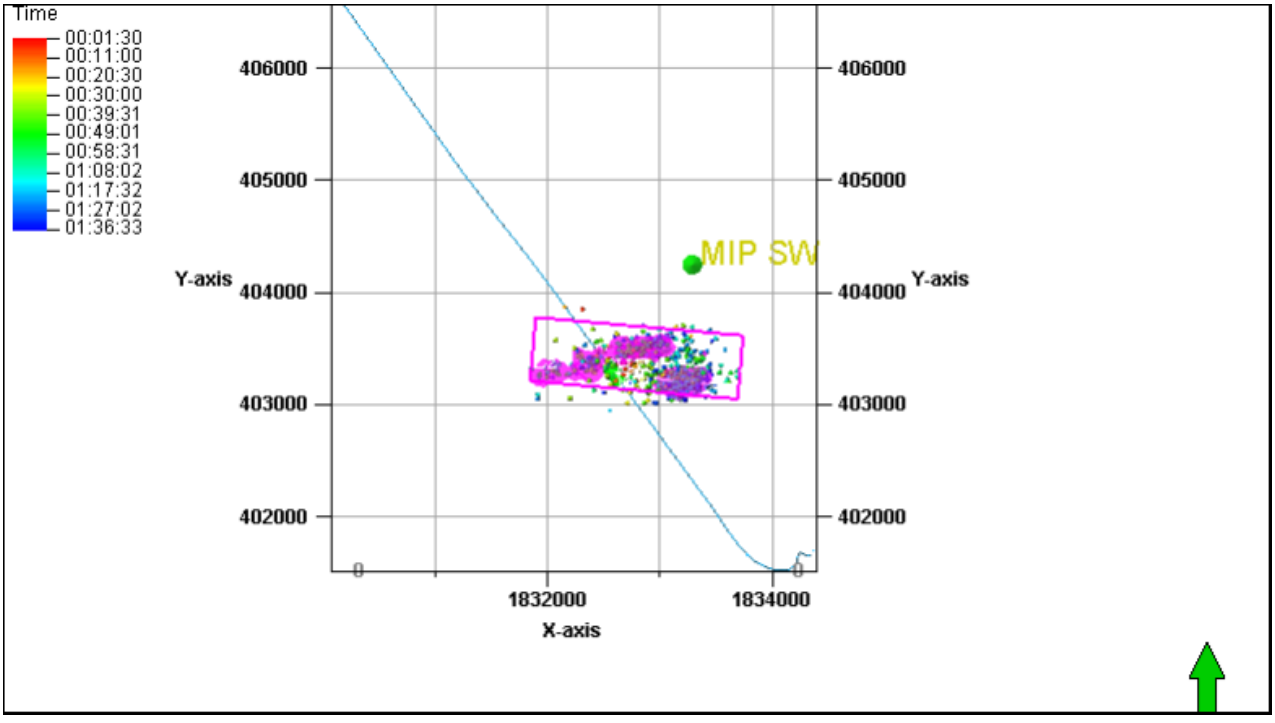



**Figure 5-67 - MIP 3H Stage 20 map view (length and width)**

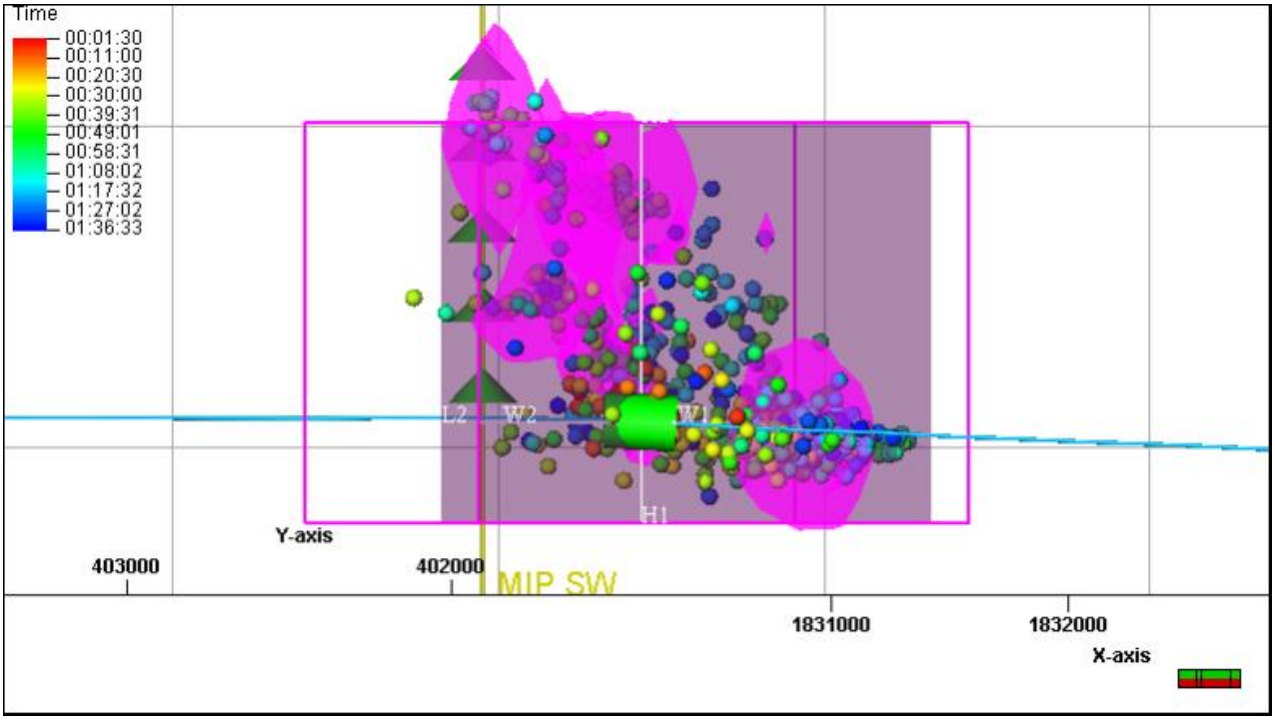



**Figure 5-68 - MIP 3H Stage 20 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 20 are shown below in map and transverse views.

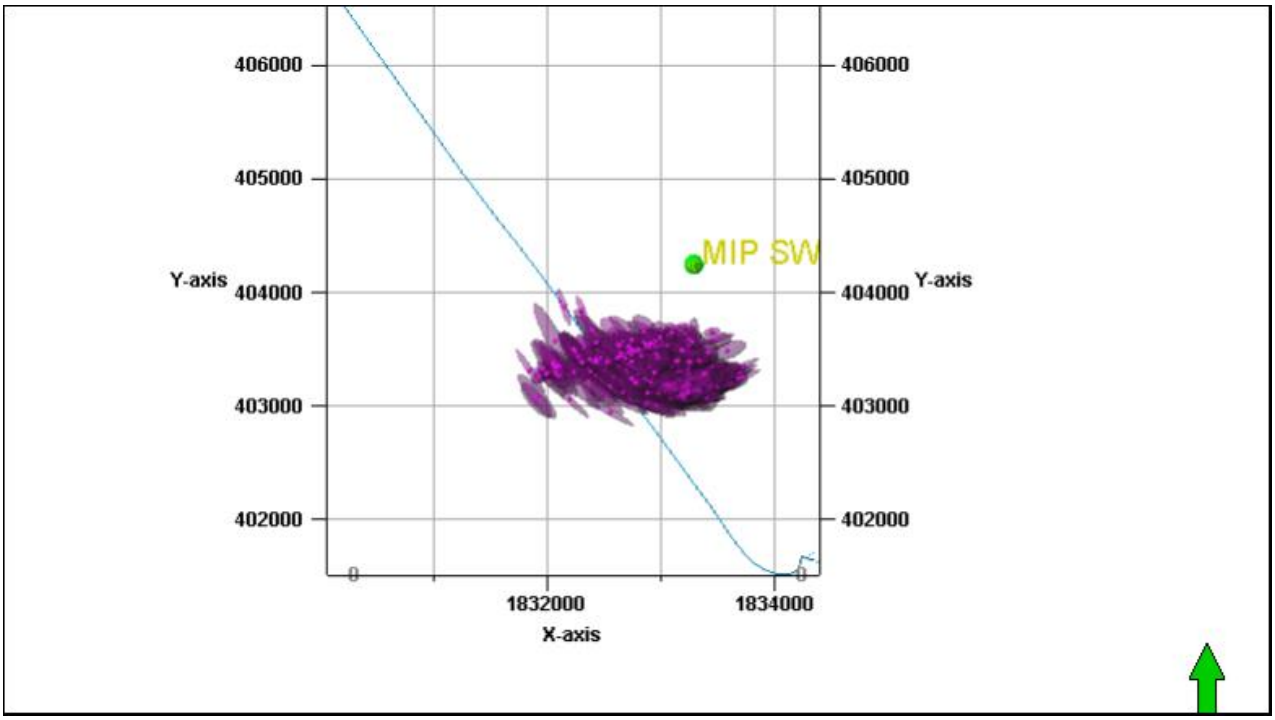



**Figure 5-69 - MIP 3H Stage 20 event location uncertainty ellipsoids – map view**

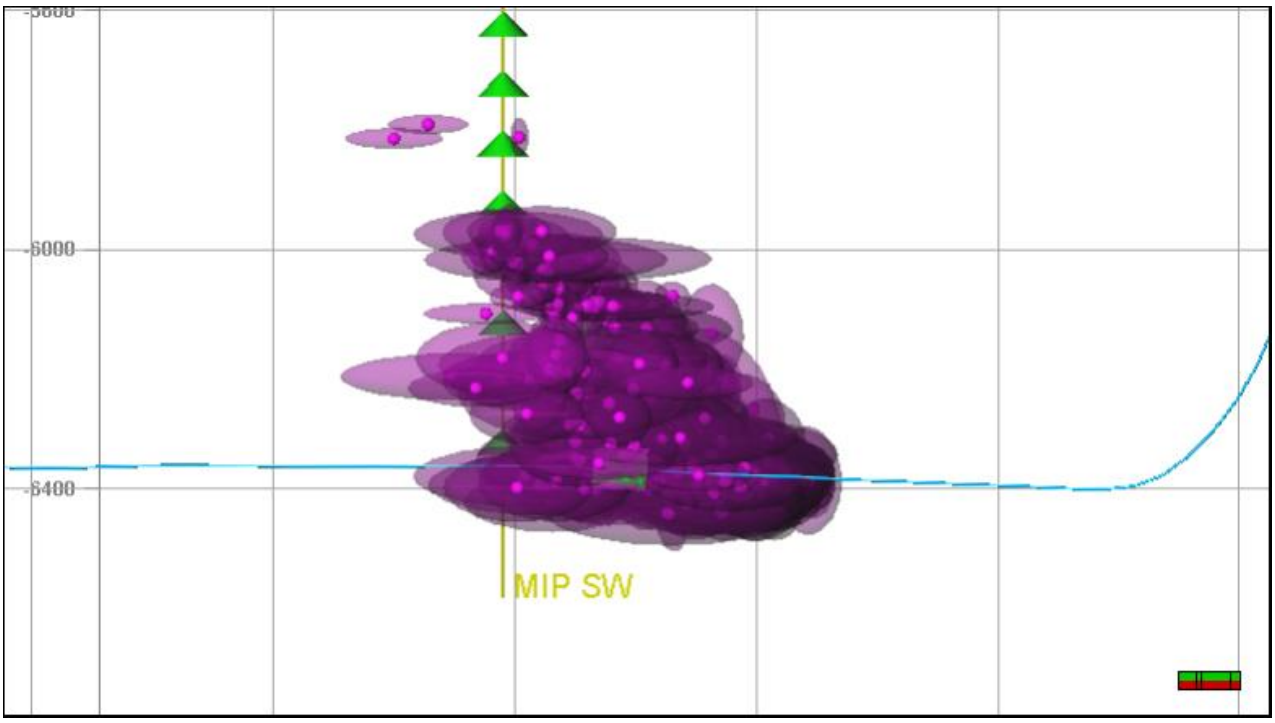



**Figure 5-70 - MIP 3H Stage 20 event location uncertainty ellipsoids – side view**

### 5.14.1 MIP 3H Stage 20 On-Site Notes and Observations

## 5.15 MIP 3H Stage 21

The MIP 3H Stage 21 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

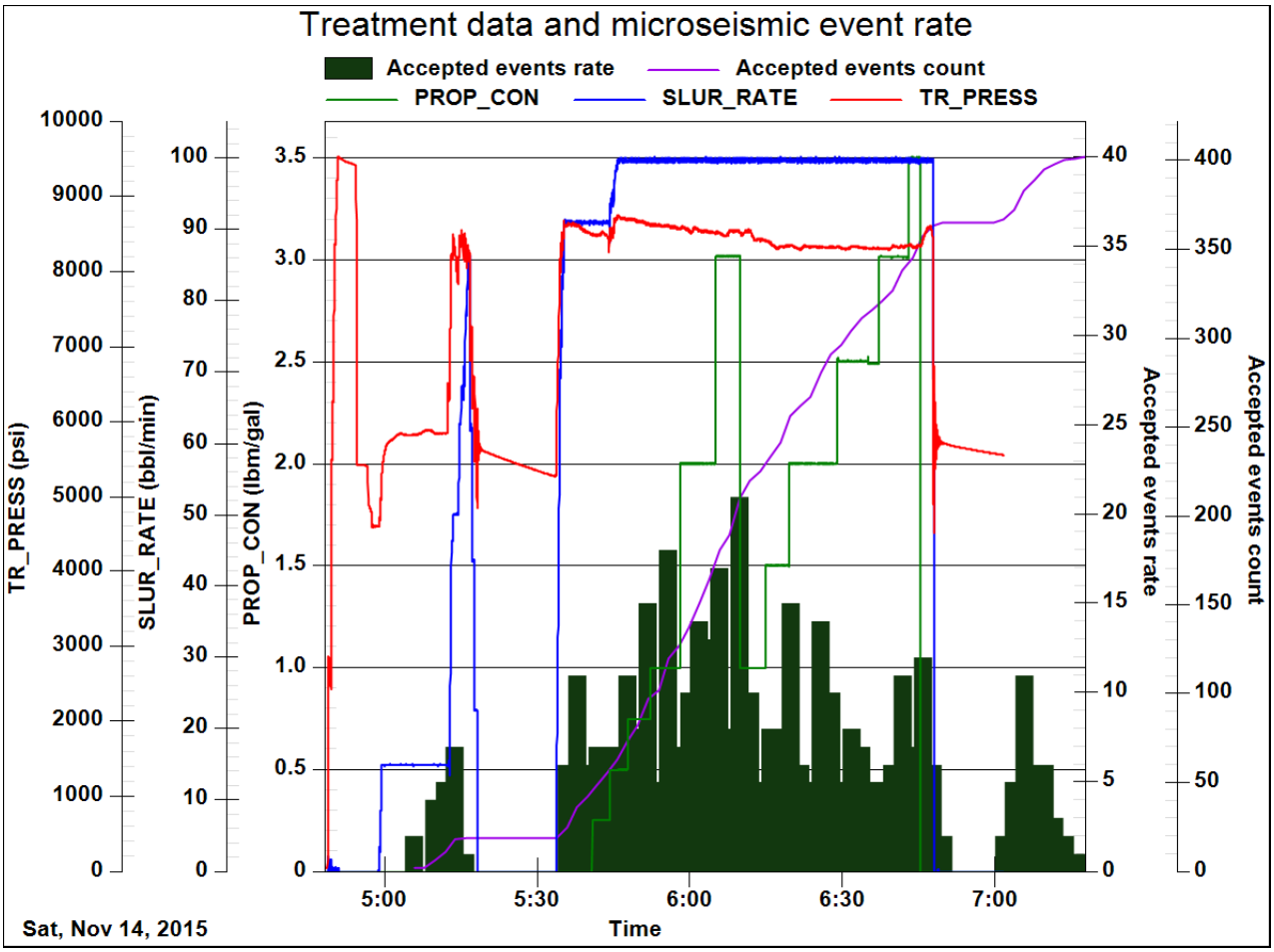



**Figure 5-71 - MIP 3H Stage 21 treatment data and microseismic event rate**

**Table 5.43 - MIP 3H Stage 21 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 254673 | 140948 |
| Sapphire (gal) | 168300 | 161774 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 424973 | 305722 |
| 100 Mesh (lbm) | 154000 | 153040 |
| 40/70 White (lbm) | 286000 | 287600 |
| Total proppants (lbm) | 440000 | 440640 |

**Table 5.44 - MIP 3H Stage 21 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 94.6 |
| Average pressure (psi) | 8365 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5898 |
| Maximum PPA (lbm/gal) | 3.505 |

**Table 5.45 - MIP 3H Stage 21 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 95 |
| MS length (ft) | 1508 |
| MS height (ft) | 478 |
| MS volume (million ft3) | 24.9 |

The microseismic data from MIP 3H Stage 21 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

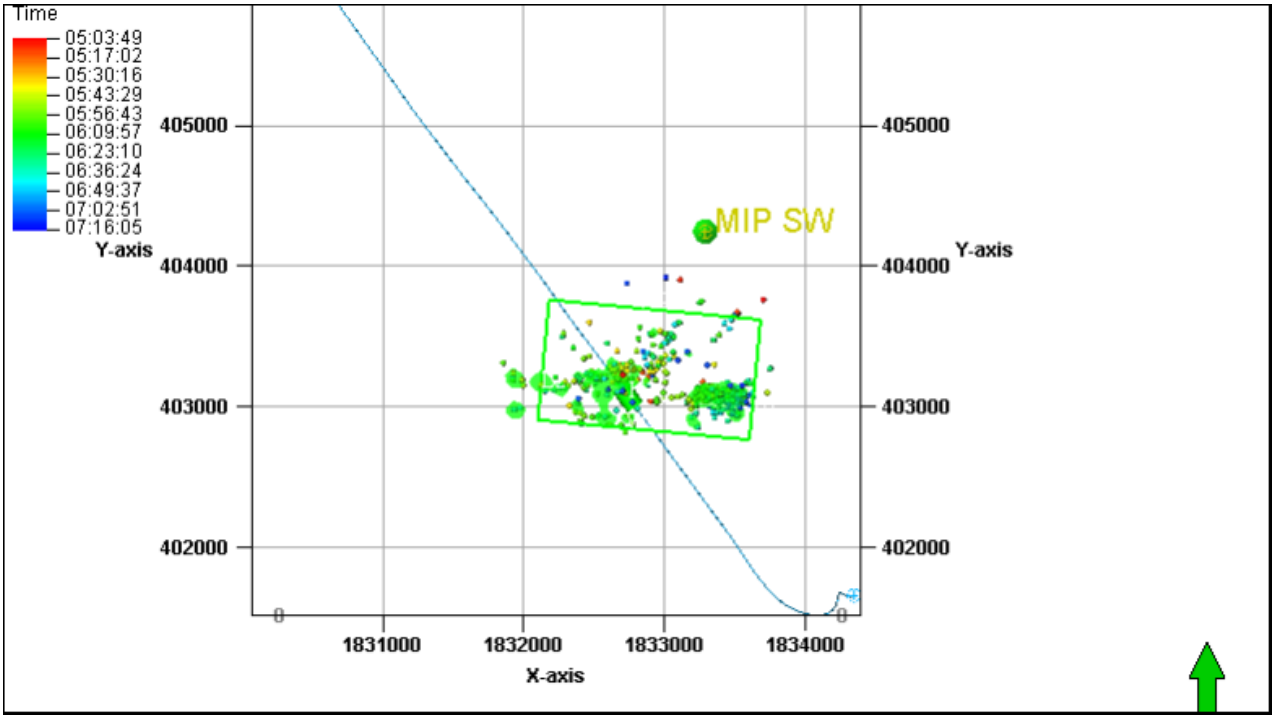



**Figure 5-72 - MIP 3H Stage 21 map view (length and width)**

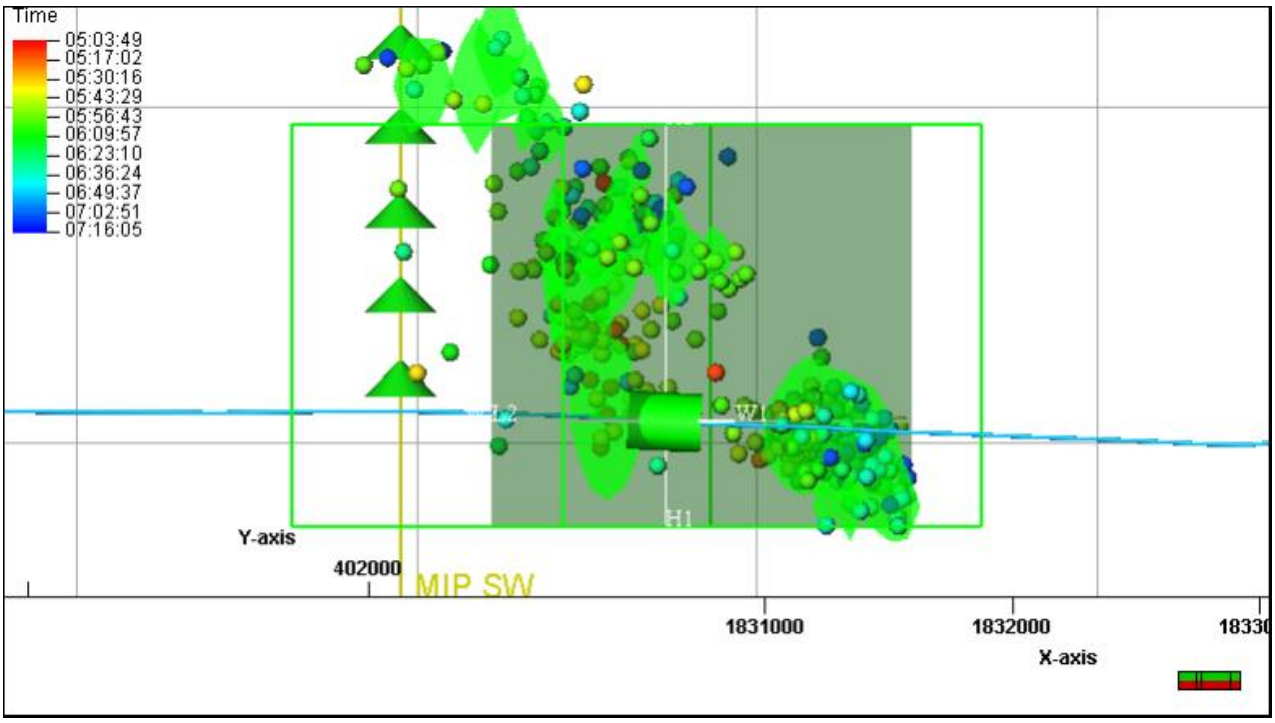



**Figure 5-73 - MIP 3H Stage 21 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 21 are shown below in map and transverse views.

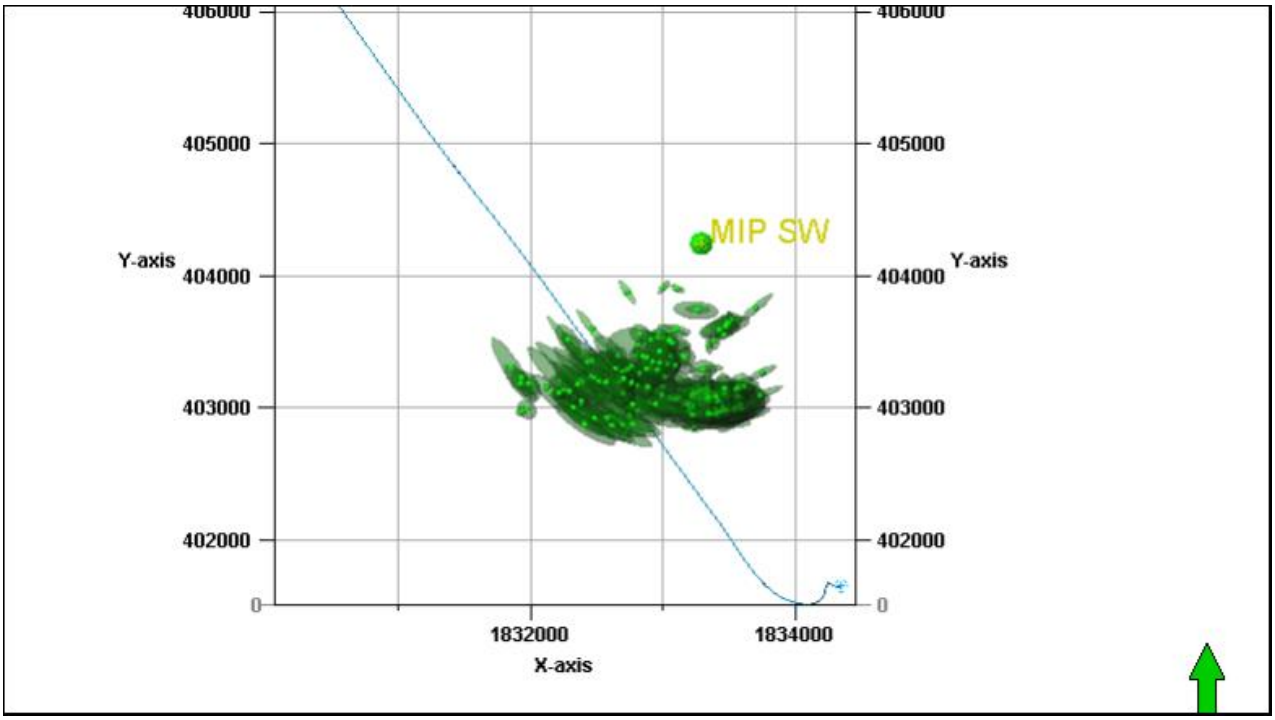



**Figure 5-74 - MIP 3H Stage 21 event location uncertainty ellipsoids – map view**

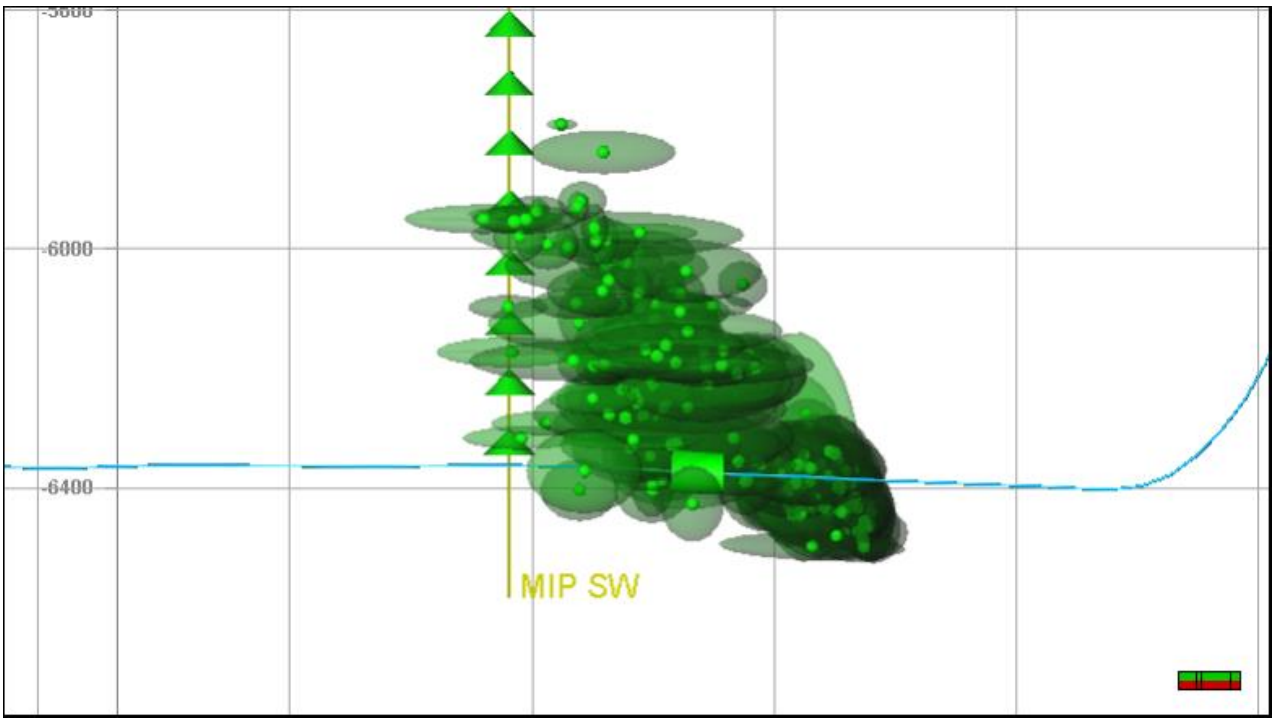



**Figure 5-75 - MIP 3H Stage 21 event location uncertainty ellipsoids – side view**

### 5.15.1 MIP 3H Stage 21 On-Site Notes and Observations

## 5.16 MIP 3H Stage 22

The MIP 3H Stage 22 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

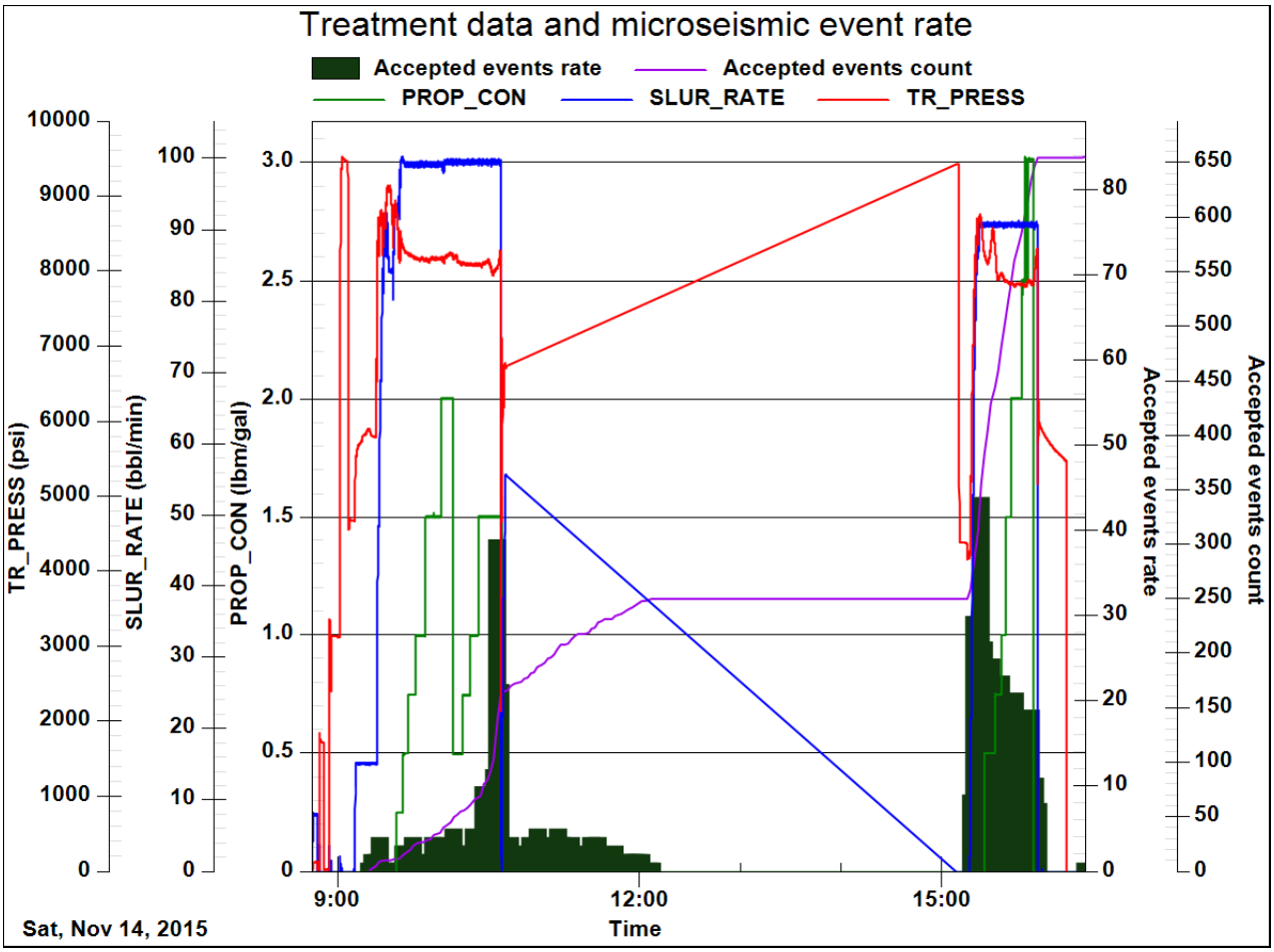



**Figure 5-76 - MIP 3H Stage 22 treatment data and microseismic event rate**

**Table 5.46 - MIP 3H Stage 22 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 381545 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 2999 |
| WF (gal) | Not used | 68168 |
| Total fluids (gal) | 311790 | 452712 |
| 100 Mesh (lbm) | 127600 | 153467 |
| 40/70 White (lbm) | 232400 | 284200 |
| Total proppants (lbm) | 360000 | 437667 |

**Table 5.47 - MIP 3H Stage 22 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 93.3 |
| Average pressure (psi) | 8089 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6022 |
| Maximum PPA (lbm/gal) | 3.024 |

**Table 5.48 - MIP 3H Stage 22 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 71 |
| MS length (ft) | 1576 |
| MS height (ft) | 492 |
| MS volume (million ft3) | 69.4 |

The microseismic data from MIP 3H Stage 22 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

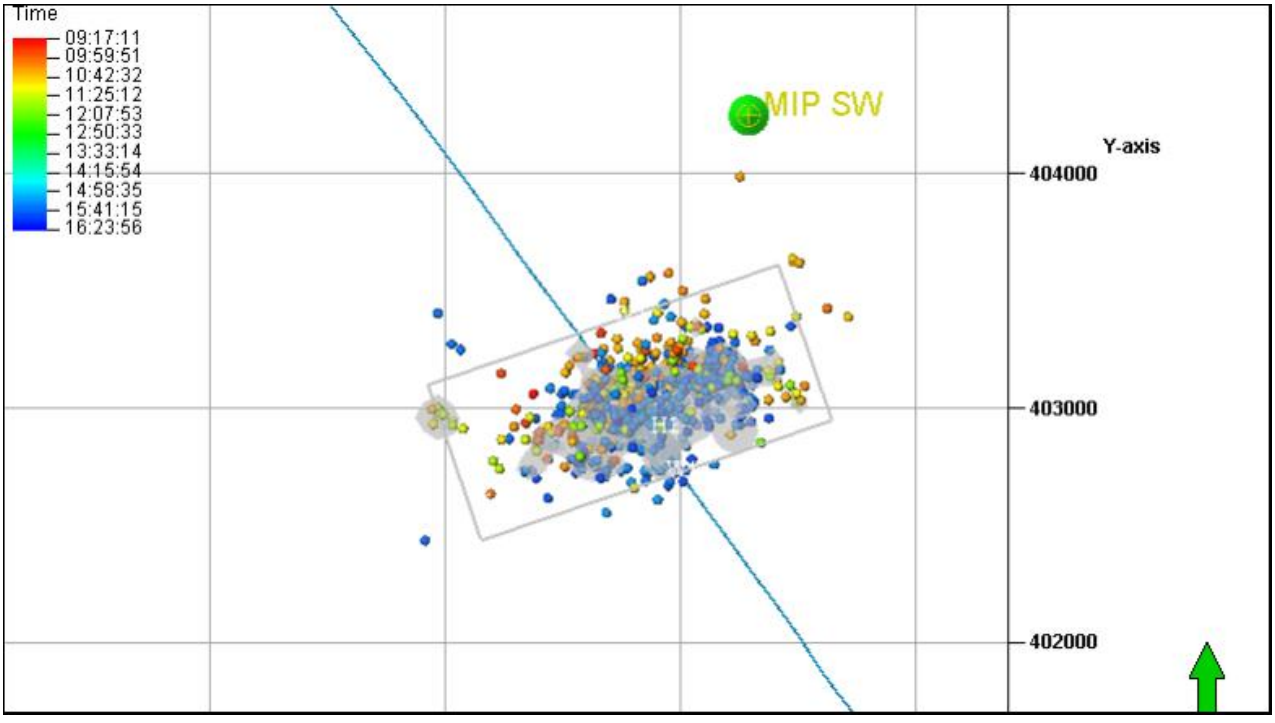



**Figure 5-77 - MIP 3H Stage 22 map view (length and width)**

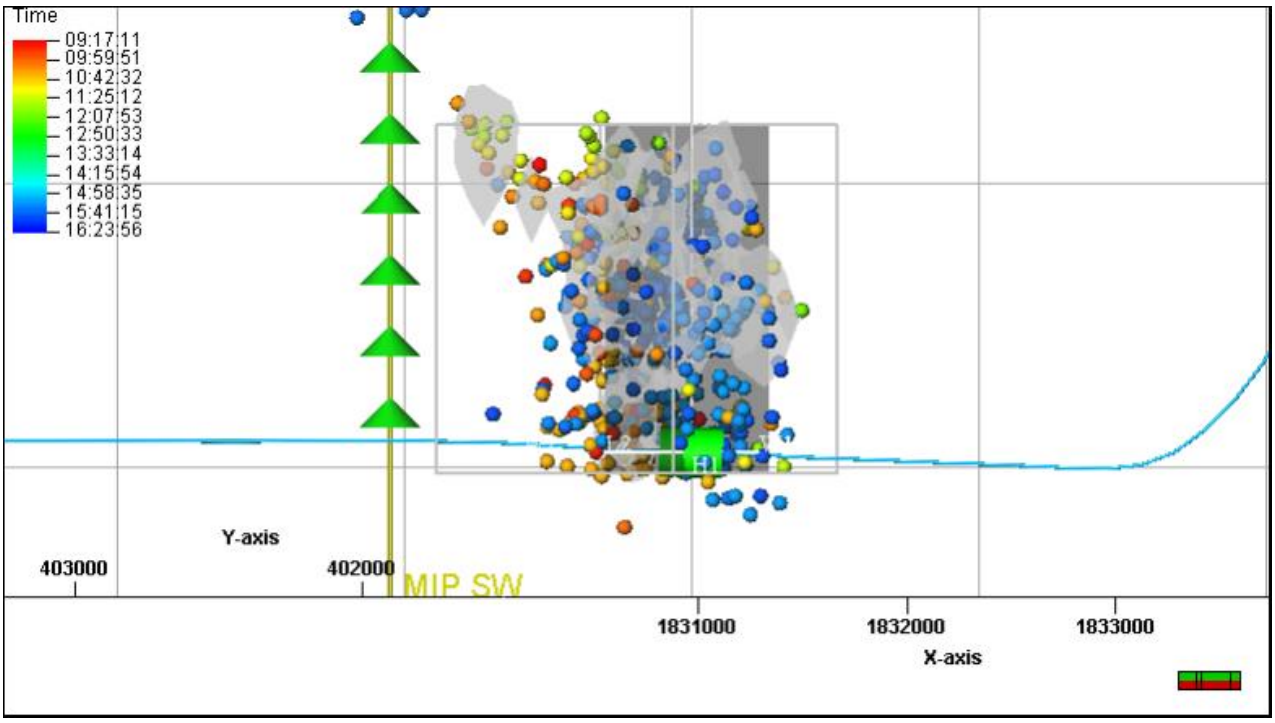



**Figure 5-78 - MIP 3H Stage 22 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 22 are shown below in map and transverse views.

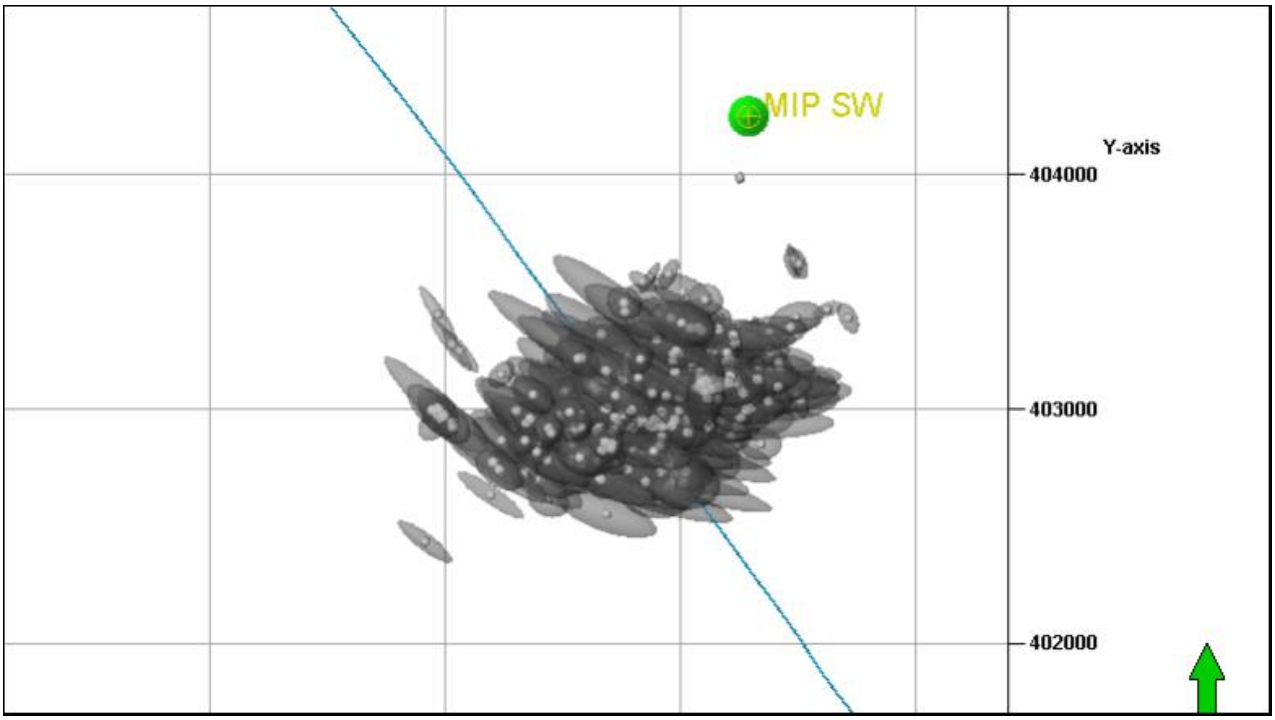



**Figure 5-79 - MIP 3H Stage 22 event location uncertainty ellipsoids – map view**

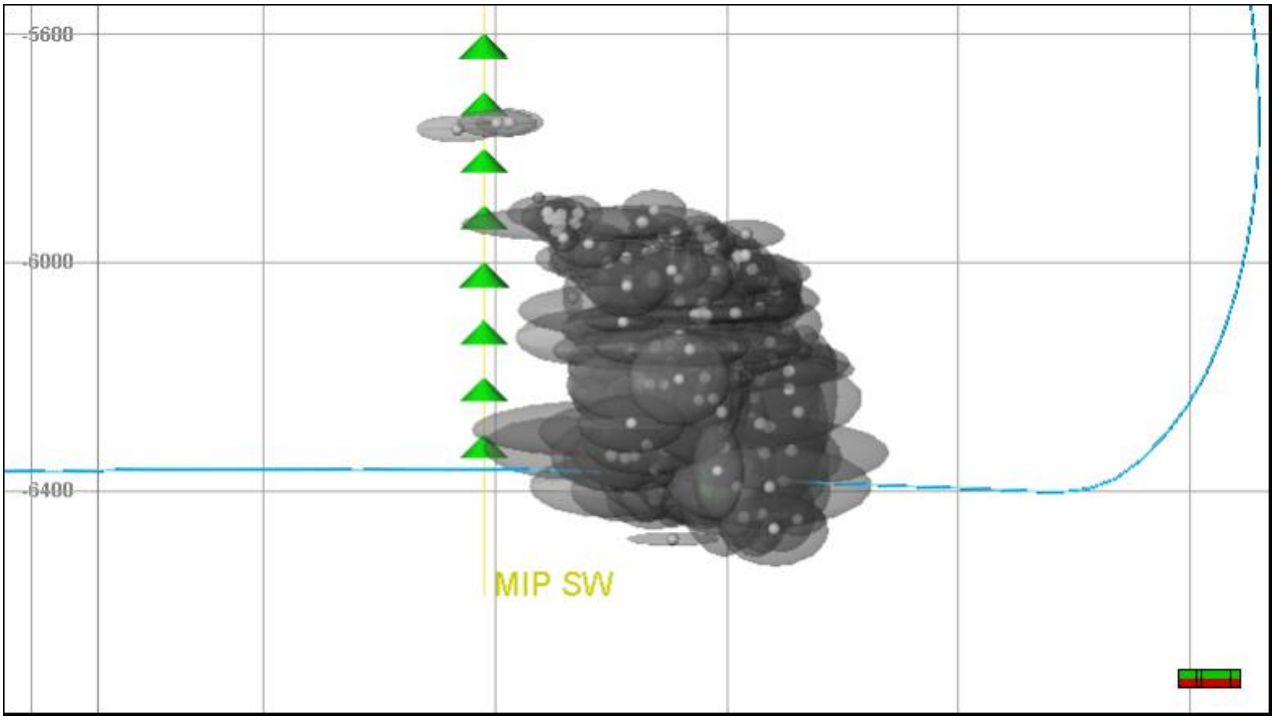



**Figure 5-80 - MIP 3H Stage 22 event location uncertainty ellipsoids – side view**

### 5.16.1 MIP 3H Stage 22 On-Site Notes and Observations

## 5.17 MIP 3H Stage 23

The MIP 3H Stage 23 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

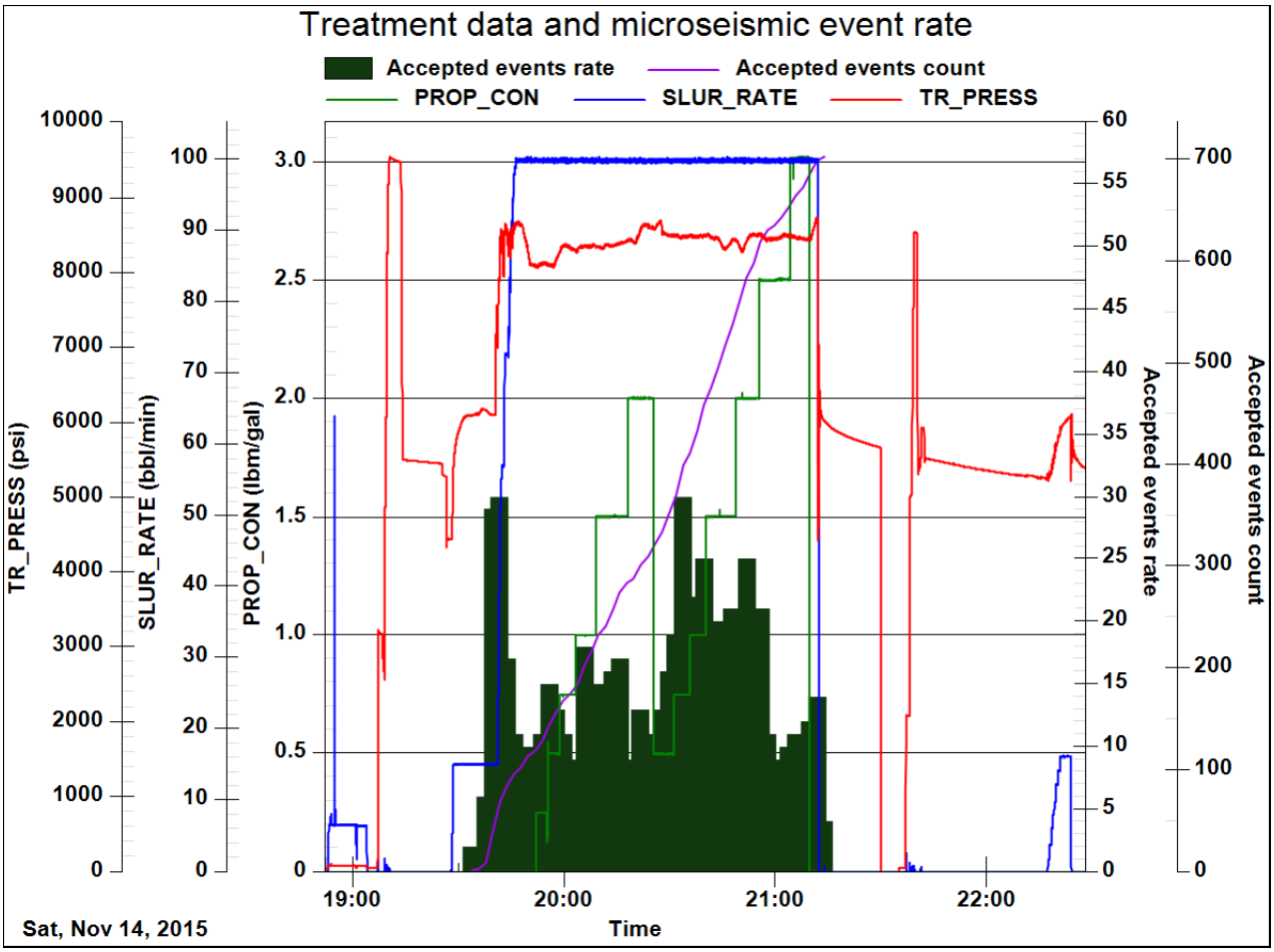



**Figure 5-81 - MIP 3H Stage 23 treatment data and microseismic event rate**

**Table 5.49 - MIP 3H Stage 23 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 309790 | 278539 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 2000 | 3000 |
| WF (gal) | Not used | 81651 |
| Total fluids (gal) | 311790 | 363190 |
| 100 Mesh (lbm) | 127600 | 155469 |
| 40/70 White (lbm) | 232400 | 280680 |
| Total proppants (lbm) | 360000 | 436149 |

**Table 5.50 - MIP 3H Stage 23 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.8 |
| Average pressure (psi) | 8418 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6223 |
| Maximum PPA (lbm/gal) | 3.02 |

**Table 5.51 - MIP 3H Stage 23 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 77 |
| MS length (ft) | 1602 |
| MS height (ft) | 516 |
| MS volume (million ft3) | 72.5 |

The microseismic data from MIP 3H Stage 23 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

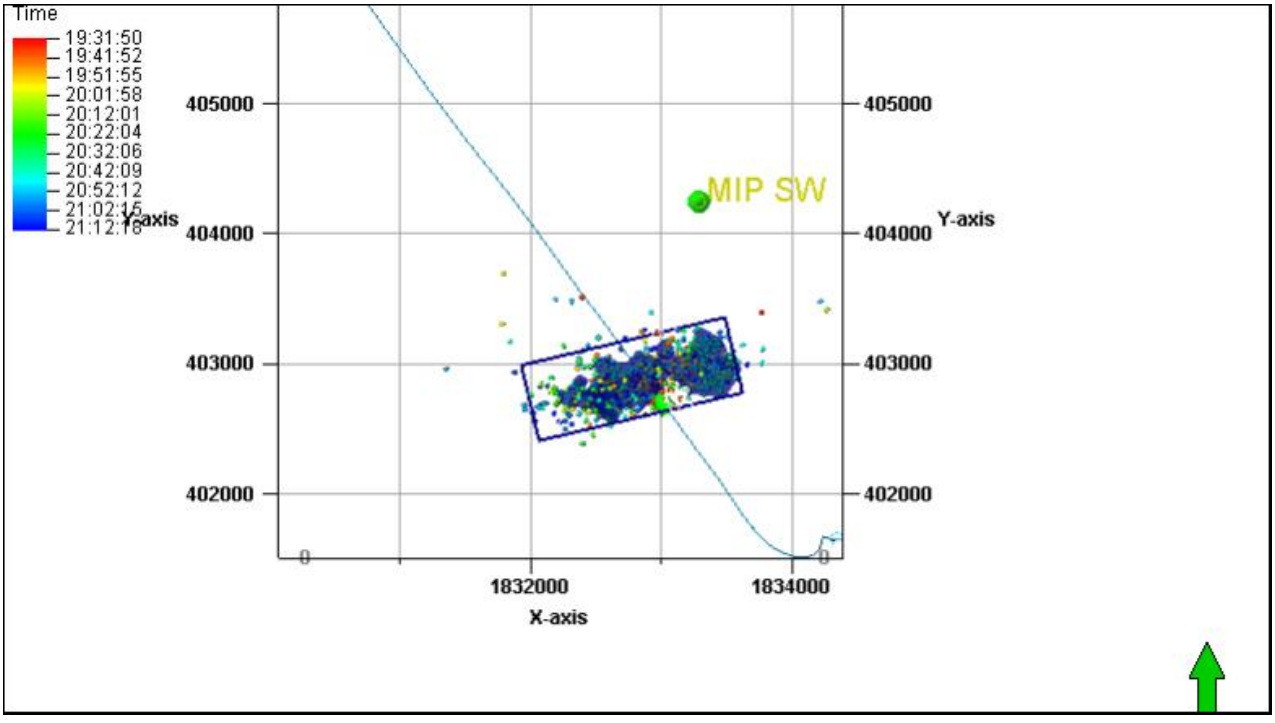



**Figure 5-82 - MIP 3H Stage 23 map view (length and width)**

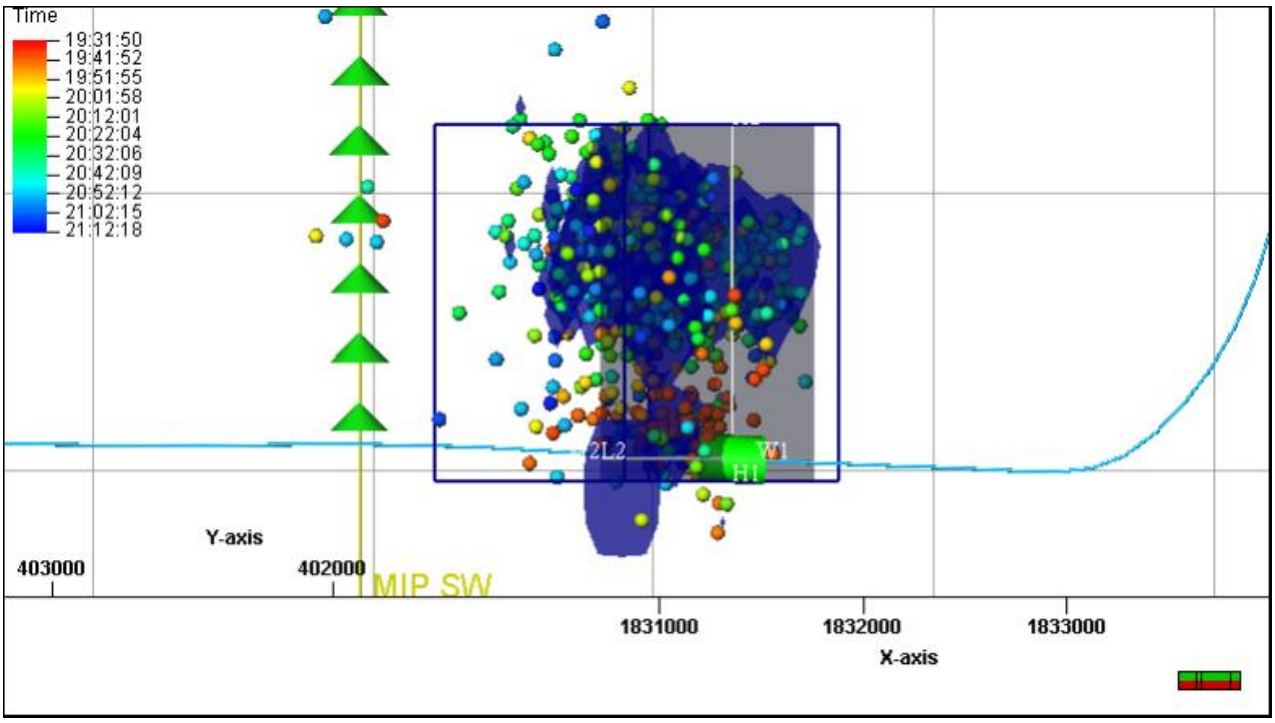



**Figure 5-83 - MIP 3H Stage 23 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 23 are shown below in map and transverse views.

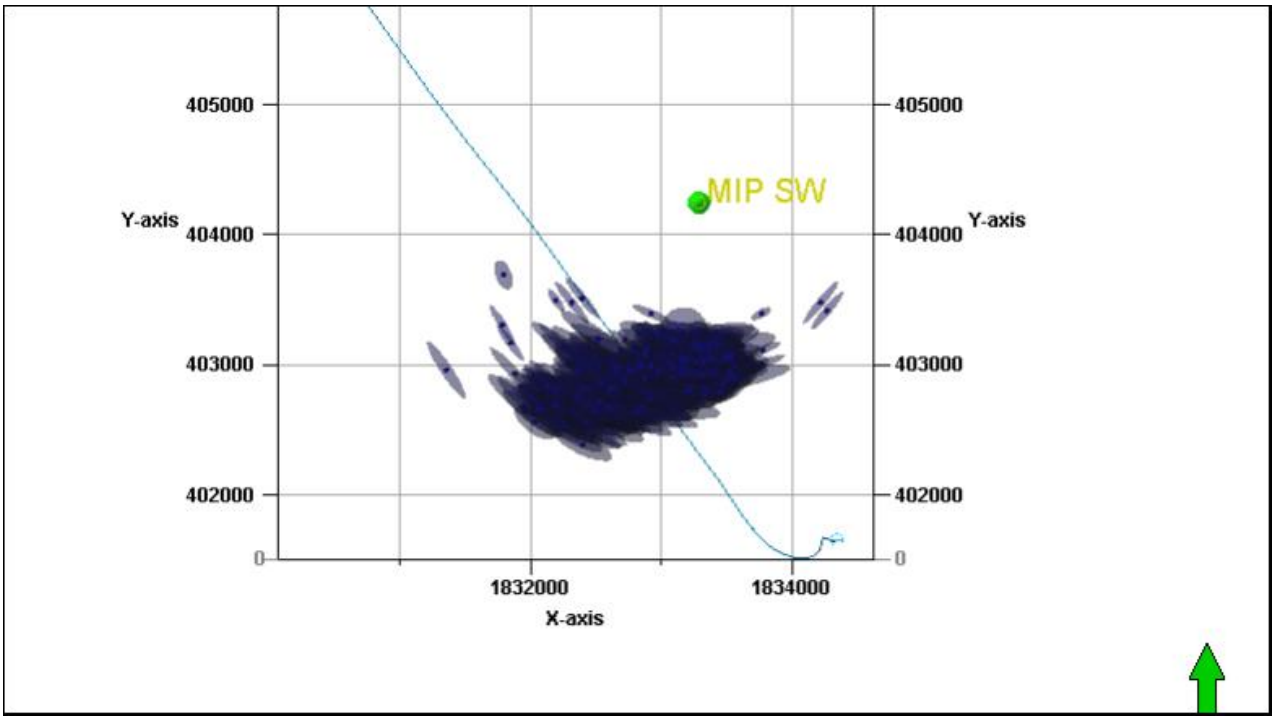



**Figure 5-84 - MIP 3H Stage 23 event location uncertainty ellipsoids – map view**

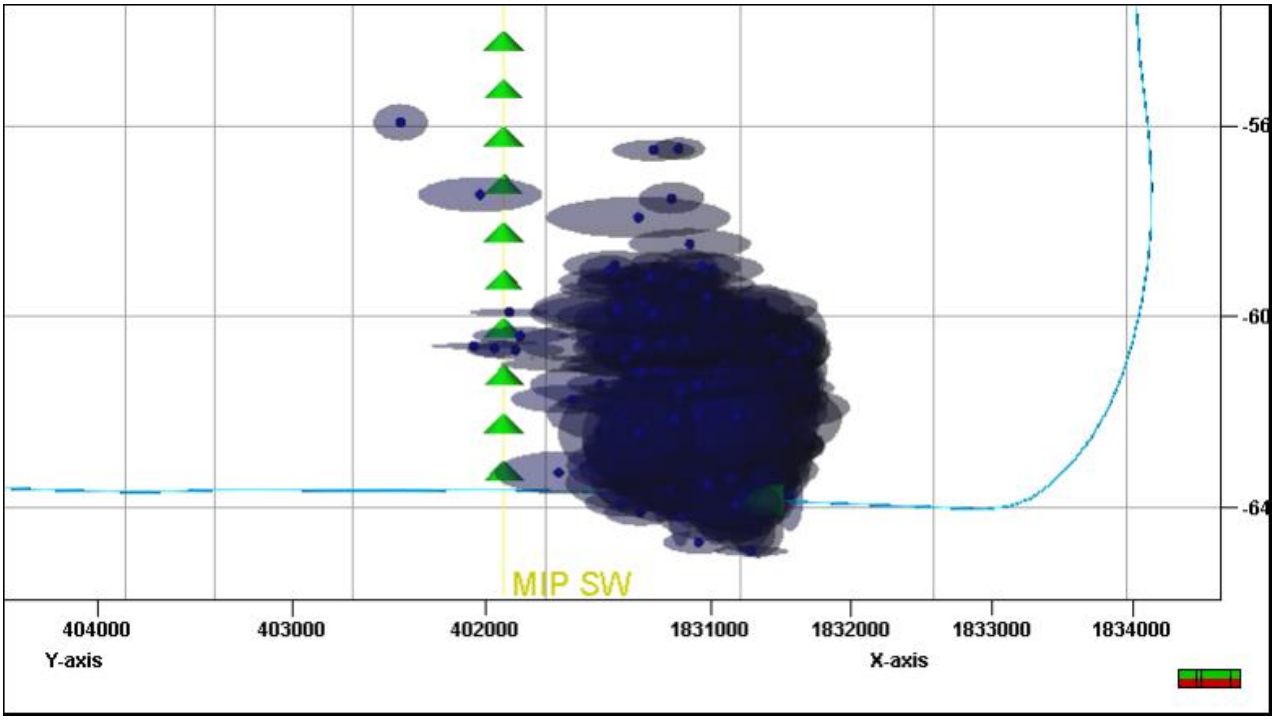



**Figure 5-85 - MIP 3H Stage 23 event location uncertainty ellipsoids – side view**

### 5.17.1 MIP 3H Stage 23 On-Site Notes and Observations

## 5.18 MIP 3H Stage 24

The MIP 3H Stage 24 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

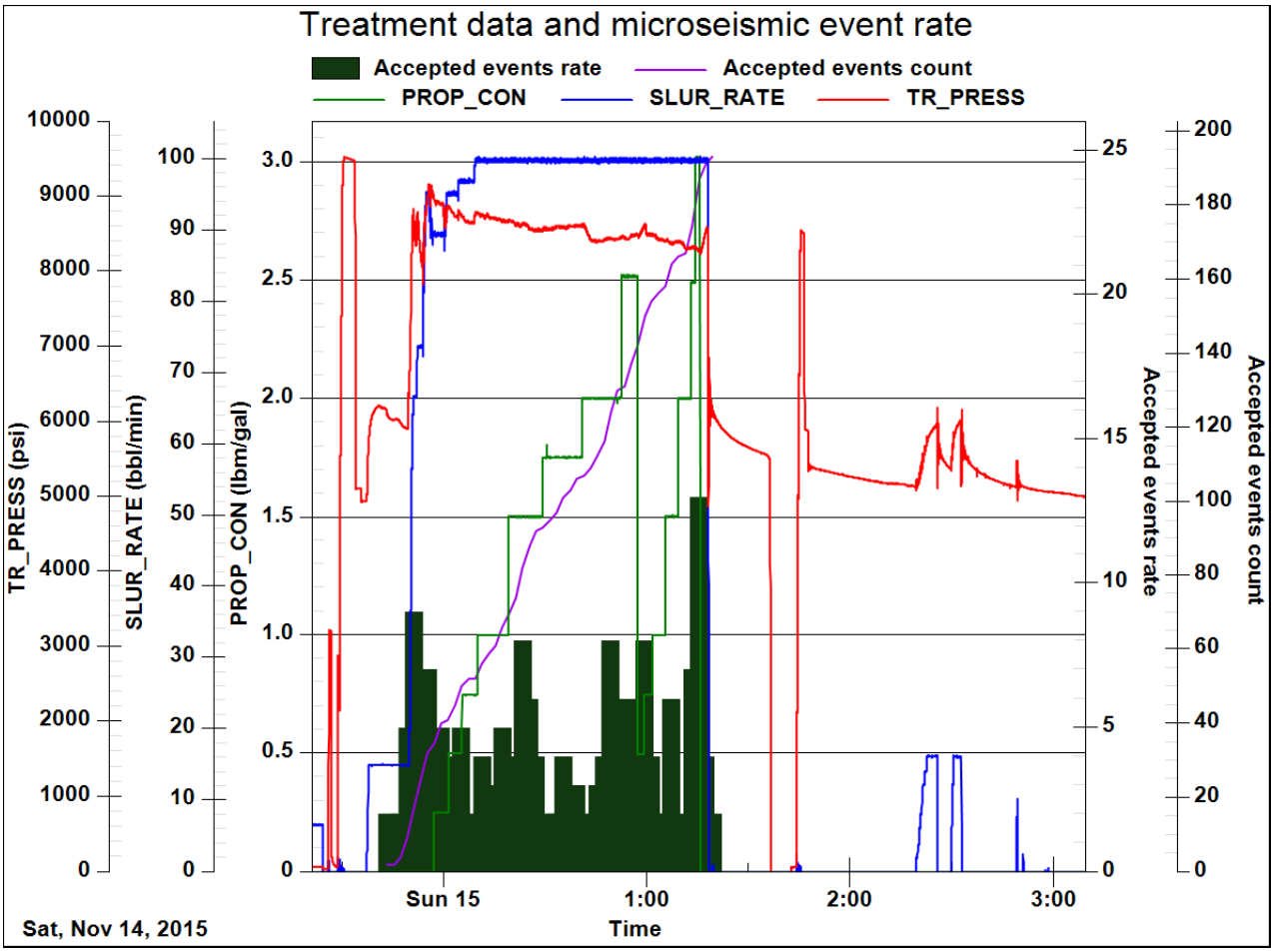



**Figure 5-86 - MIP 3H Stage 24 treatment data and microseismic event rate**

**Table 5.52 - MIP 3H Stage 24 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 344249 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 369060 | 347249 |
| 100 Mesh (lbm) | 155200 | 329540 |
| 40/70 White (lbm) | 284800 | 110740 |
| Total proppants (lbm) | 440000 | 440280 |

**Table 5.53 - MIP 3H Stage 24 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 98.8 |
| Average pressure (psi) | 8562 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6333 |
| Maximum PPA (lbm/gal) | 3.02 |

**Table 5.54 - MIP 3H Stage 24 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 83 |
| MS length (ft) | 2403 |
| MS height (ft) | 410 |
| MS volume (million ft3) | 30.6 |

The microseismic data from MIP 3H Stage 24 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

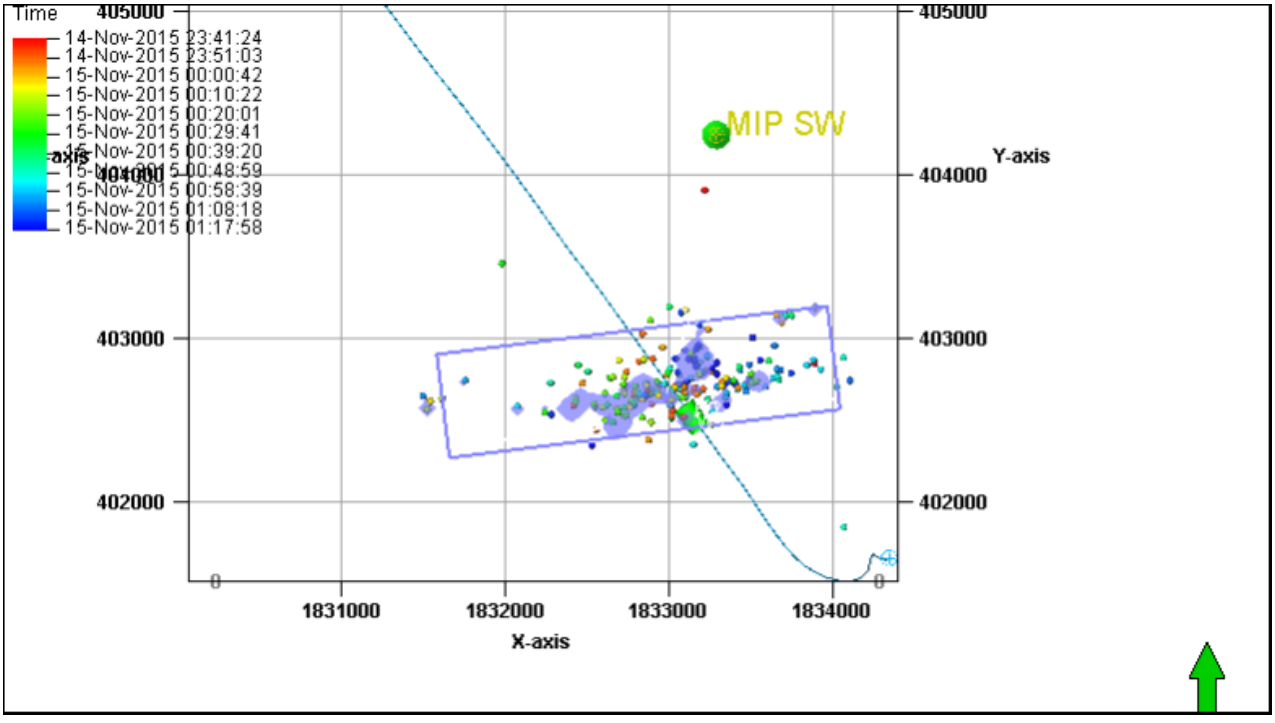



**Figure 5-87 - MIP 3H Stage 24 map view (length and width)**

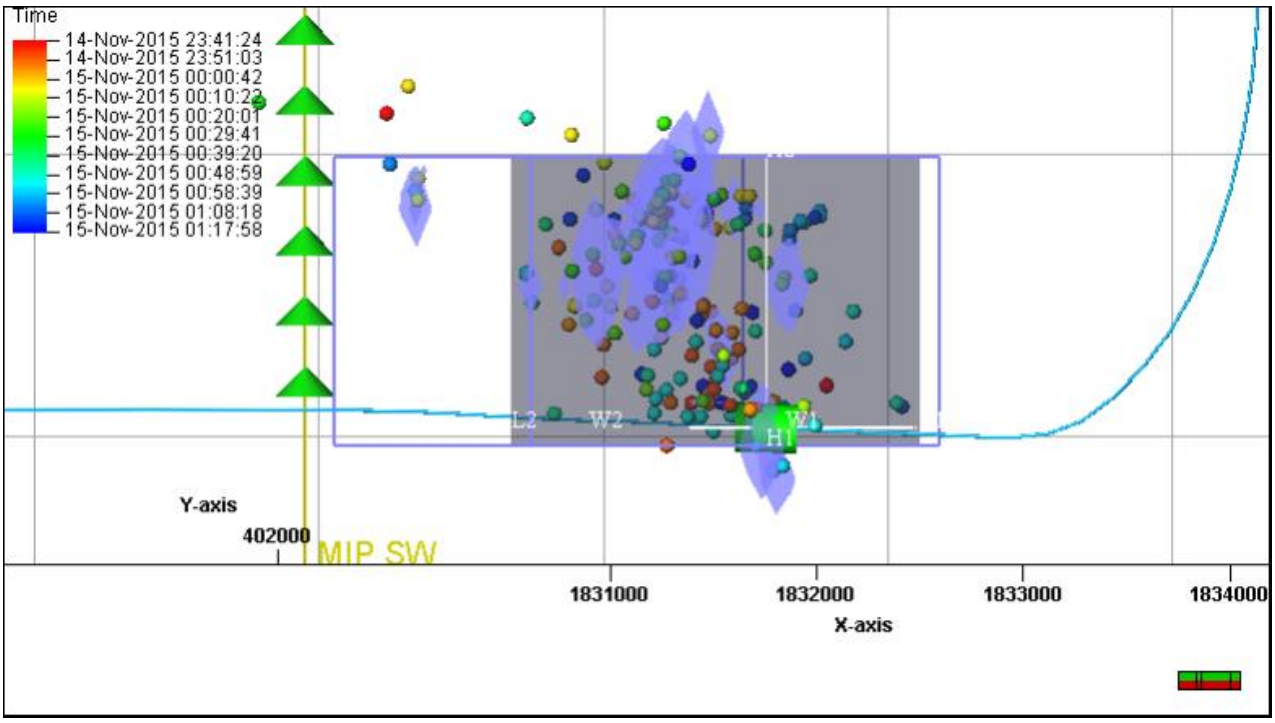



**Figure 5-88 - MIP 3H Stage 24 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 24 are shown below in map and transverse views.

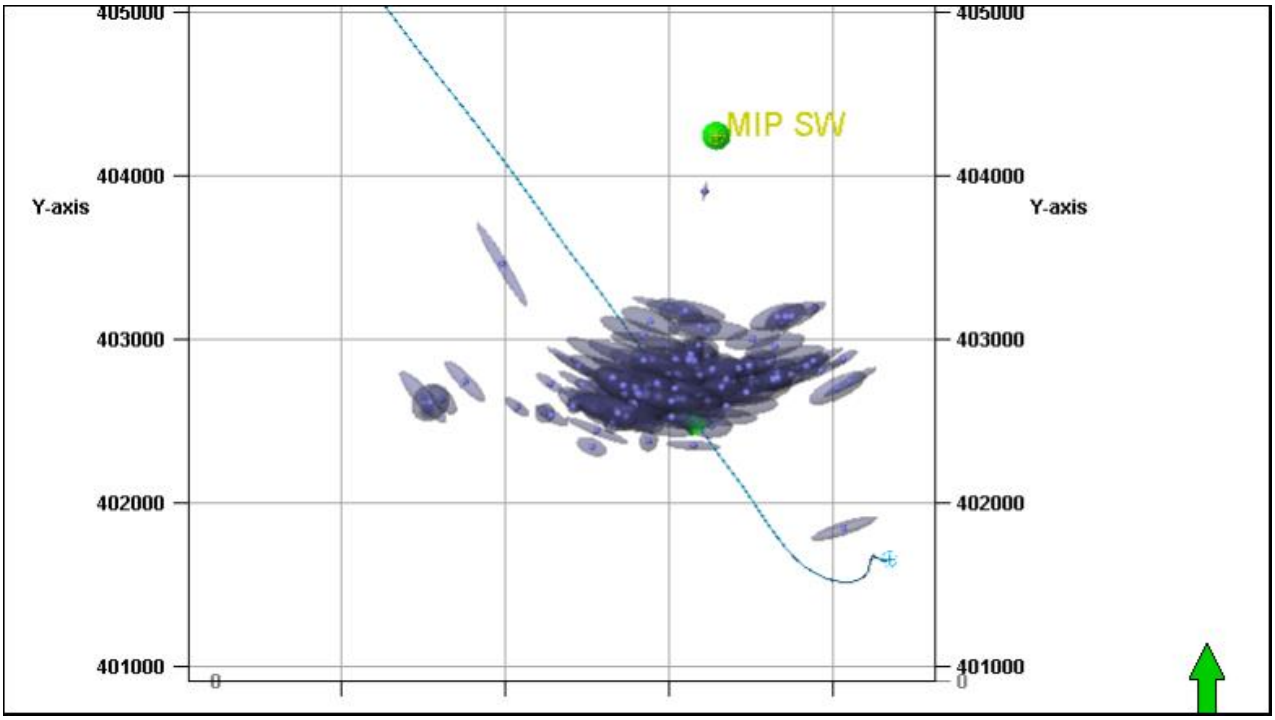



**Figure 5-89 - MIP 3H Stage 24 event location uncertainty ellipsoids – map view**

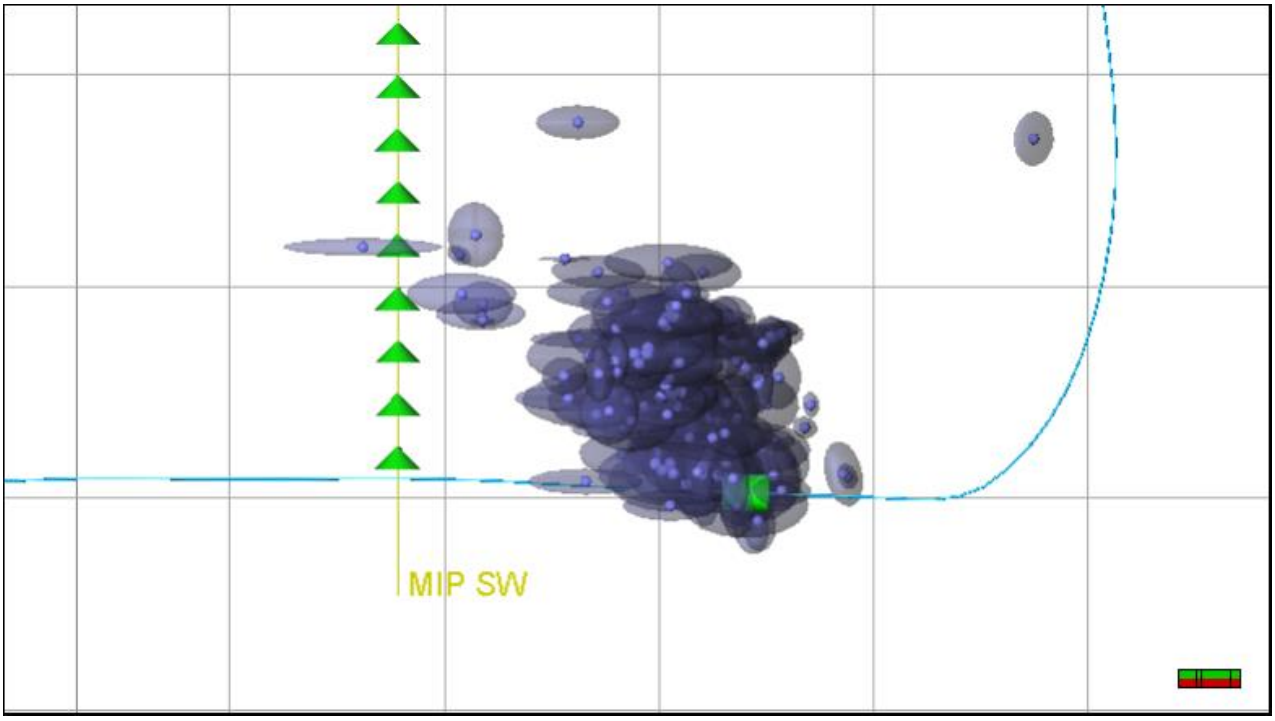



**Figure 5-90 - MIP 3H Stage 24 event location uncertainty ellipsoids – side view**

### 5.18.1 MIP 3H Stage 24 On-Site Notes and Observations

## 5.19 MIP 3H Stage 25

The MIP 3H Stage 25 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

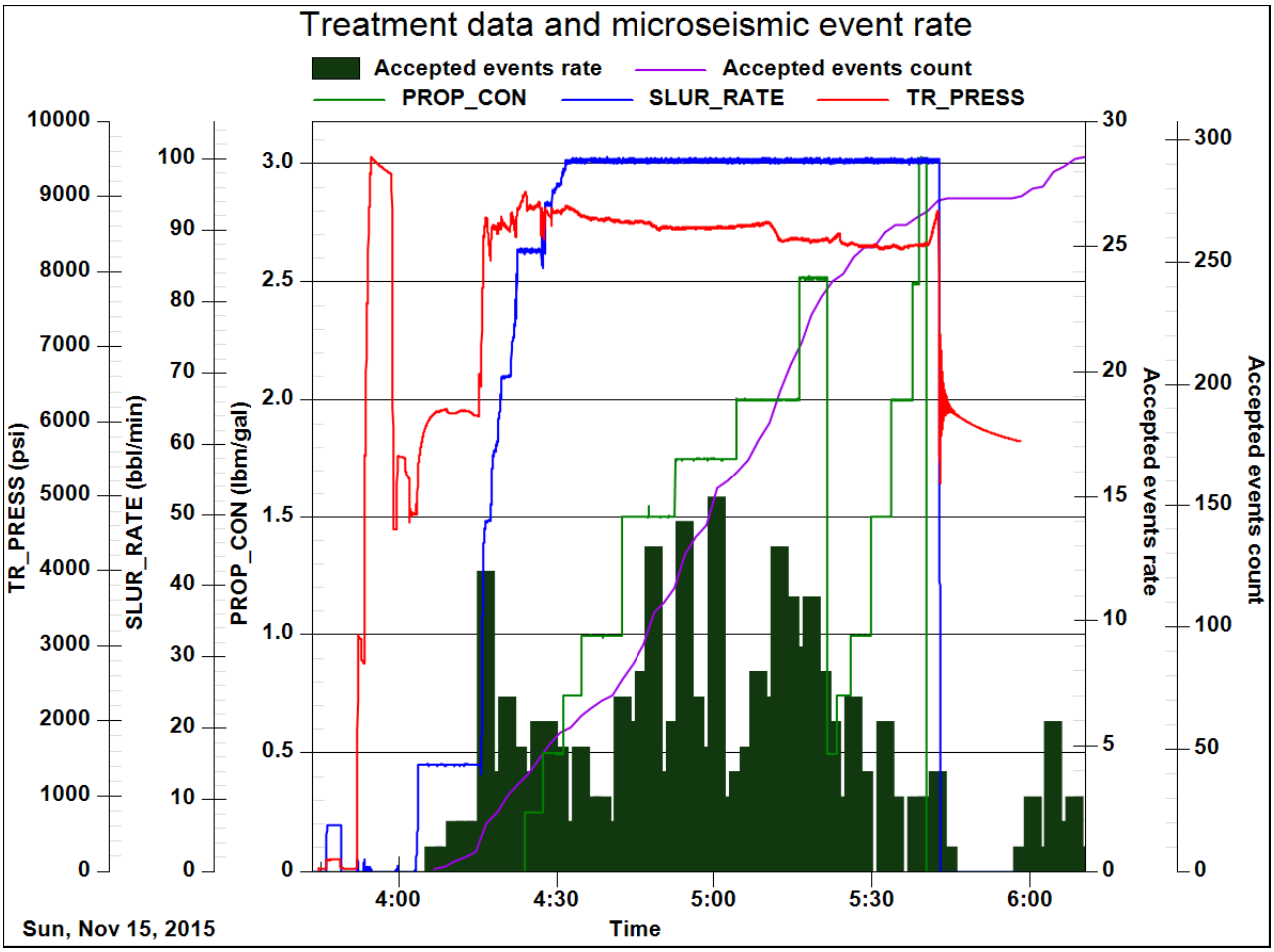



**Figure 5-91 - MIP 3H Stage 25 treatment data and microseismic event rate**

**Table 5.55 - MIP 3H Stage 25 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 335687 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 369060 | 338687 |
| 100 Mesh (lbm) | 155200 | 332640 |
| 40/70 White (lbm) | 284800 | 110060 |
| Total proppants (lbm) | 440000 | 442700 |

**Table 5.56 - MIP 3H Stage 25 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 98.7 |
| Average pressure (psi) | 8560 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6459 |
| Maximum PPA (lbm/gal) | 3.028 |

**Table 5.57 - MIP 3H Stage 25 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 67 |
| MS length (ft) | 1679 |
| MS height (ft) | 419 |
| MS volume (million ft3) | 24.3 |

The microseismic data from MIP 3H Stage 25 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

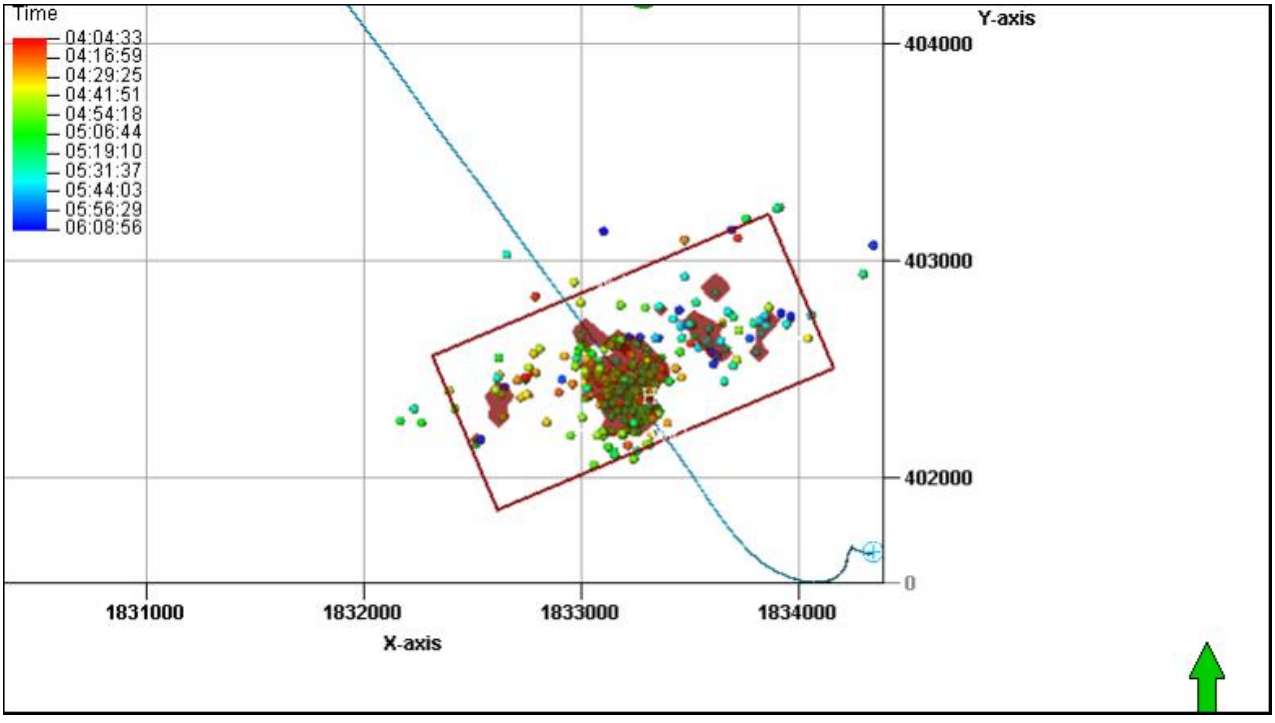



**Figure 5-92 - MIP 3H Stage 25 map view (length and width)**

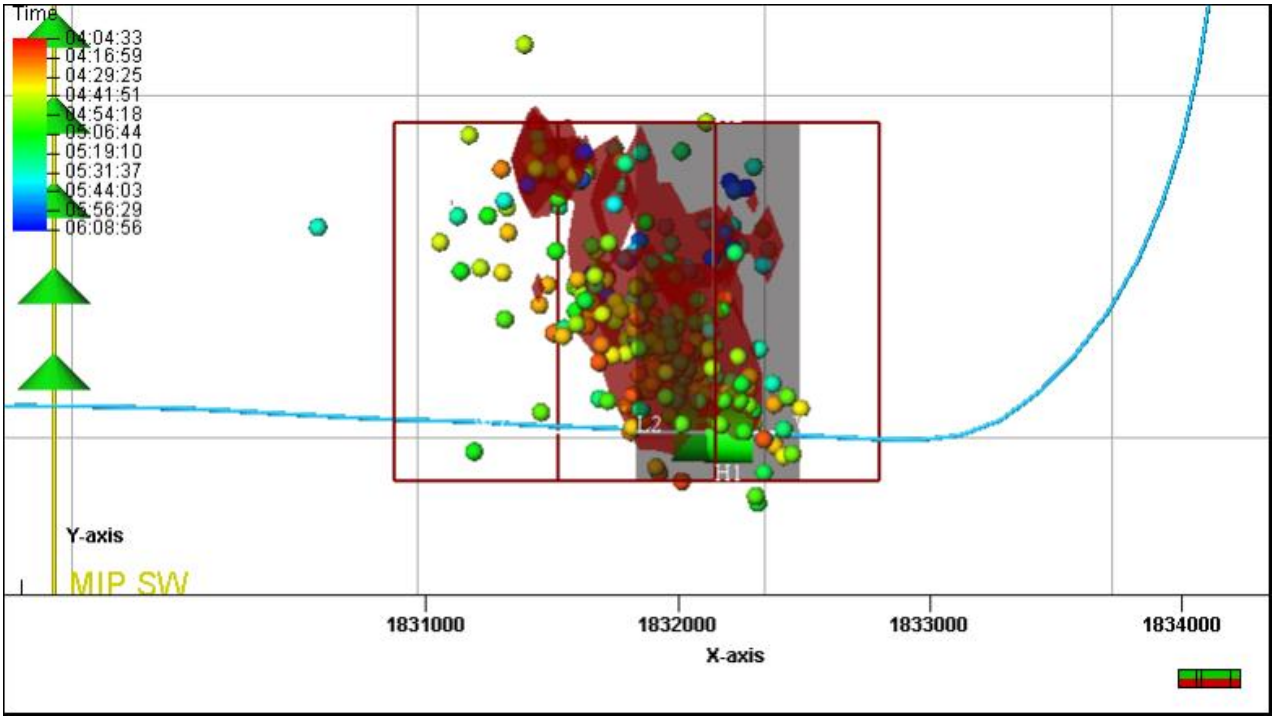



**Figure 5-93 - MIP 3H Stage 25 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 25 are shown below in map and transverse views.

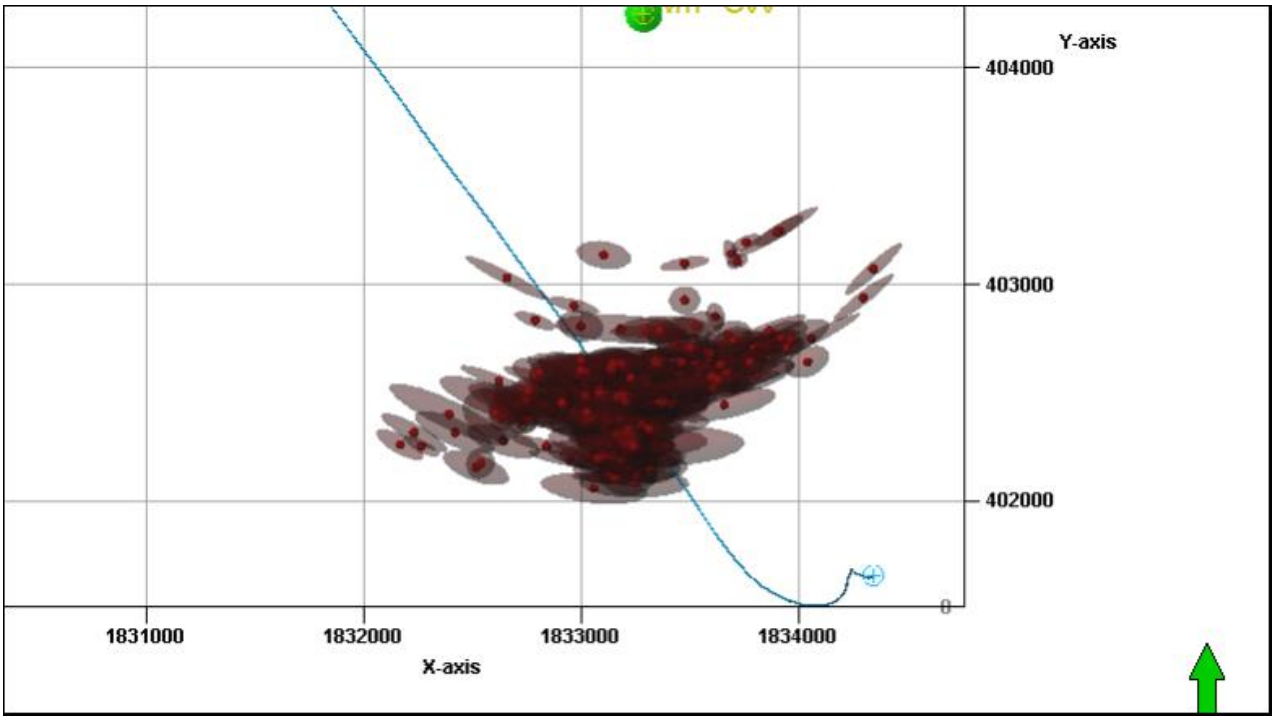



**Figure 5-94 - MIP 3H Stage 25 event location uncertainty ellipsoids – map view**

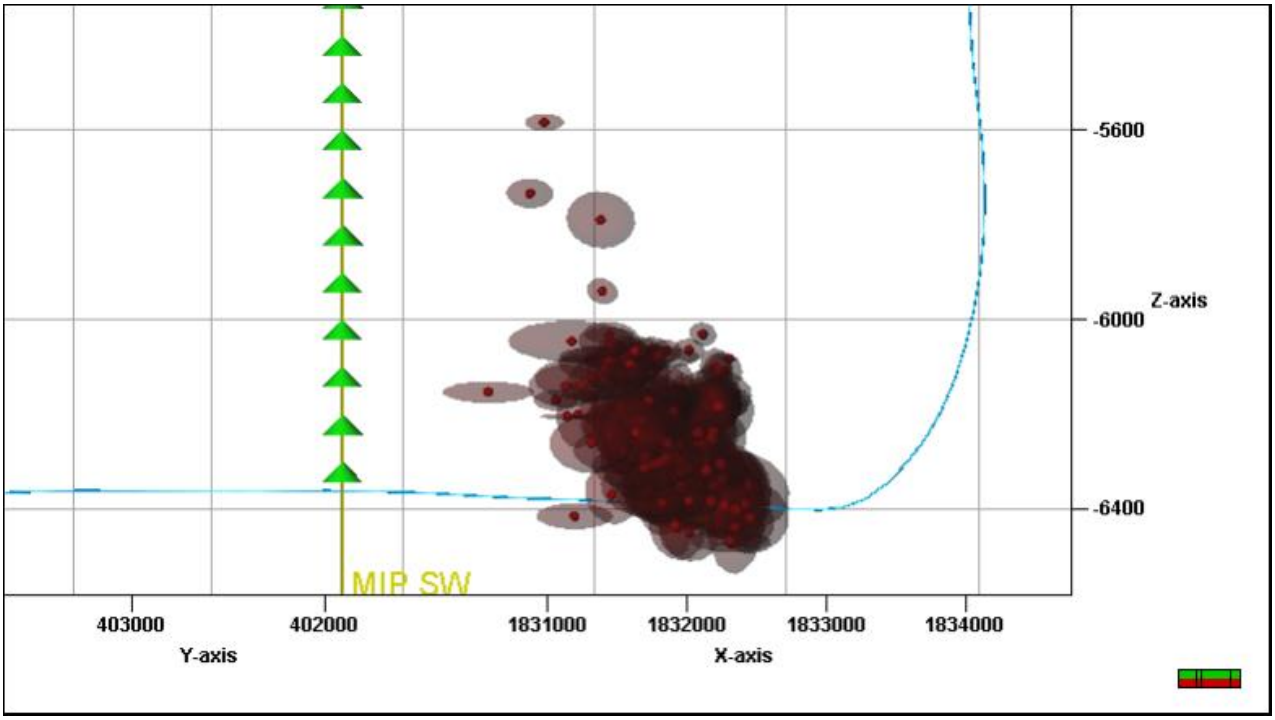



**Figure 5-95 - MIP 3H Stage 25 event location uncertainty ellipsoids – side view**

### 5.19.1 MIP 3H Stage 25 On-Site Notes and Observations

## 5.20 MIP 3H Stage 26

The MIP 3H Stage 26 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

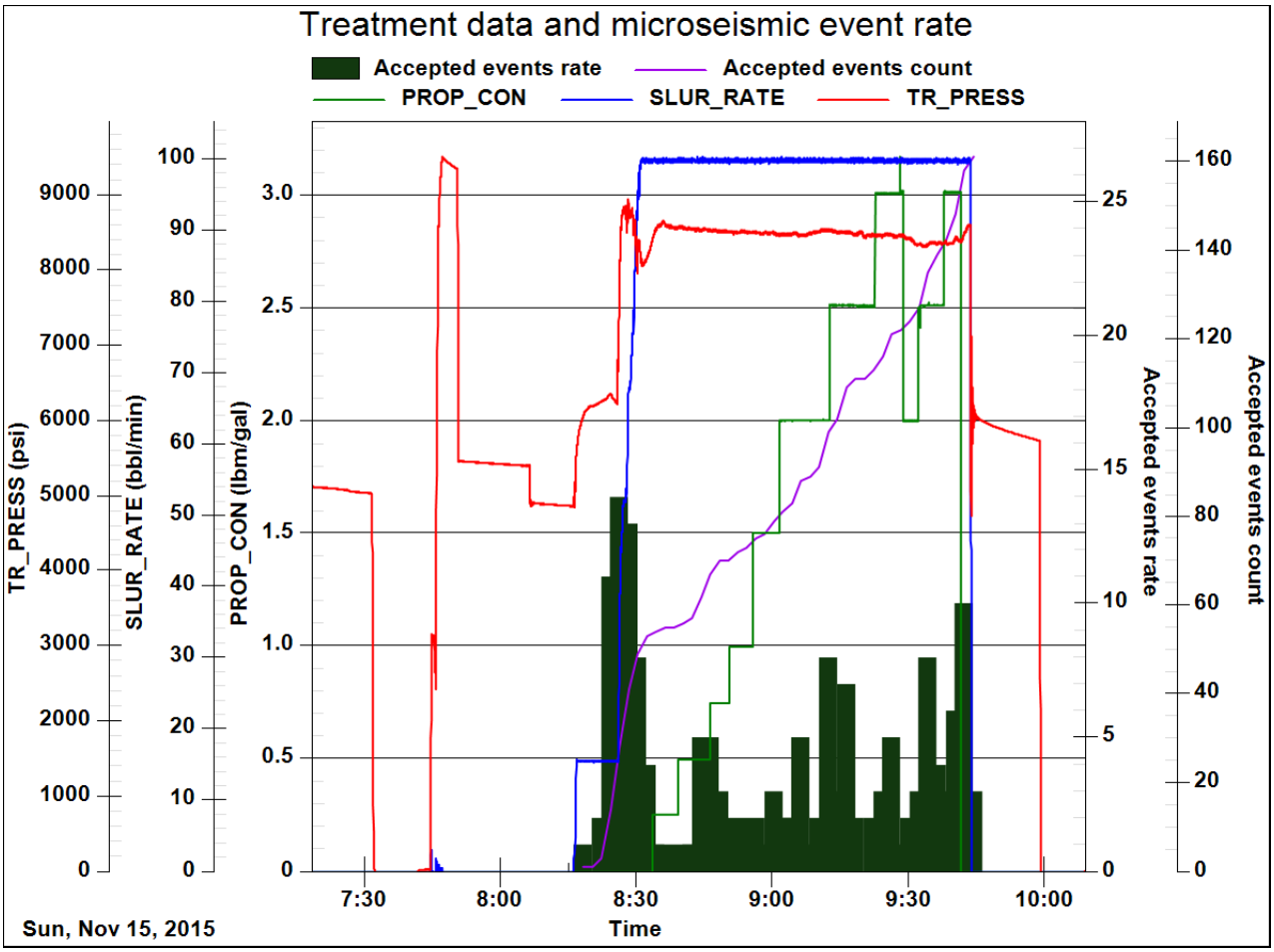



**Figure 5-96 - MIP 3H Stage 26 treatment data and microseismic event rate**

**Table 5.58 - MIP 3H Stage 26 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 182396 |
| Sapphire (gal) | 0 | 118668 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 369060 | 304064 |
| 100 Mesh (lbm) | 155200 | 330820 |
| 40/70 White (lbm) | 284800 | 109320 |
| Total proppants (lbm) | 440000 | 440140 |

**Table 5.59 - MIP 3H Stage 26 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.7 |
| Average pressure (psi) | 8472 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6205 |
| Maximum PPA (lbm/gal) | 3.17 |

**Table 5.60 - MIP 3H Stage 26 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 82 |
| MS length (ft) | 2055 |
| MS height (ft) | 478 |
| MS volume (million ft3) | 19.2 |

The microseismic data from MIP 3H Stage 26 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

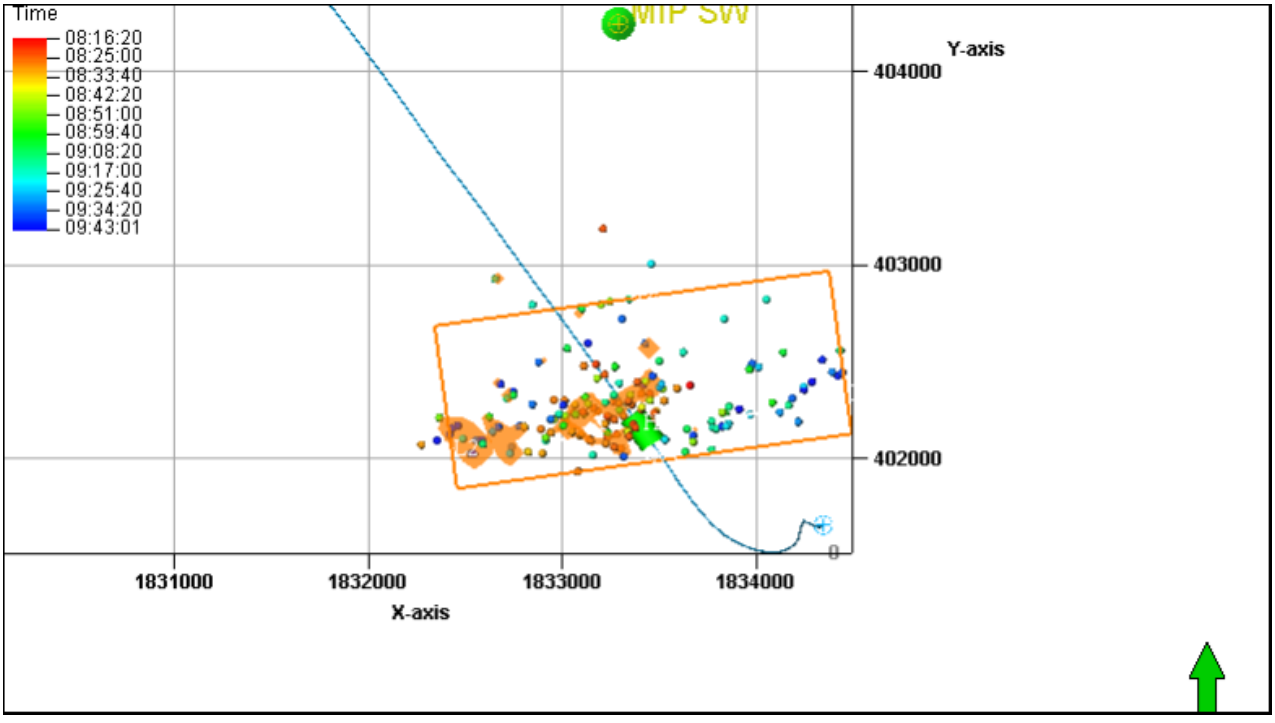



**Figure 5-97 - MIP 3H Stage 26 map view (length and width)**

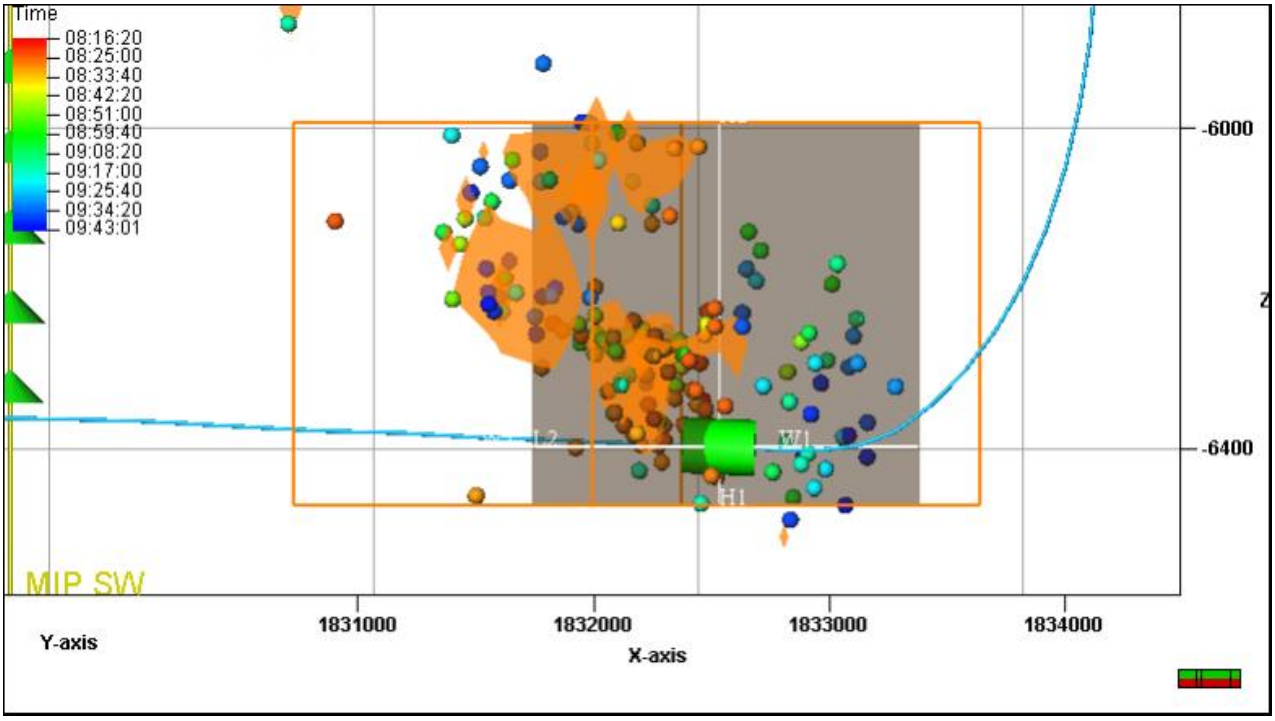



**Figure 5-98 - MIP 3H Stage 26 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 26 are shown below in map and transverse views.

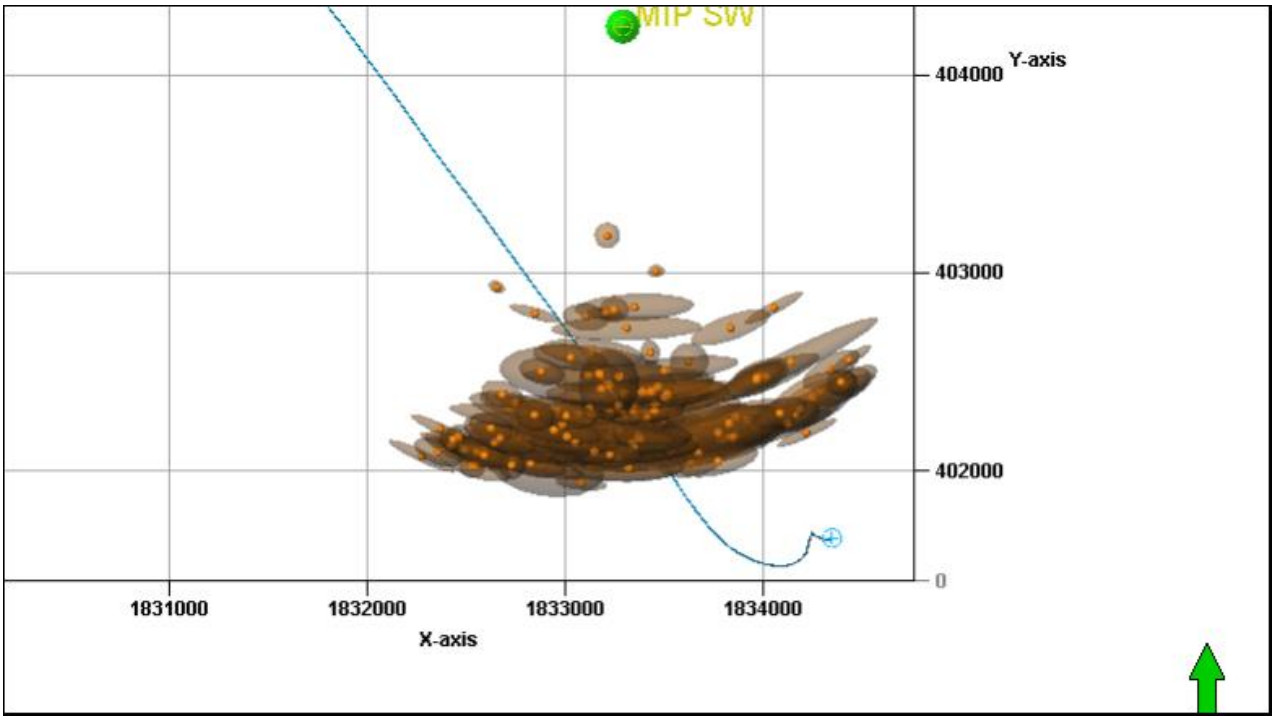



**Figure 5-99 - MIP 3H Stage 26 event location uncertainty ellipsoids – map view**

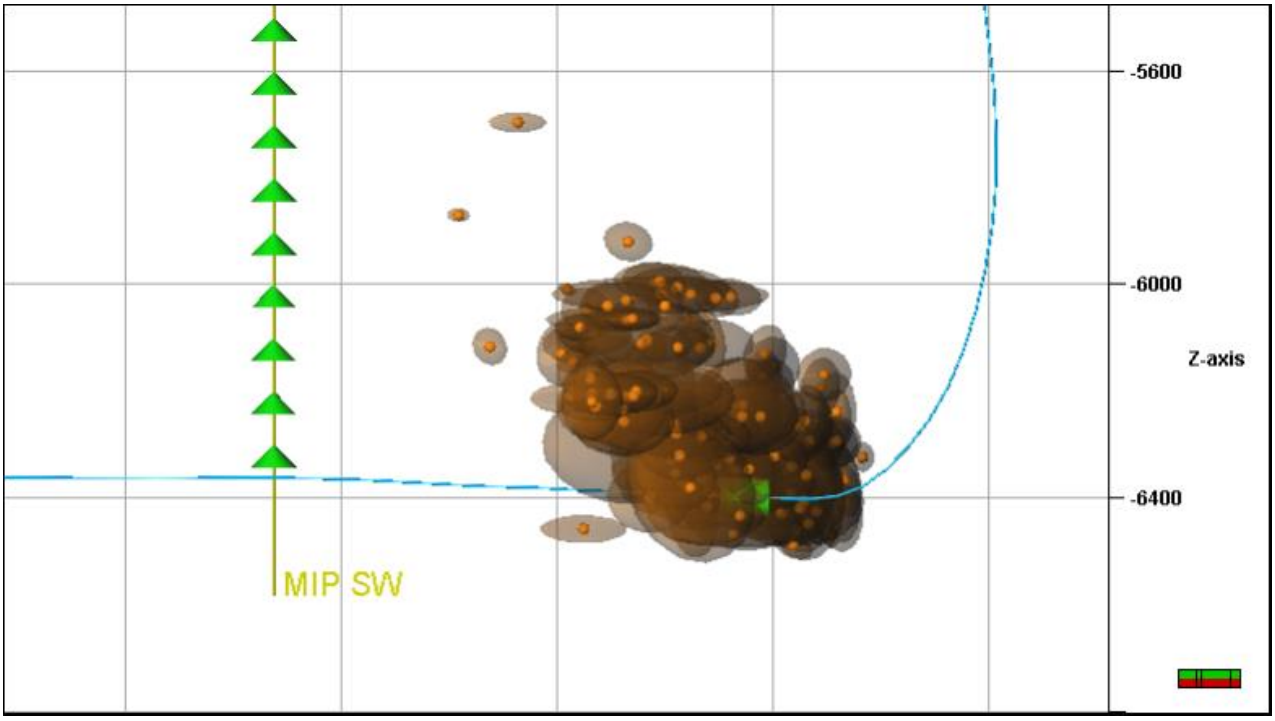



**Figure 5-100 - MIP 3H Stage 26 event location uncertainty ellipsoids – side view**

### 5.20.1 MIP 3H Stage 26 On-Site Notes and Observations

## 5.21 MIP 3H Stage 27

The MIP 3H Stage 27 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

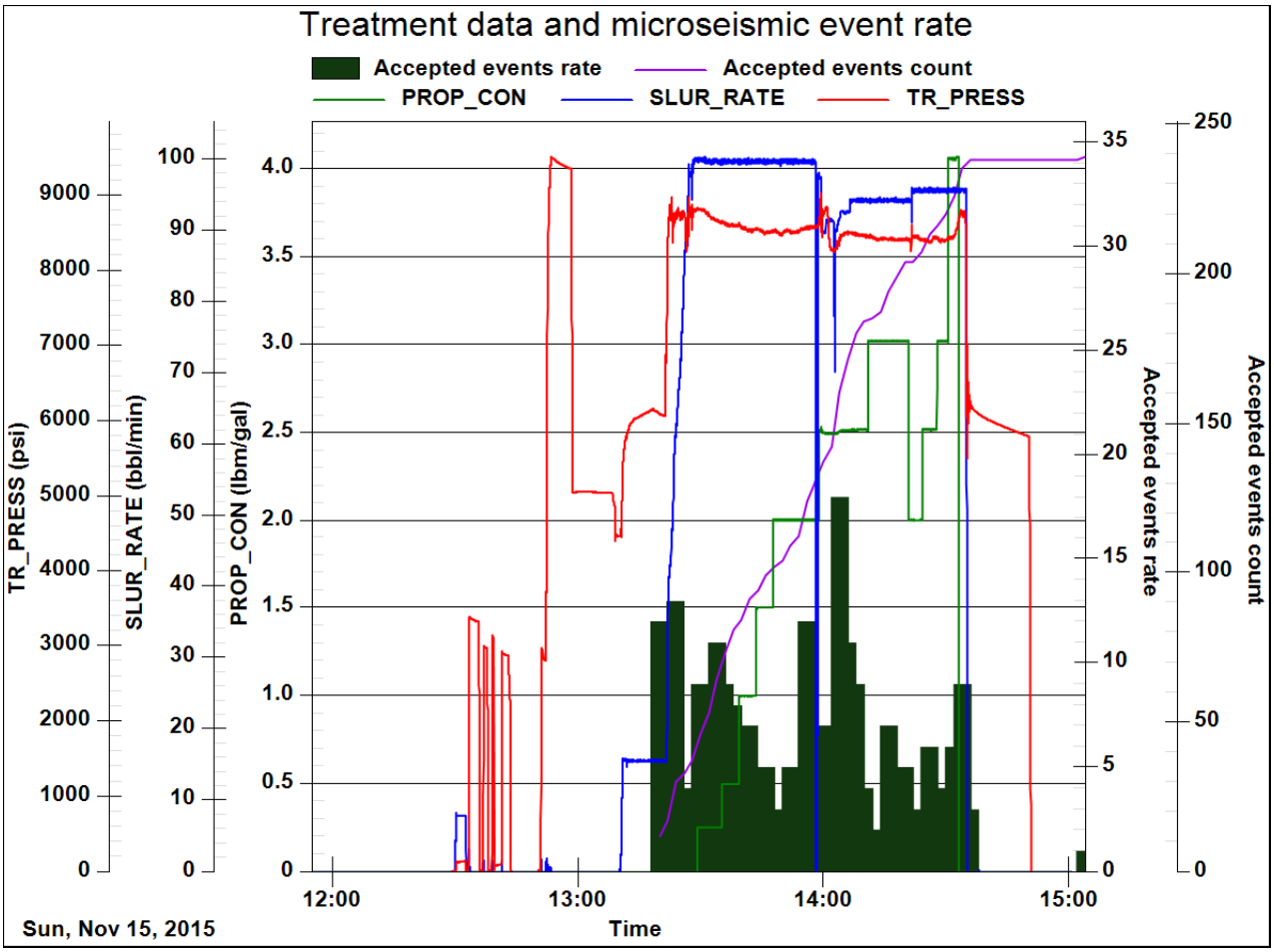



**Figure 5-101 - MIP 3H Stage 27 treatment data and microseismic event rate**

**Table 5.61 - MIP 3H Stage 27 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 151241 |
| Sapphire (gal) | 0 | 120324 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 369060 | 274565 |
| 100 Mesh (lbm) | 155200 | 342560 |
| 40/70 White (lbm) | 284800 | 110700 |
| Total proppants (lbm) | 440000 | 453260 |

**Table 5.62 - MIP 3H Stage 27 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 93.4 |
| Average pressure (psi) | 8469 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6335 |
| Maximum PPA (lbm/gal) | 4.067 |

**Table 5.63 - MIP 3H Stage 27 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 83 |
| MS length (ft) | 1662 |
| MS height (ft) | 482 |
| MS volume (million ft3) | 29 |

The microseismic data from MIP 3H Stage 27 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

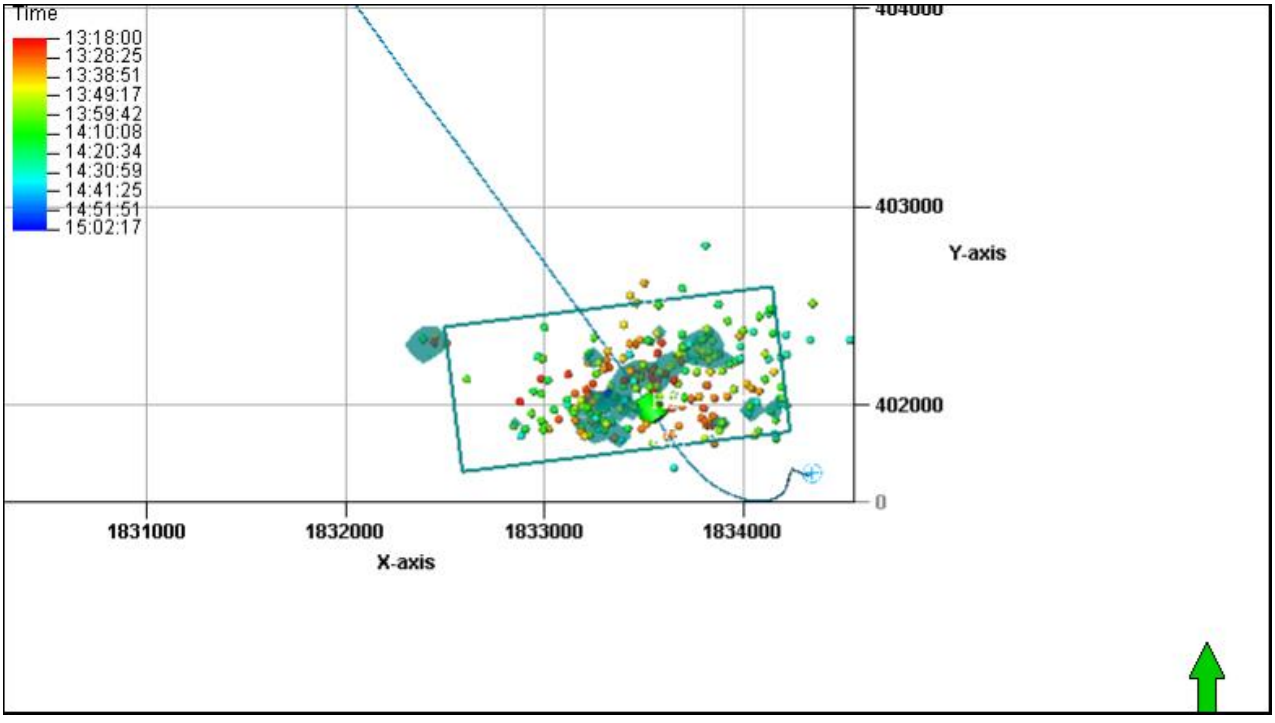



**Figure 5-102 - MIP 3H Stage 27 map view (length and width)**

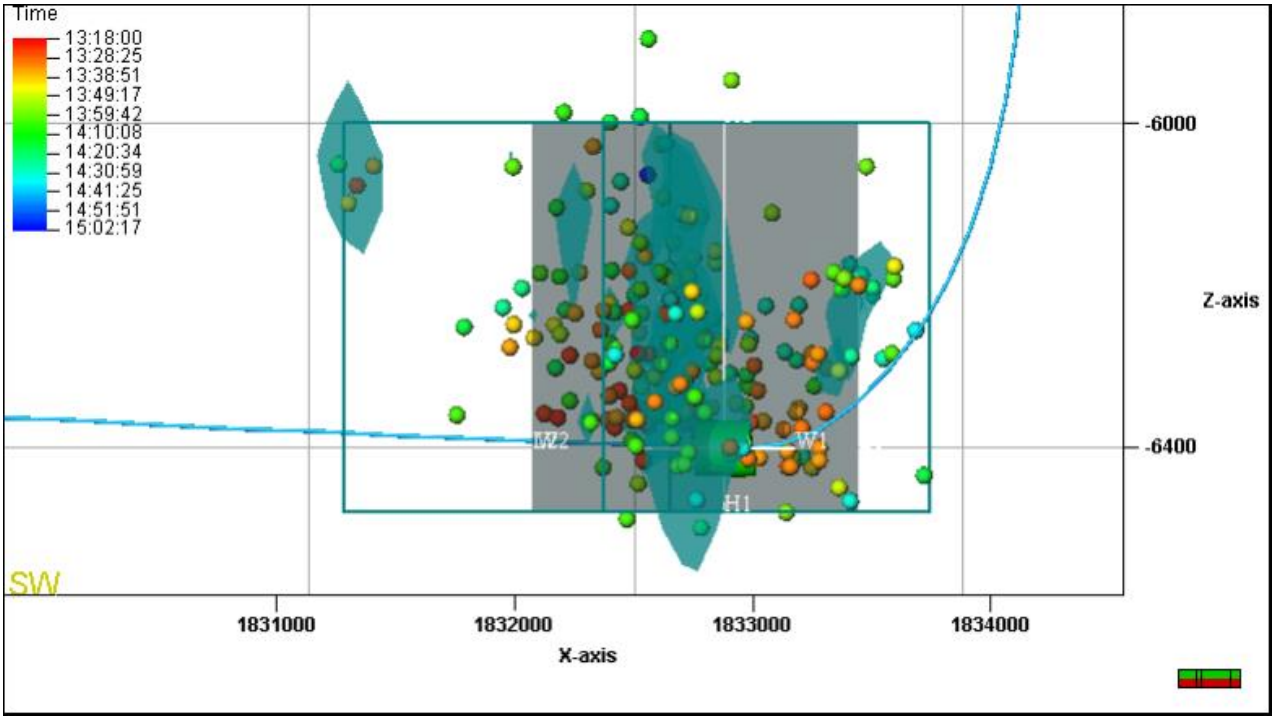



**Figure 5-103 - MIP 3H Stage 27 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 27 are shown below in map and transverse views.

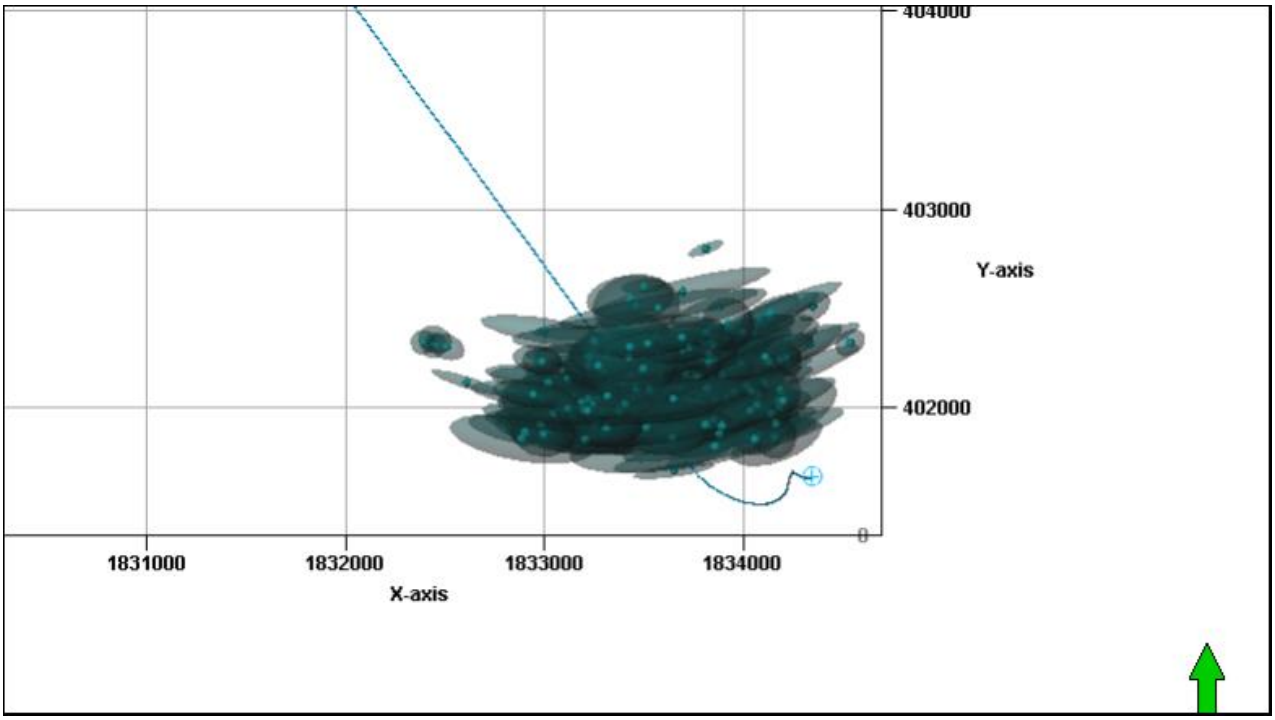



**Figure 5-104 - MIP 3H Stage 27 event location uncertainty ellipsoids – map view**

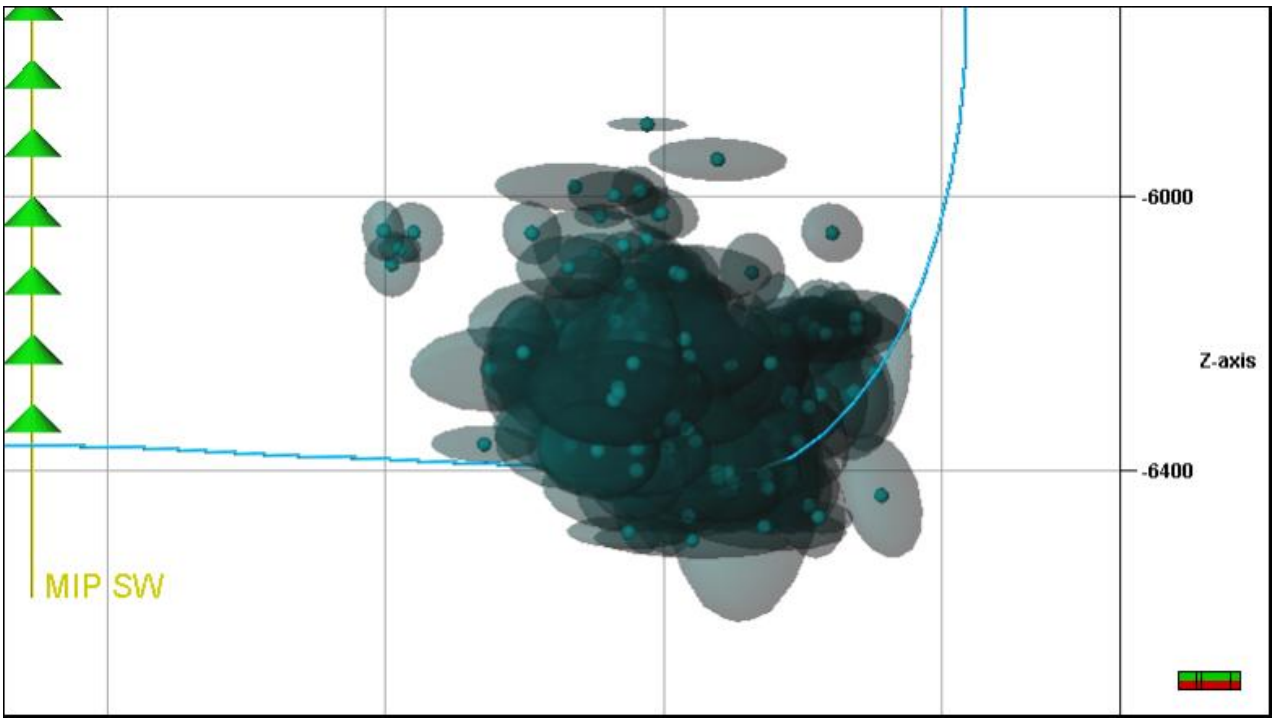



**Figure 5-105 - MIP 3H Stage 27 event location uncertainty ellipsoids – side view**

### 5.21.1 MIP 3H Stage 27 On-Site Notes and Observations

## 5.22 MIP 3H Stage 28

The MIP 3H Stage 28 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

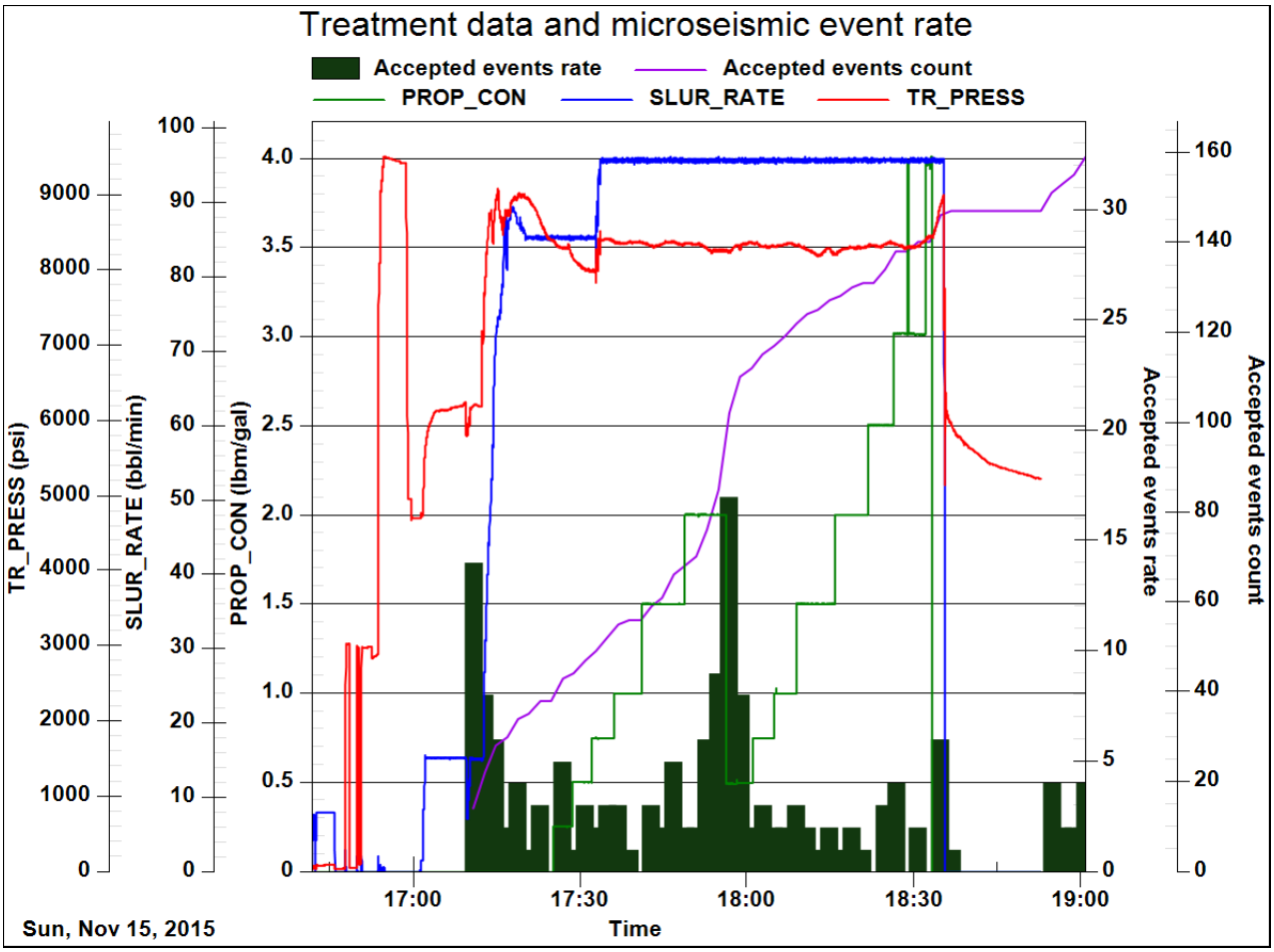



**Figure 5-106 - MIP 3H Stage 28 treatment data and microseismic event rate**

**Table 5.64 - MIP 3H Stage 28 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 366060 | 242074 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3082 |
| WF (gal) | Not used | 64642 |
| Total fluids (gal) | 369060 | 309798 |
| 100 Mesh (lbm) | 155200 | 128320 |
| 40/70 White (lbm) | 284800 | 237635 |
| Total proppants (lbm) | 440000 | 365955 |

**Table 5.65 - MIP 3H Stage 28 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 94.1 |
| Average pressure (psi) | 8324 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6335 |
| Maximum PPA (lbm/gal) | 4.008 |

**Table 5.66 - MIP 3H Stage 28 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 78 |
| MS length (ft) | 1372 |
| MS height (ft) | 296 |
| MS volume (million ft3) | 20.1 |

The microseismic data from MIP 3H Stage 28 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

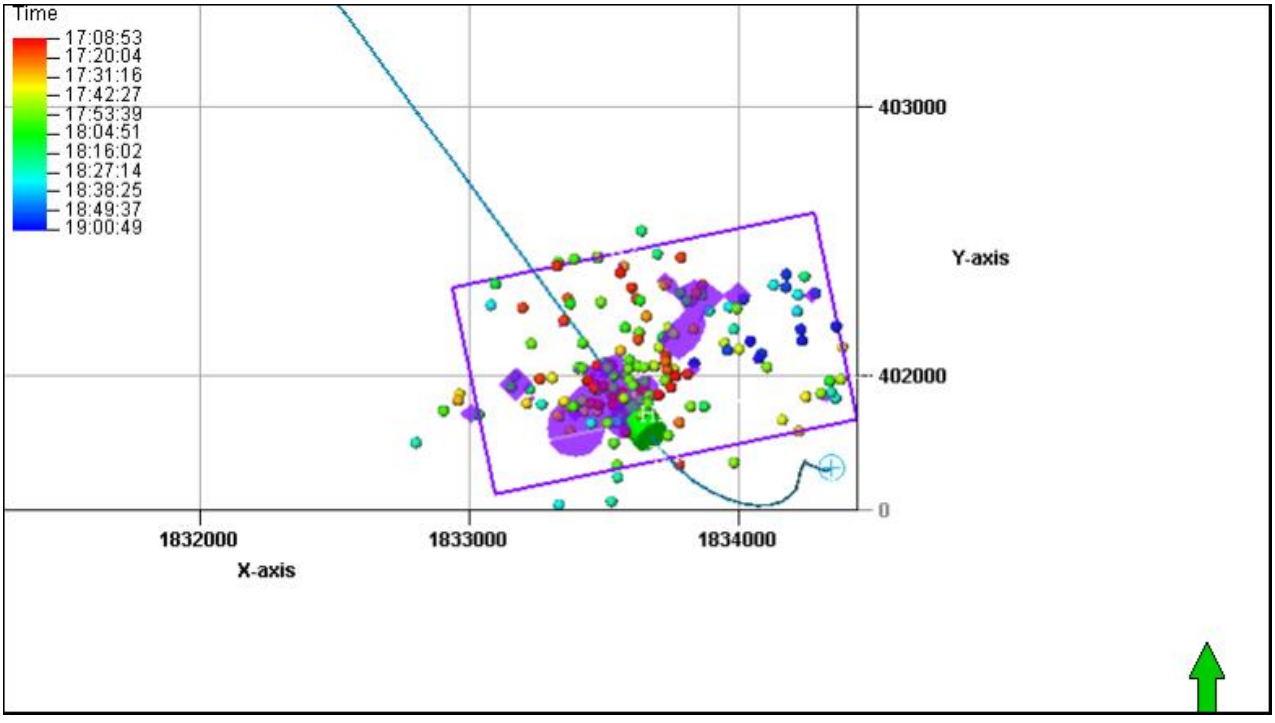



**Figure 5-107 - MIP 3H Stage 28 map view (length and width)**

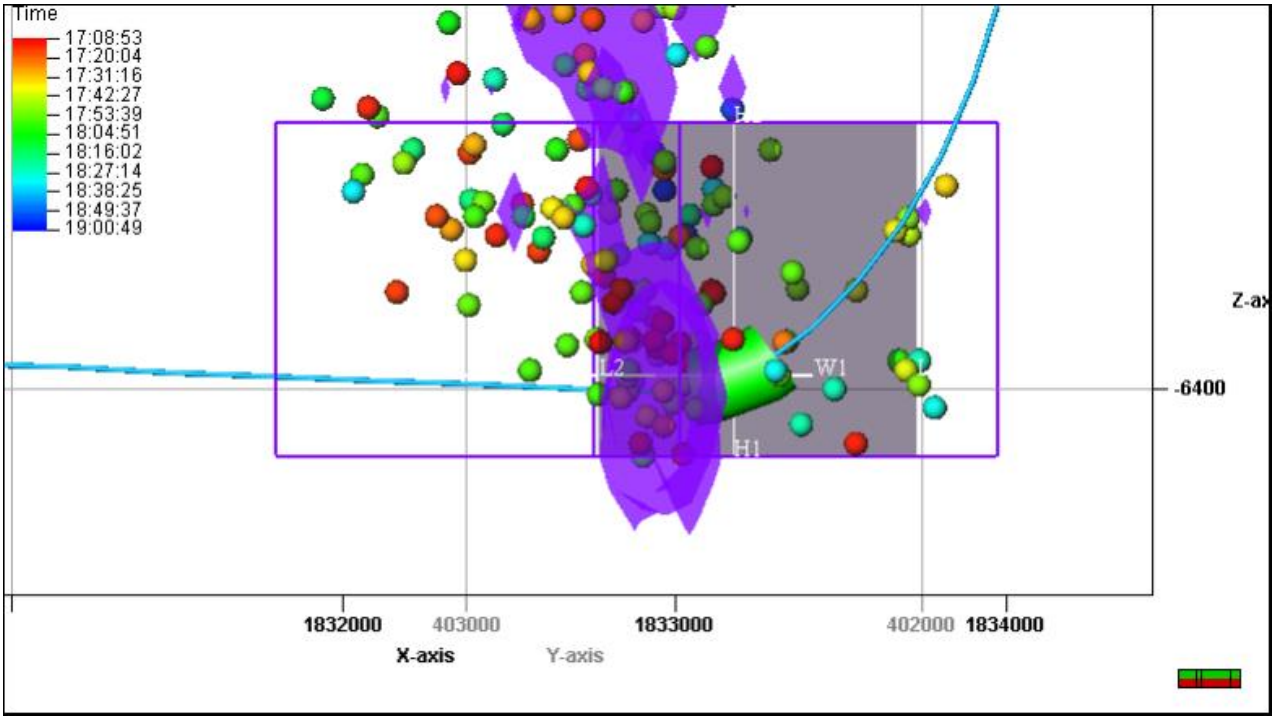



**Figure 5-108 - MIP 3H Stage 28 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 3H Stage 28 are shown below in map and transverse views.

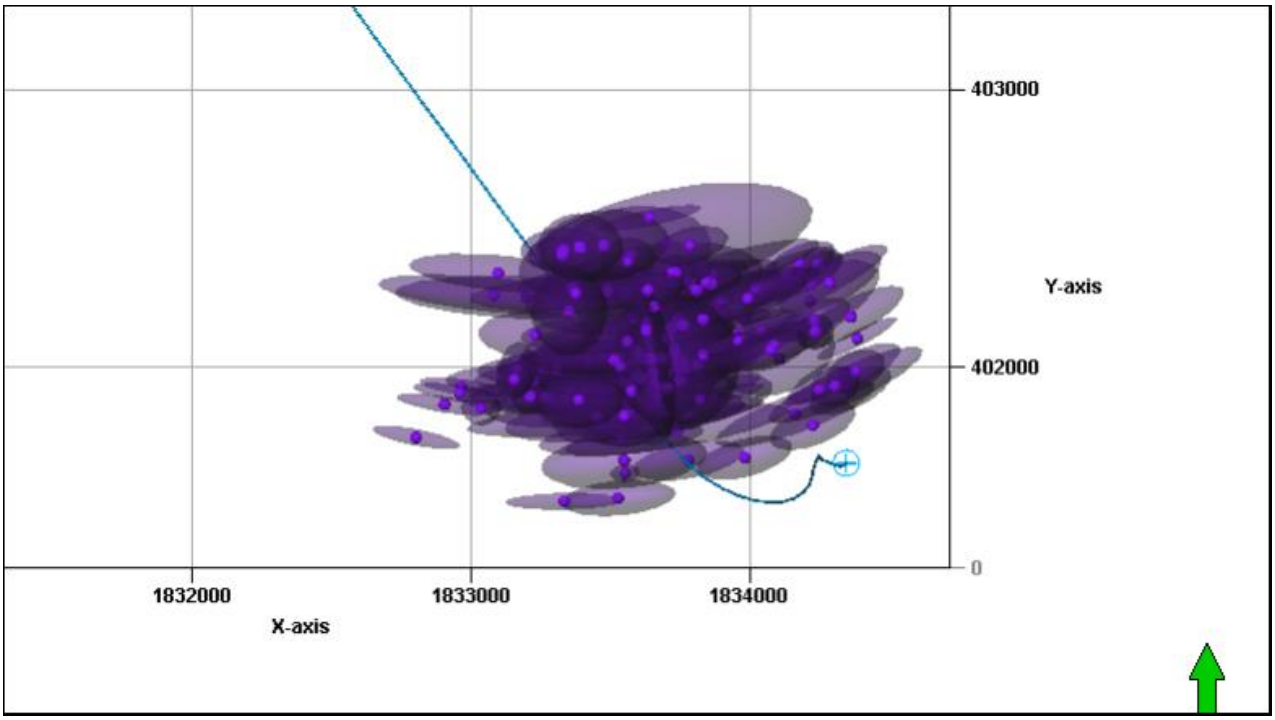



**Figure 5-109 - MIP 3H Stage 28 event location uncertainty ellipsoids – map view**

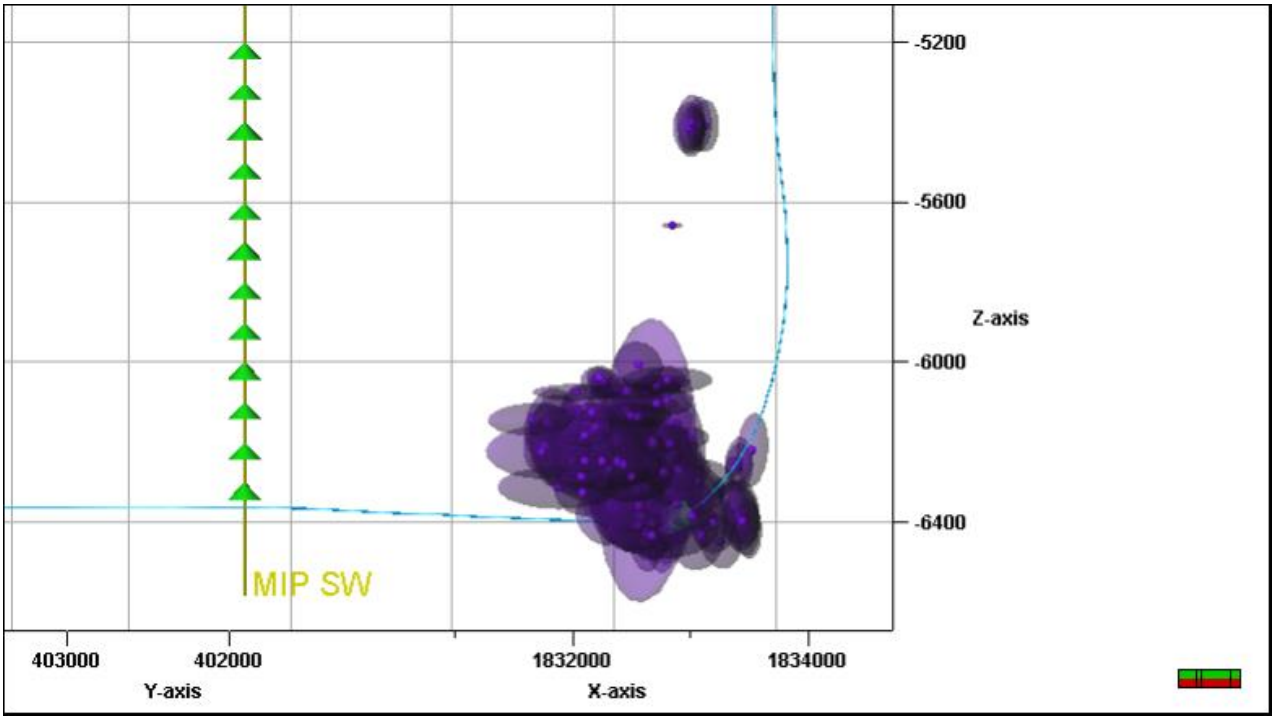



**Figure 5-110 - MIP 3H Stage 28 event location uncertainty ellipsoids – side view**

### 5.22.1 MIP 3H Stage 28 On-Site Notes and Observations

## 5.23 MIP 5H Stage 1

The MIP 5H Stage 1 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

**Table 5.67 - MIP 5H Stage 1 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 258671 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 8941 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 267612 |
| 100 Mesh (lbm) | 140000 | 137614 |
| 40/70 White (lbm) | 260000 | Not used |
| 40/70 Sand (lbm) | Not used | 191266 |
| Total proppants (lbm) | 400000 | 328880 |

**Table 5.68 - MIP 5H Stage 1 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 69.8 |
| Average pressure (psi) | 8305 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 0 |
| Maximum PPA (lbm/gal) | 3.018 |

**Table 5.69 - MIP 5H Stage 1 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | N/A |
| MS length (ft) | N/A |
| MS height (ft) | N/A |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 1 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.


**Figure 5-111 - MIP 5H Stage 1 map view (length and width)**


**Figure 5-112 - MIP 5H Stage 1 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 1 are shown below in map and transverse views.


**Figure 5-113 - MIP 5H Stage 1 event location uncertainty ellipsoids – map view**


**Figure 5-114 - MIP 5H Stage 1 event location uncertainty ellipsoids – side view**

### 5.23.1 MIP 5H Stage 1 On-Site Notes and Observations

## 5.24 MIP 5H Stage 2

The MIP 5H Stage 2 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

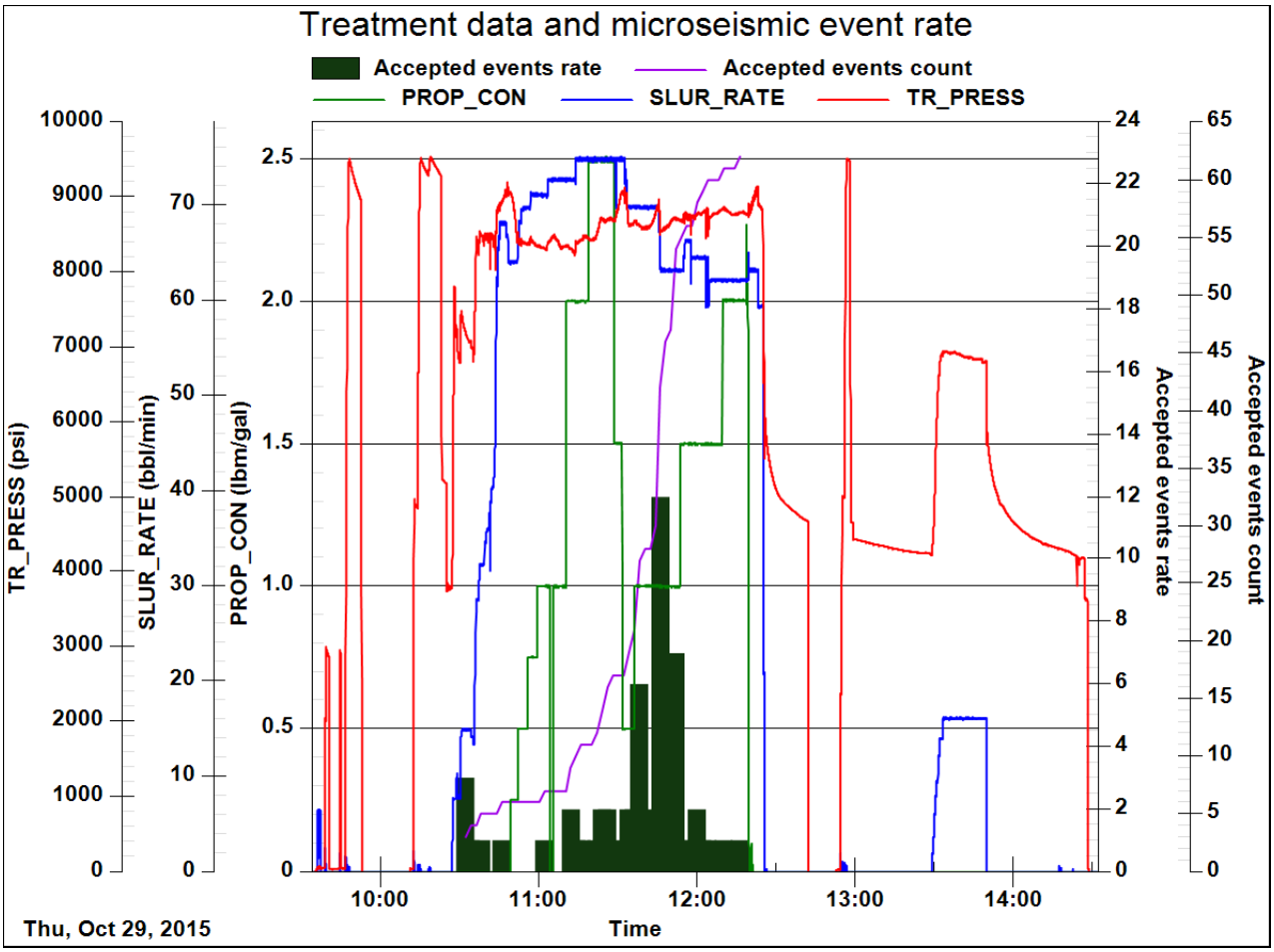



**Figure 5-115 - MIP 5H Stage 2 treatment data and microseismic event rate**

**Table 5.70 - MIP 5H Stage 2 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 220994 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3200 |
| WF (gal) | Not used | 66199 |
| Total fluids (gal) | 247840 | 290393 |
| 100 Mesh (lbm) | 140000 | 140660 |
| 40/70 White (lbm) | 260000 | 188360 |
| Total proppants (lbm) | 400000 | 329020 |

**Table 5.71 - MIP 5H Stage 2 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 68.5 |
| Average pressure (psi) | 8619 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5965 |
| Maximum PPA (lbm/gal) | 2.506 |

**Table 5.72 - MIP 5H Stage 2 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 33 |
| MS length (ft) | 1003 |
| MS height (ft) | 578 |
| MS volume (million ft3) | 78.7 |

The microseismic data from MIP 5H Stage 2 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

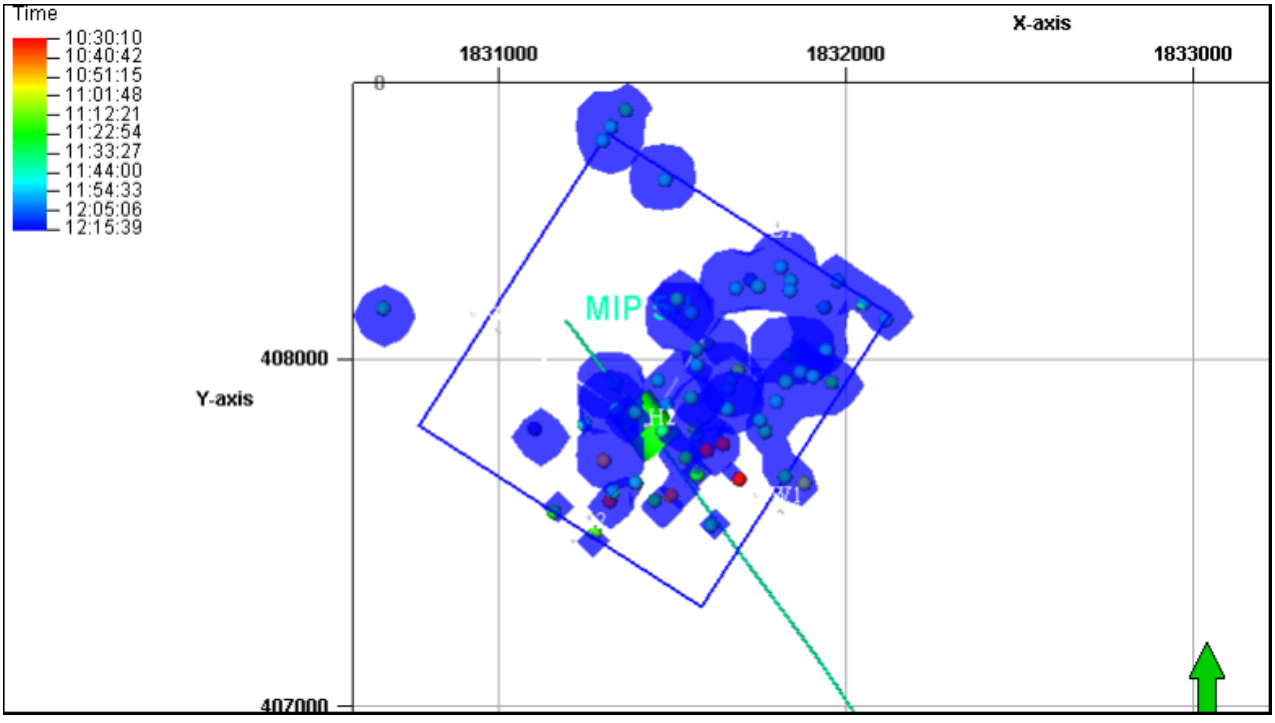



**Figure 5-116 - MIP 5H Stage 2 map view (length and width)**

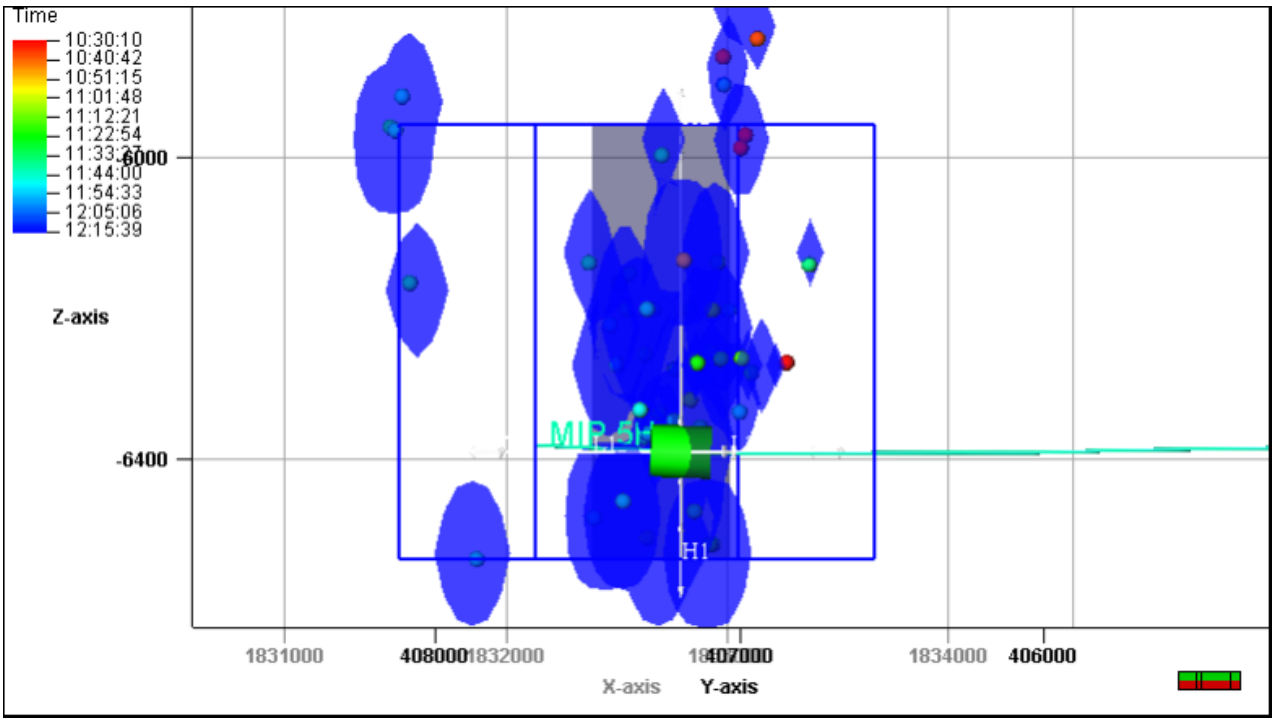



**Figure 5-117 - MIP 5H Stage 2 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 2 are shown below in map and transverse views.

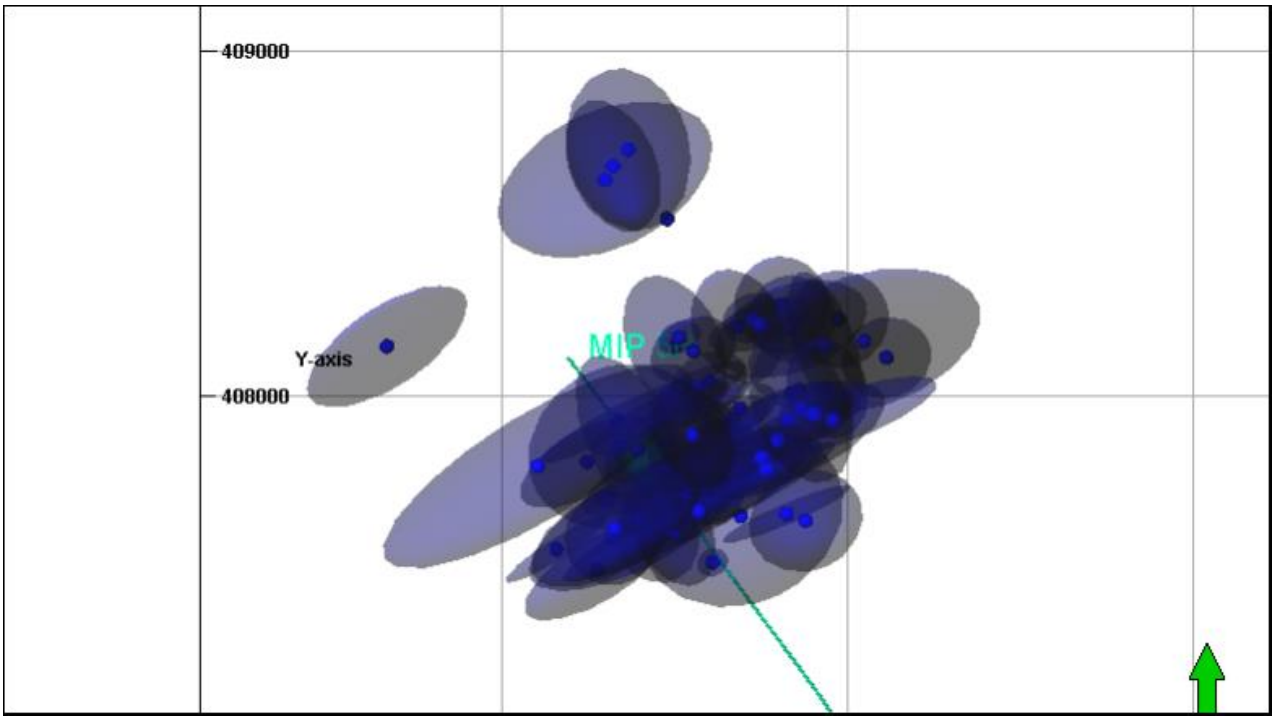



**Figure 5-118 - MIP 5H Stage 2 event location uncertainty ellipsoids – map view**

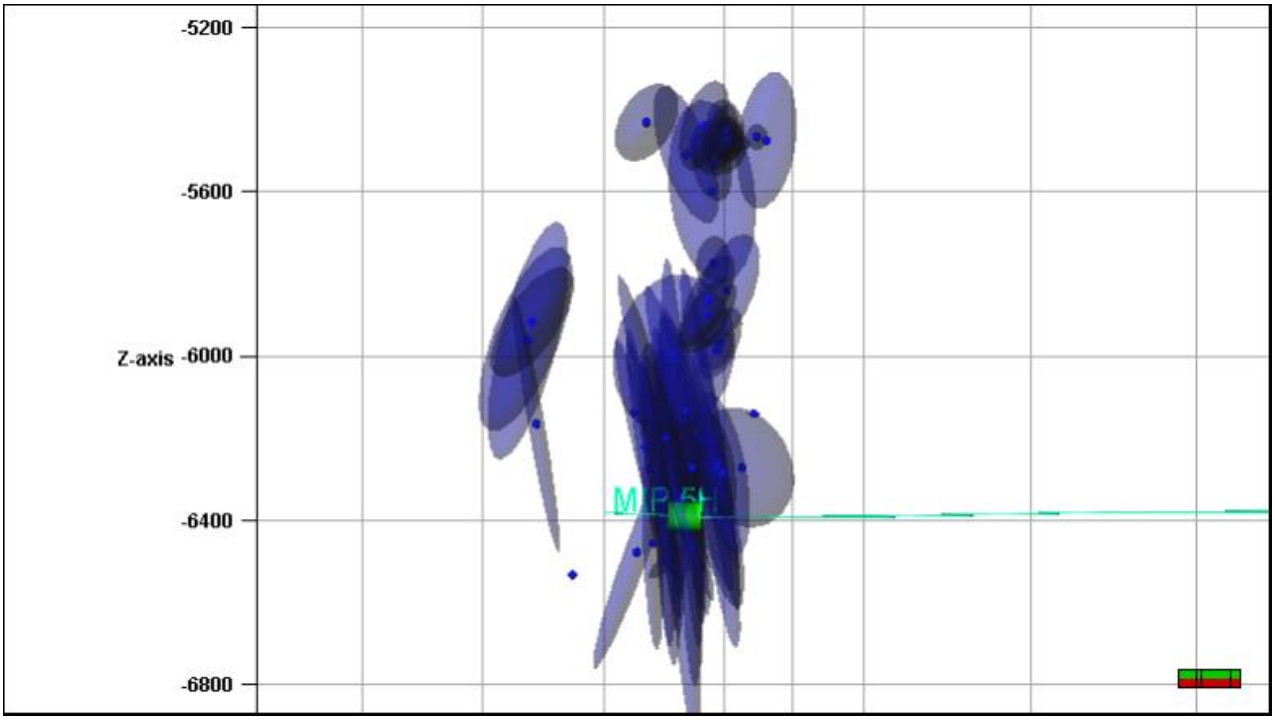



**Figure 5-119 - MIP 5H Stage 2 event location uncertainty ellipsoids – side view**

### 5.24.1 MIP 5H Stage 2 On-Site Notes and Observations

## 5.25 MIP 5H Stage 3

The MIP 5H Stage 3 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

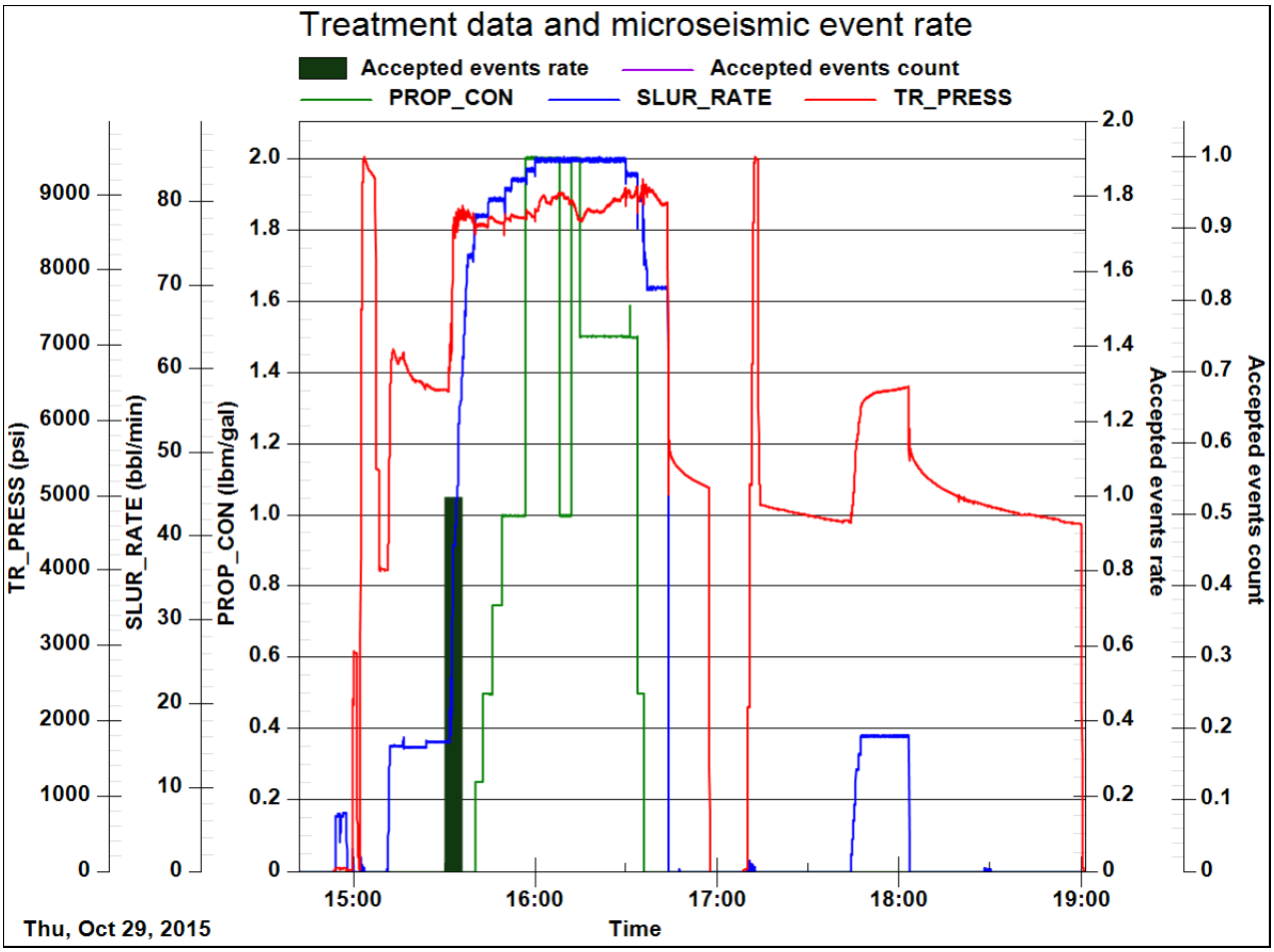



**Figure 5-120 - MIP 5H Stage 3 treatment data and microseismic event rate**

**Table 5.73 - MIP 5H Stage 3 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 185592 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3038 |
| WF (gal) | Not used | 46200 |
| Total fluids (gal) | 247840 | 234830 |
| 100 Mesh (lbm) | 140000 | 142340 |
| 40/70 White (lbm) | 260000 | 123300 |
| Total proppants (lbm) | 400000 | 265640 |

**Table 5.74 - MIP 5H Stage 3 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 81.8 |
| Average pressure (psi) | 8827 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5885 |
| Maximum PPA (lbm/gal) | 2.006 |

**Table 5.75 - MIP 5H Stage 3 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | N/A |
| MS length (ft) | N/A |
| MS height (ft) | N/A |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 3 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

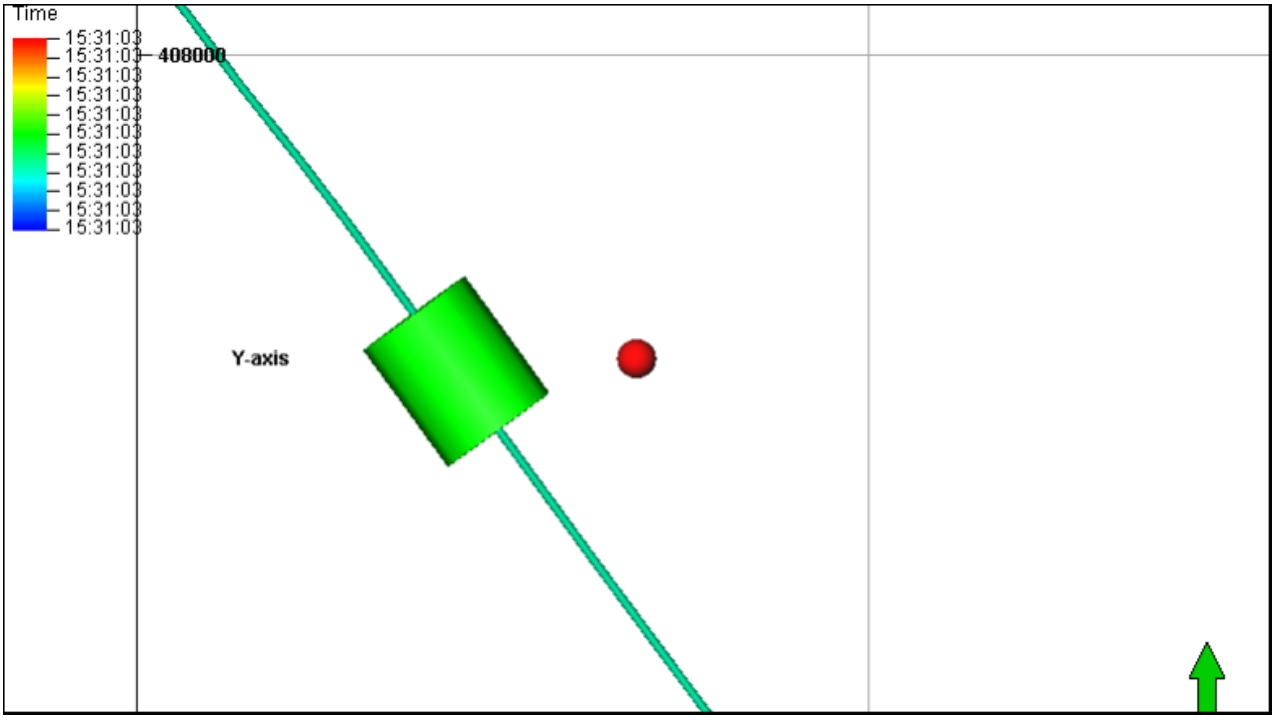



**Figure 5-121 - MIP 5H Stage 3 map view (length and width)**

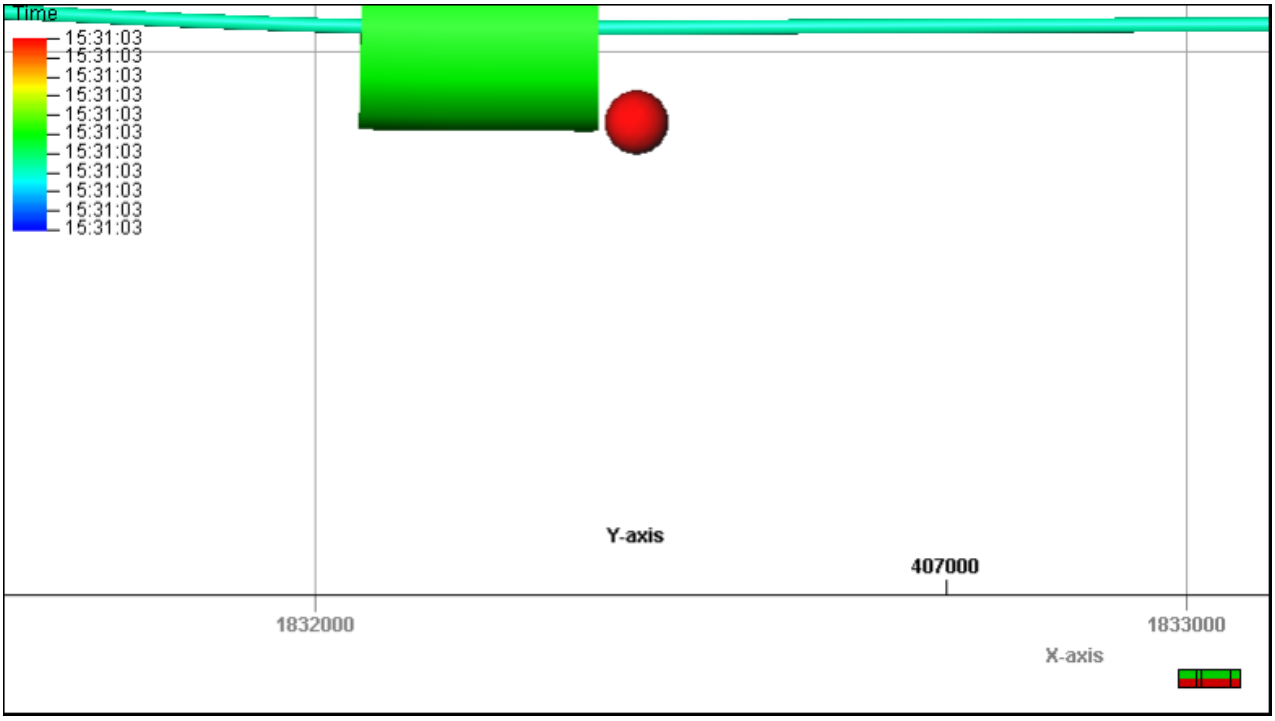



**Figure 5-122 - MIP 5H Stage 3 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 3 are shown below in map and transverse views.

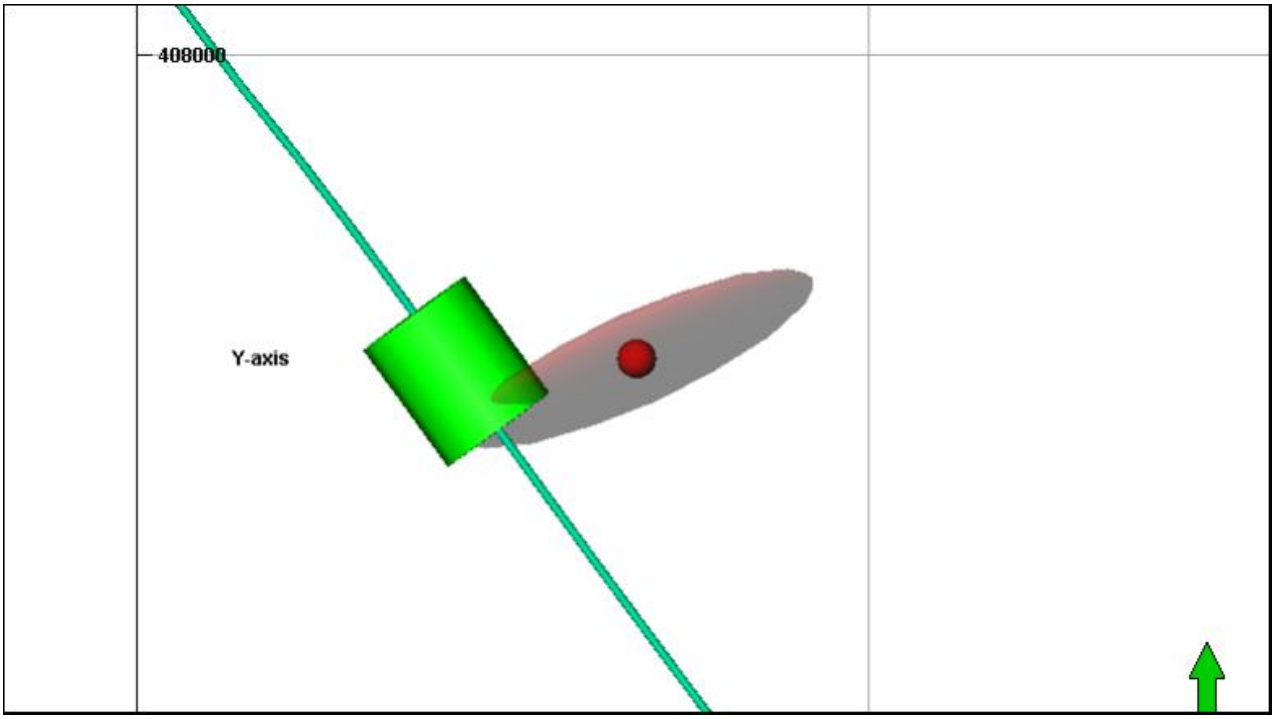



**Figure 5-123 - MIP 5H Stage 3 event location uncertainty ellipsoids – map view**

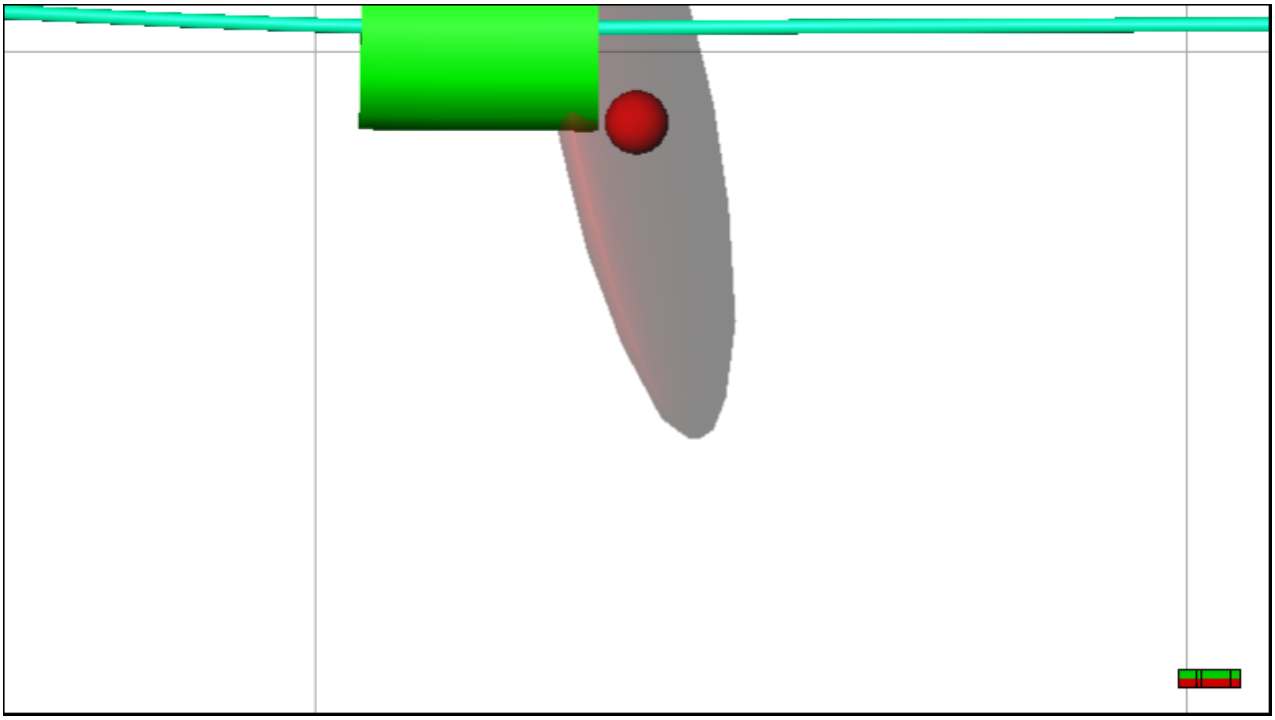


**Figure 5-124 - MIP 5H Stage 3 event location uncertainty ellipsoids – side view**

### 5.25.1 MIP 5H Stage 3 On-Site Notes and Observations

## 5.26 MIP 5H Stage 4

The MIP 5H Stage 4 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

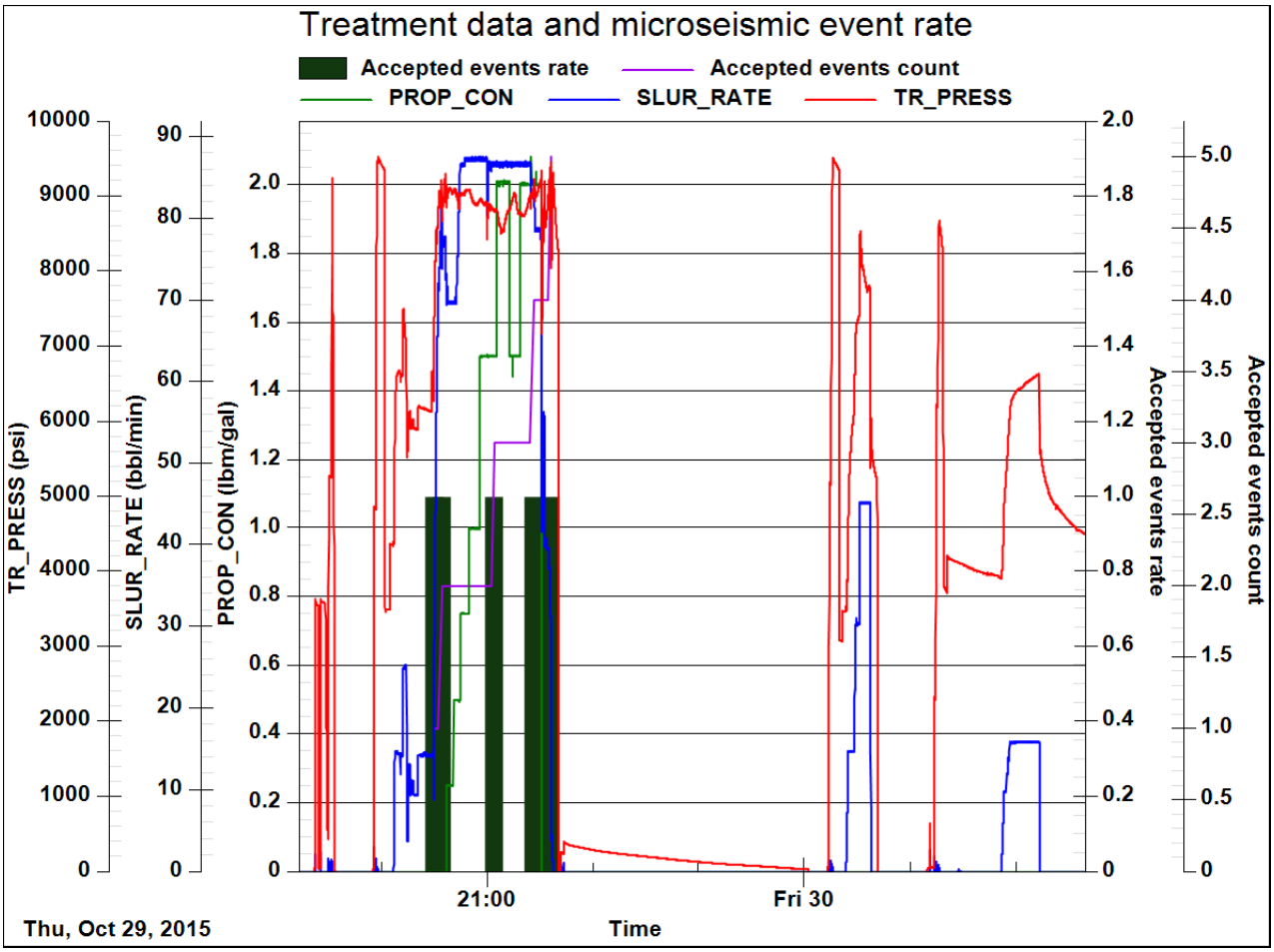



**Figure 5-125 - MIP 5H Stage 4 treatment data and microseismic event rate**

**Table 5.76 - MIP 5H Stage 4 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 217573 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 220573 |
| 100 Mesh (lbm) | 140000 | 140660 |
| 40/70 White (lbm) | 260000 | 119800 |
| Total proppants (lbm) | 400000 | 260460 |

**Table 5.77 - MIP 5H Stage 4 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 77.4 |
| Average pressure (psi) | 8735 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 0 |
| Maximum PPA (lbm/gal) | 2.081 |

**Table 5.78 - MIP 5H Stage 4 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | N/A |
| MS length (ft) | N/A |
| MS height (ft) | N/A |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 4 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

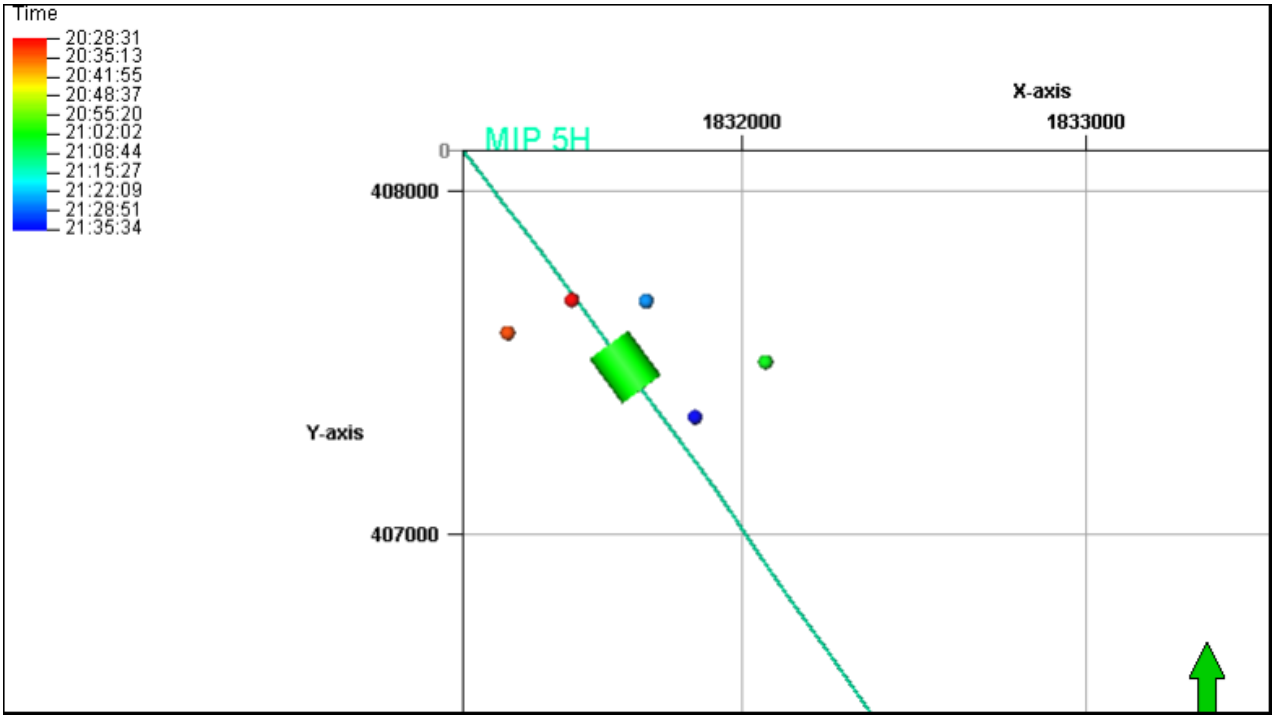



**Figure 5-126 - MIP 5H Stage 4 map view (length and width)**

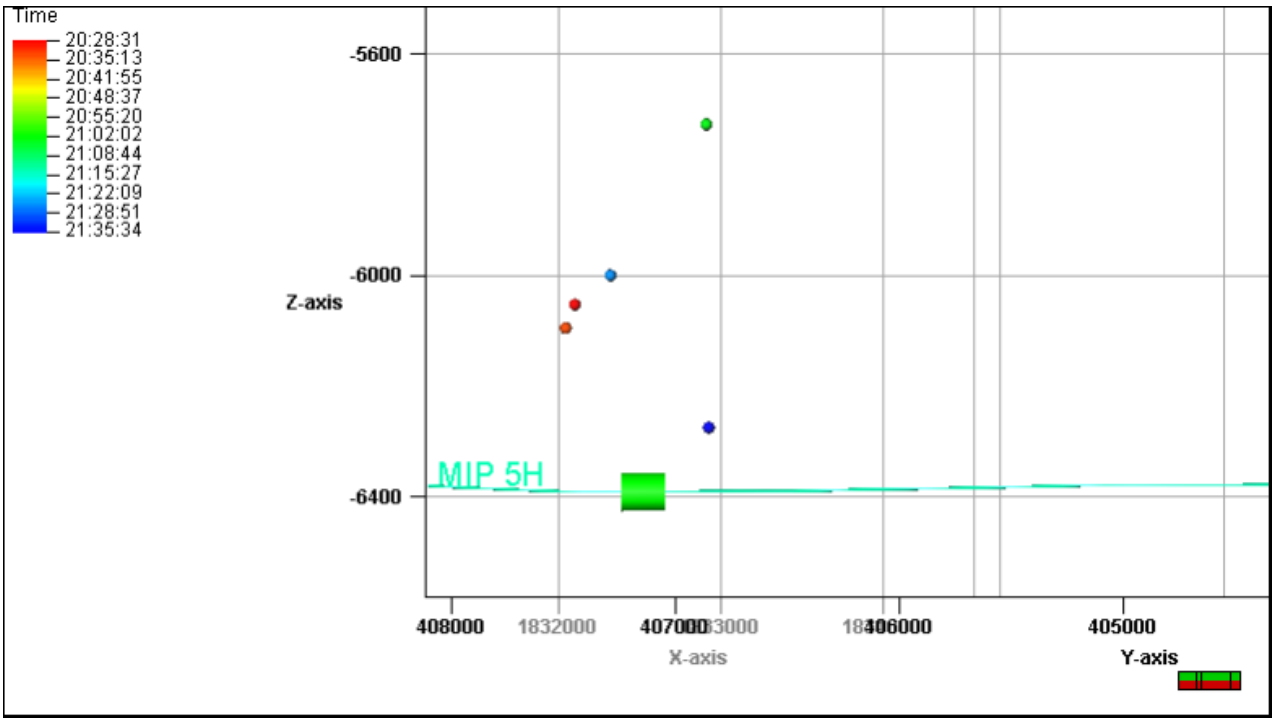



**Figure 5-127 - MIP 5H Stage 4 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 4 are shown below in map and transverse views.

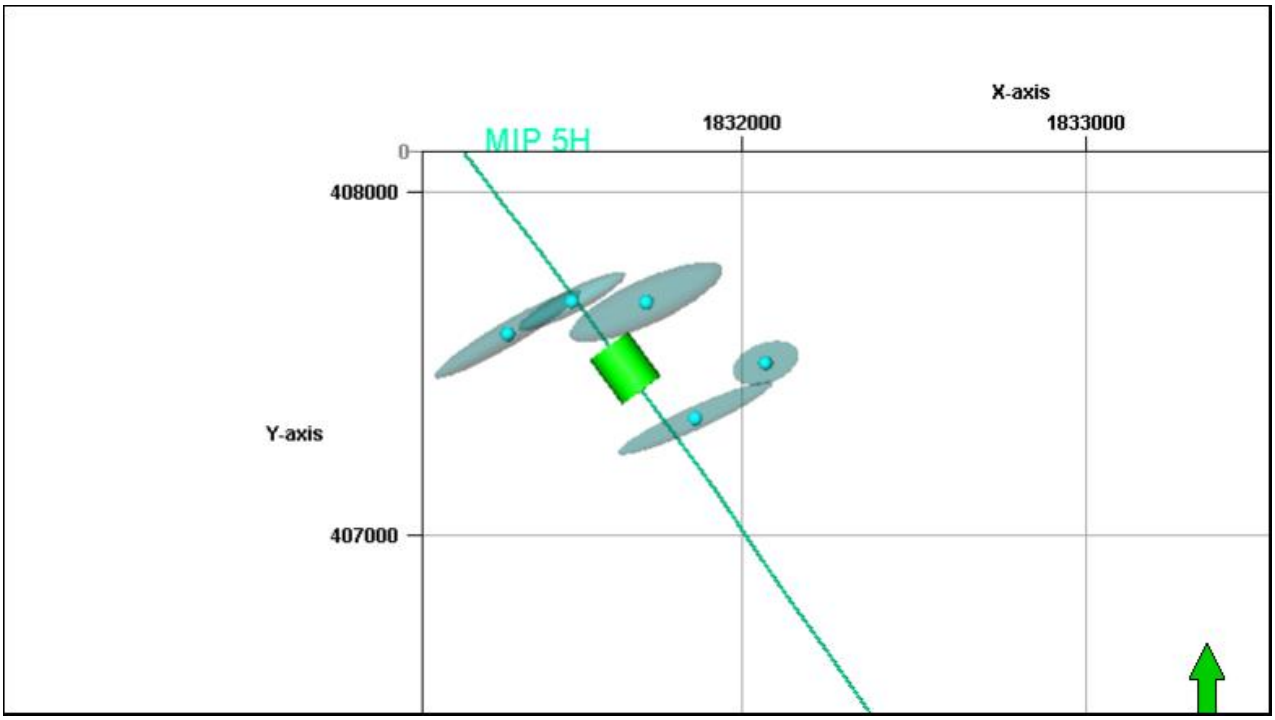



**Figure 5-128 - MIP 5H Stage 4 event location uncertainty ellipsoids – map view**

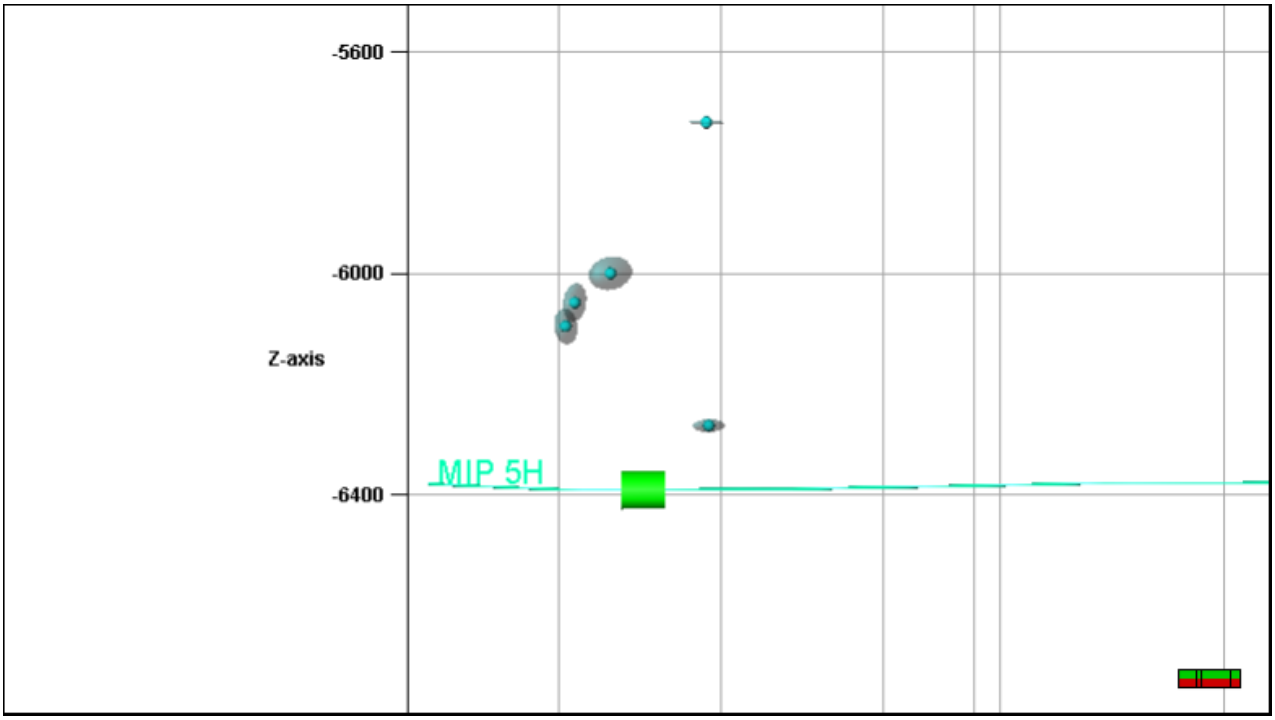



**Figure 5-129 - MIP 5H Stage 4 event location uncertainty ellipsoids – side view**

### 5.26.1 MIP 5H Stage 4 On-Site Notes and Observations

## 5.27 MIP 5H Stage 5

The MIP 5H Stage 5 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

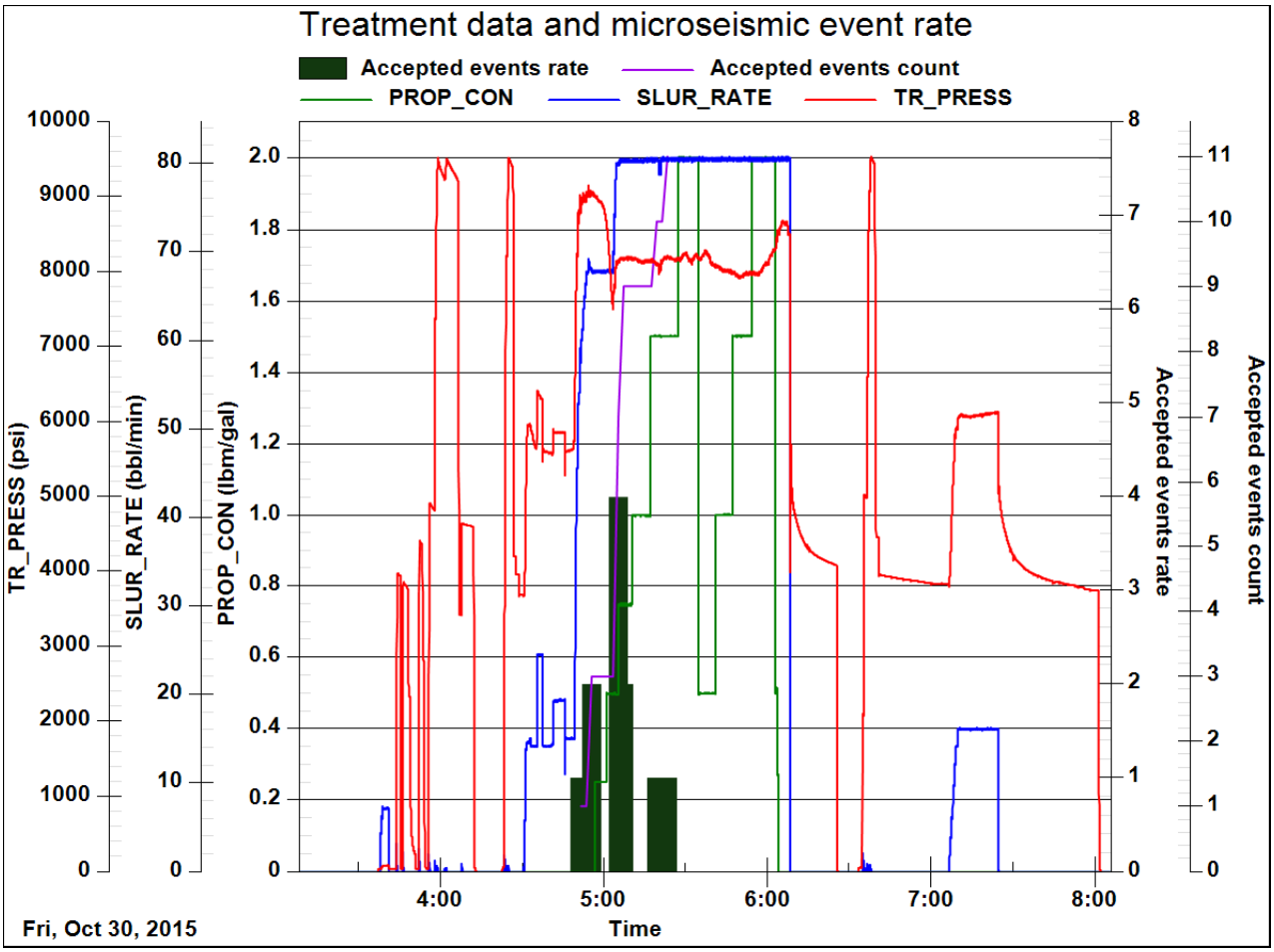



**Figure 5-130 - MIP 5H Stage 5 treatment data and microseismic event rate**

**Table 5.79 - MIP 5H Stage 5 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 254805 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 257805 |
| 100 Mesh (lbm) | 140000 | 143720 |
| 40/70 White (lbm) | 260000 | 128560 |
| Total proppants (lbm) | 400000 | 272280 |

**Table 5.80 - MIP 5H Stage 5 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 75.1 |
| Average pressure (psi) | 8111 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5278 |
| Maximum PPA (lbm/gal) | 2.004 |

**Table 5.81 - MIP 5H Stage 5 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 70 |
| MS length (ft) | 498 |
| MS height (ft) | 426 |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 5 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

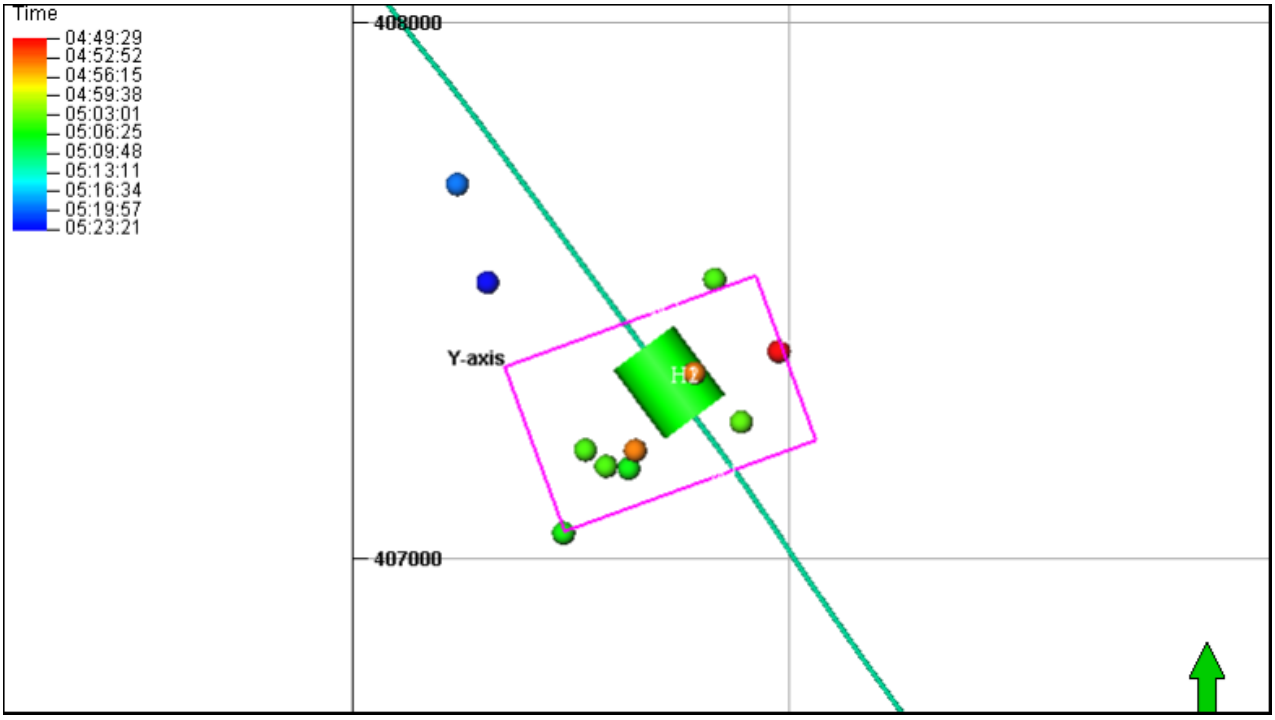



**Figure 5-131 - MIP 5H Stage 5 map view (length and width)**

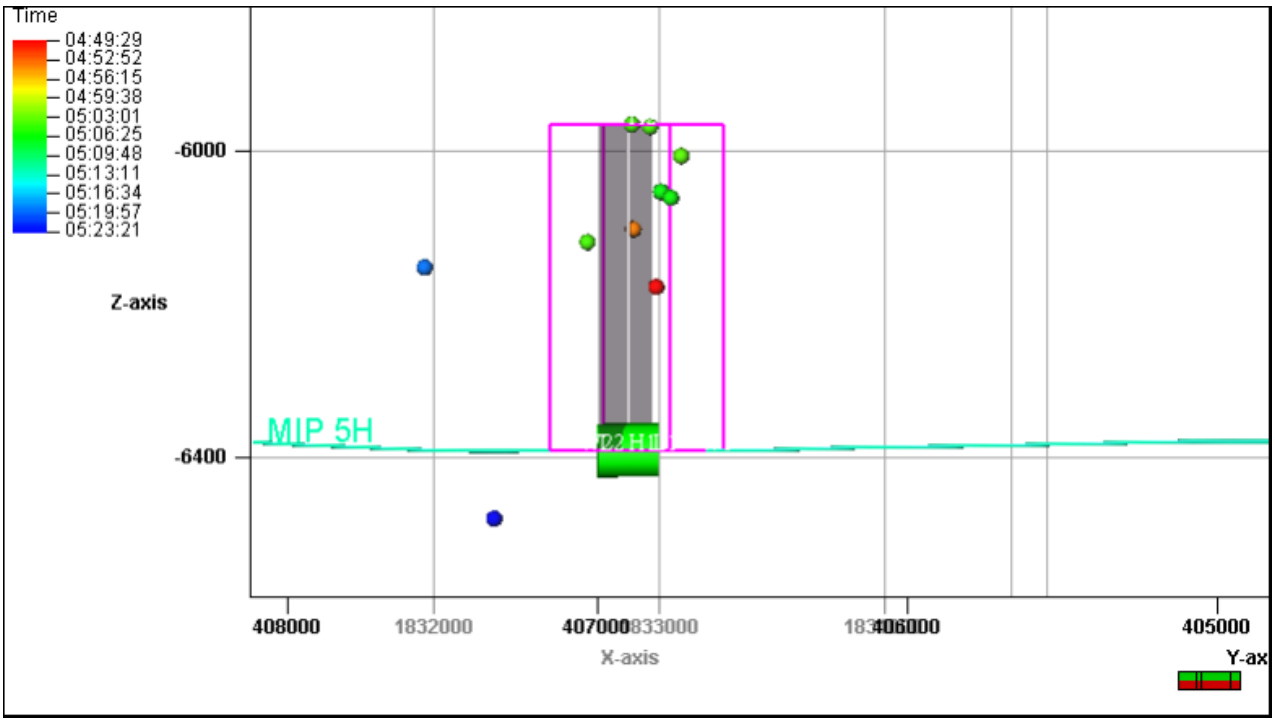



**Figure 5-132 - MIP 5H Stage 5 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 5 are shown below in map and transverse views.

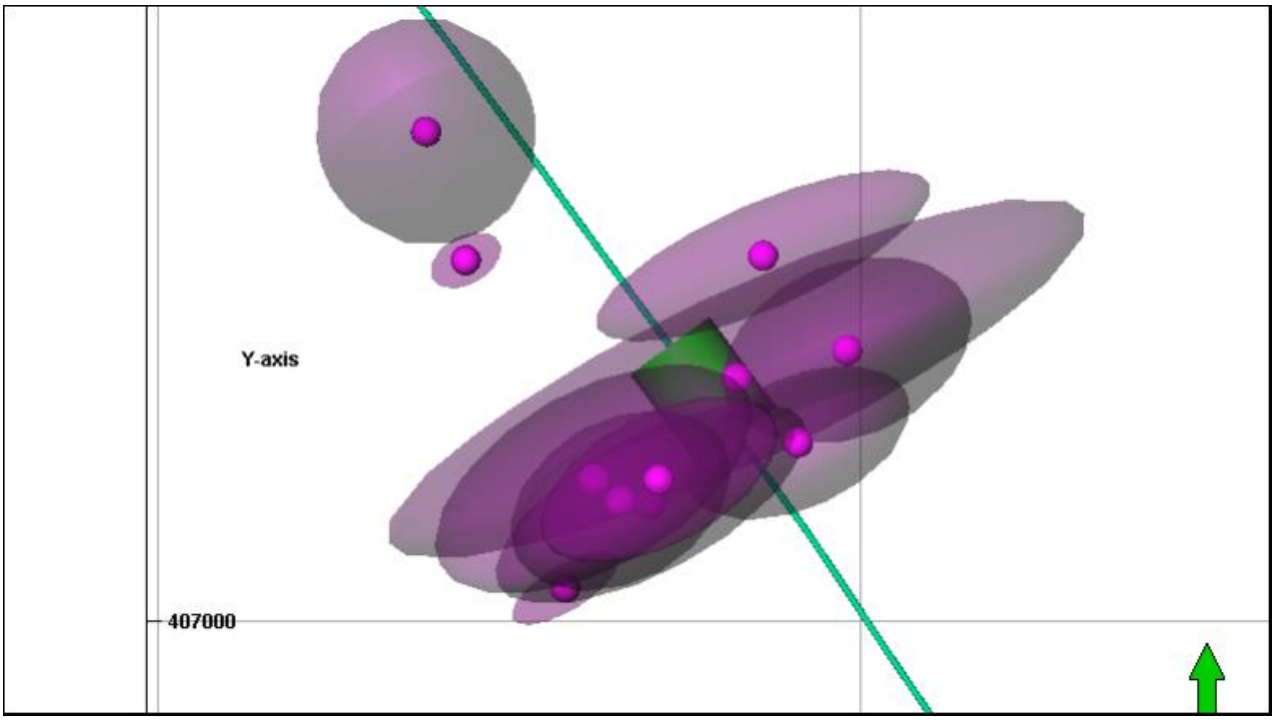



**Figure 5-133 - MIP 5H Stage 5 event location uncertainty ellipsoids – map view**

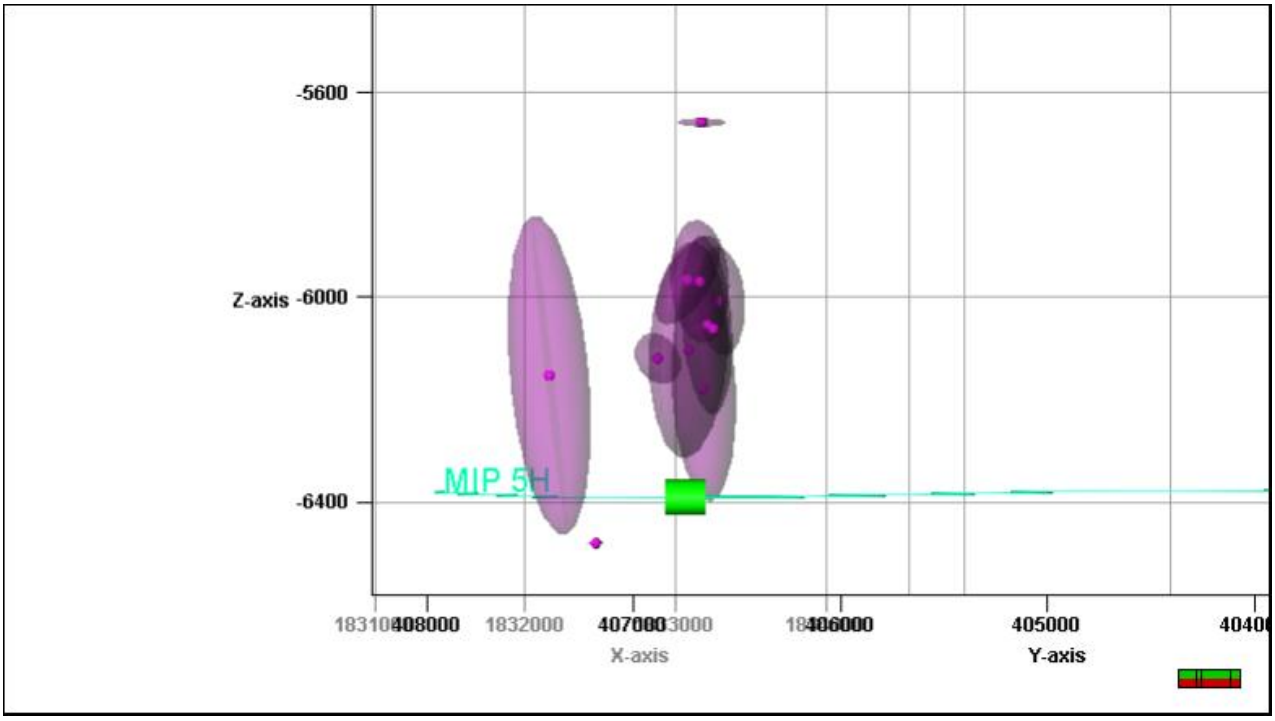



**Figure 5-134 - MIP 5H Stage 5 event location uncertainty ellipsoids – side view**

### 5.27.1 MIP 5H Stage 5 On-Site Notes and Observations

## 5.28 MIP 5H Stage 6

The MIP 5H Stage 6 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

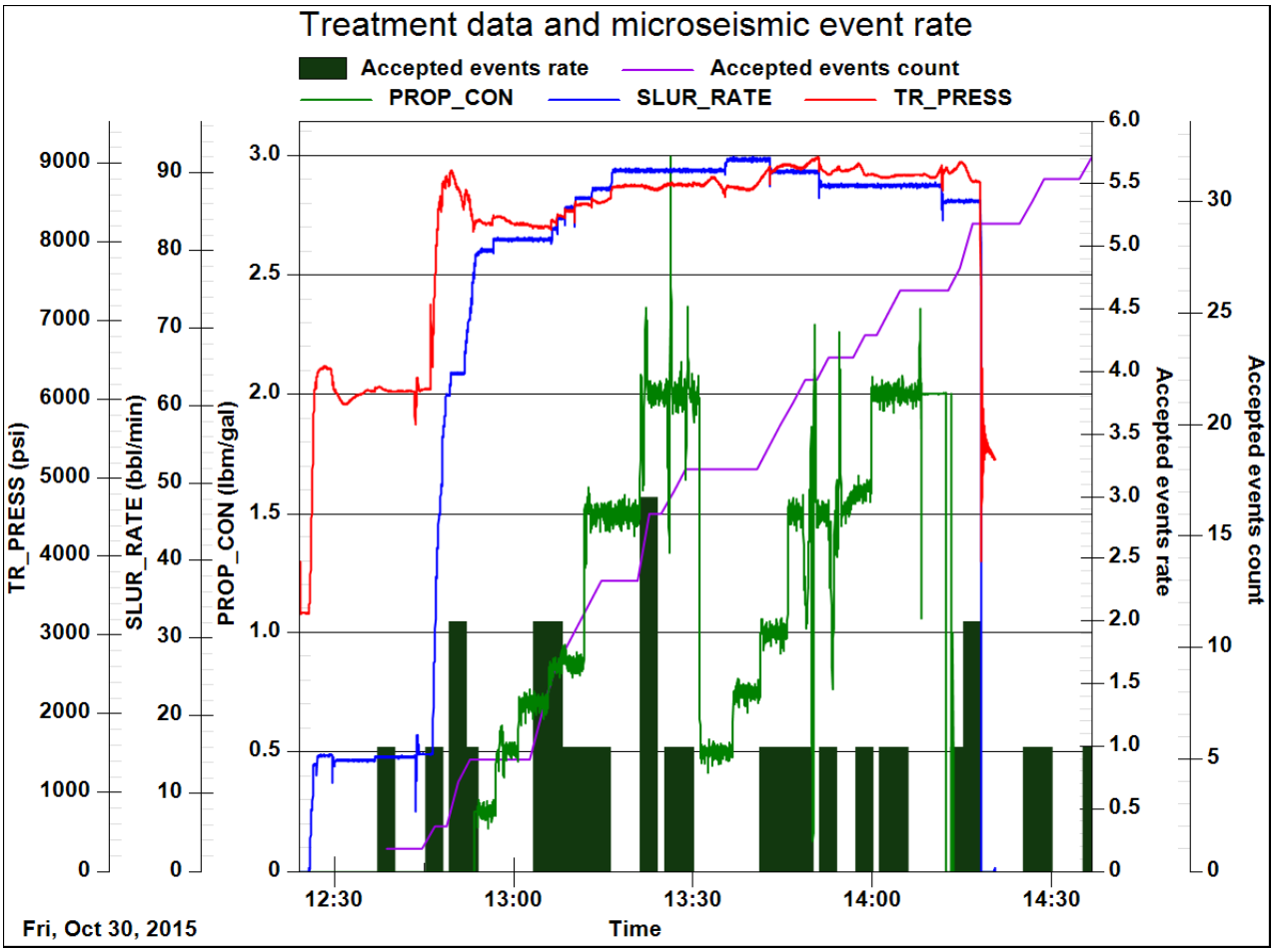



**Figure 5-135 - MIP 5H Stage 6 treatment data and microseismic event rate**

**Table 5.82 - MIP 5H Stage 6 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 323280 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 326280 |
| 100 Mesh (lbm) | 140000 | 140140 |
| 40/70 White (lbm) | 260000 | 127280 |
| Total proppants (lbm) | 400000 | 267420 |

**Table 5.83 - MIP 5H Stage 6 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 87.5 |
| Average pressure (psi) | 8691 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5817 |
| Maximum PPA (lbm/gal) | 2.994 |

**Table 5.84 - MIP 5H Stage 6 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 79 |
| MS length (ft) | 1042 |
| MS height (ft) | 848 |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 6 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

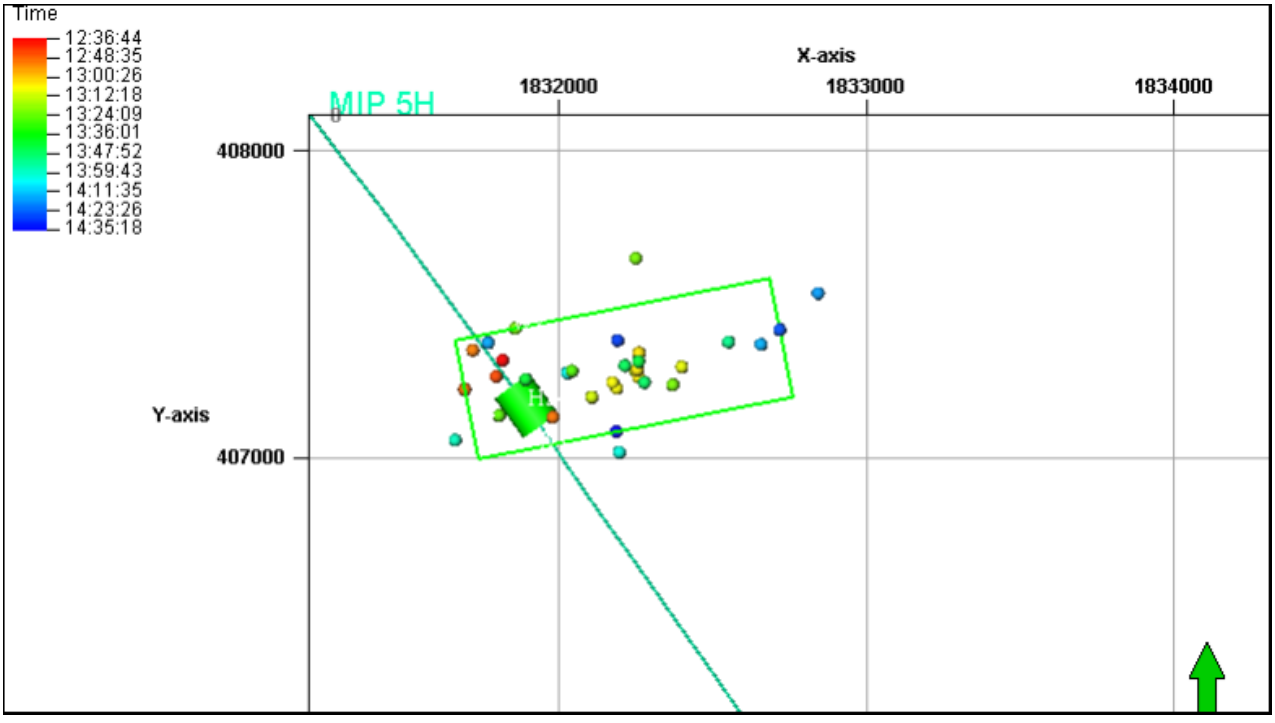



**Figure 5-136 - MIP 5H Stage 6 map view (length and width)**

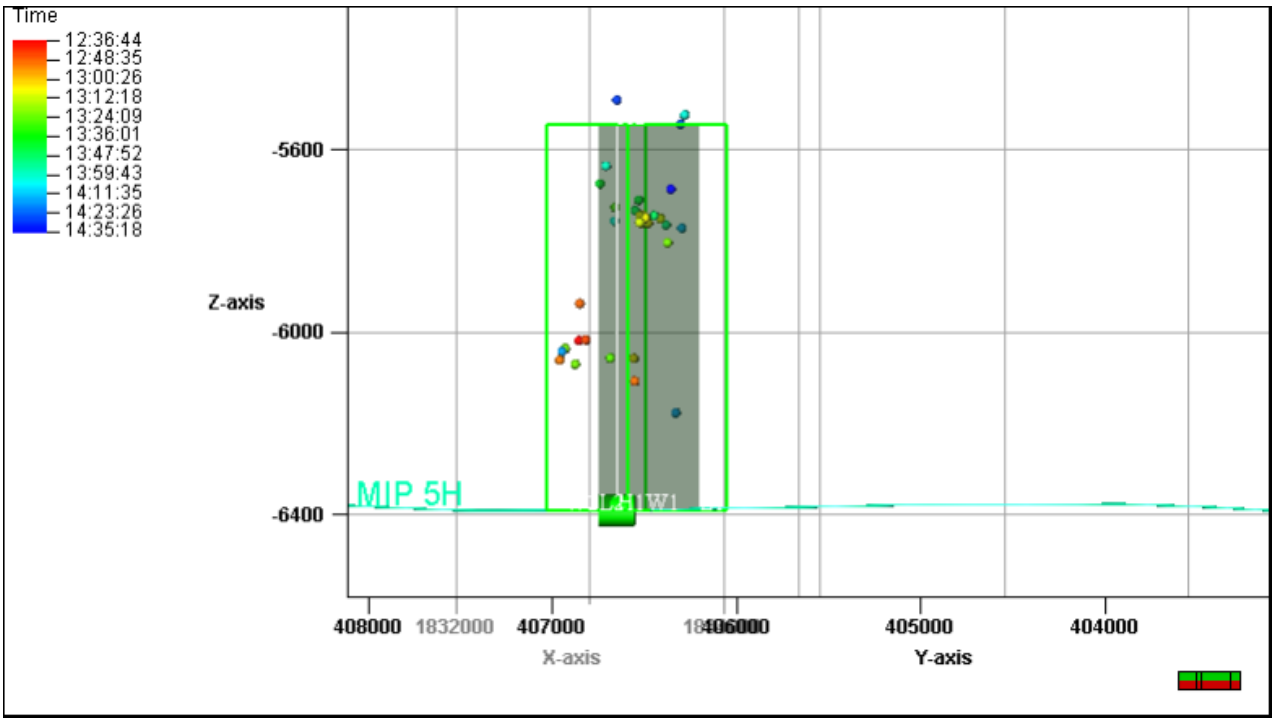



**Figure 5-137 - MIP 5H Stage 6 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 6 are shown below in map and transverse views.

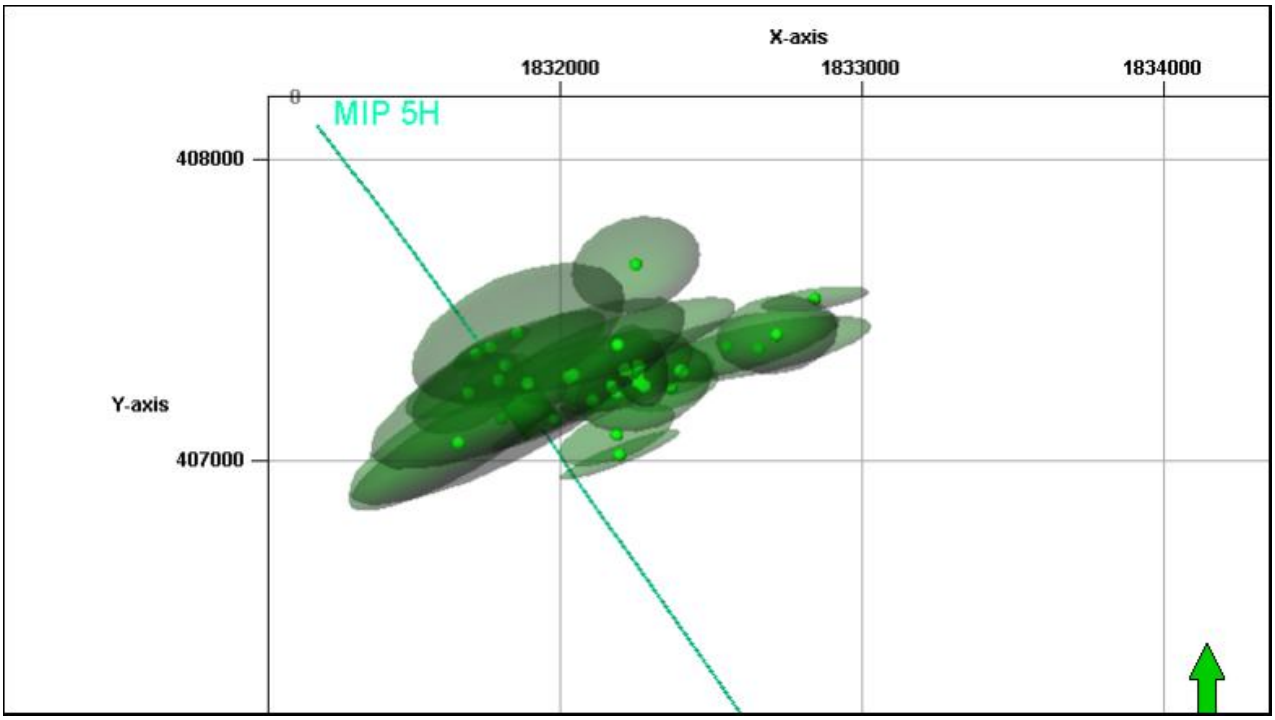



**Figure 5-138 - MIP 5H Stage 6 event location uncertainty ellipsoids – map view**

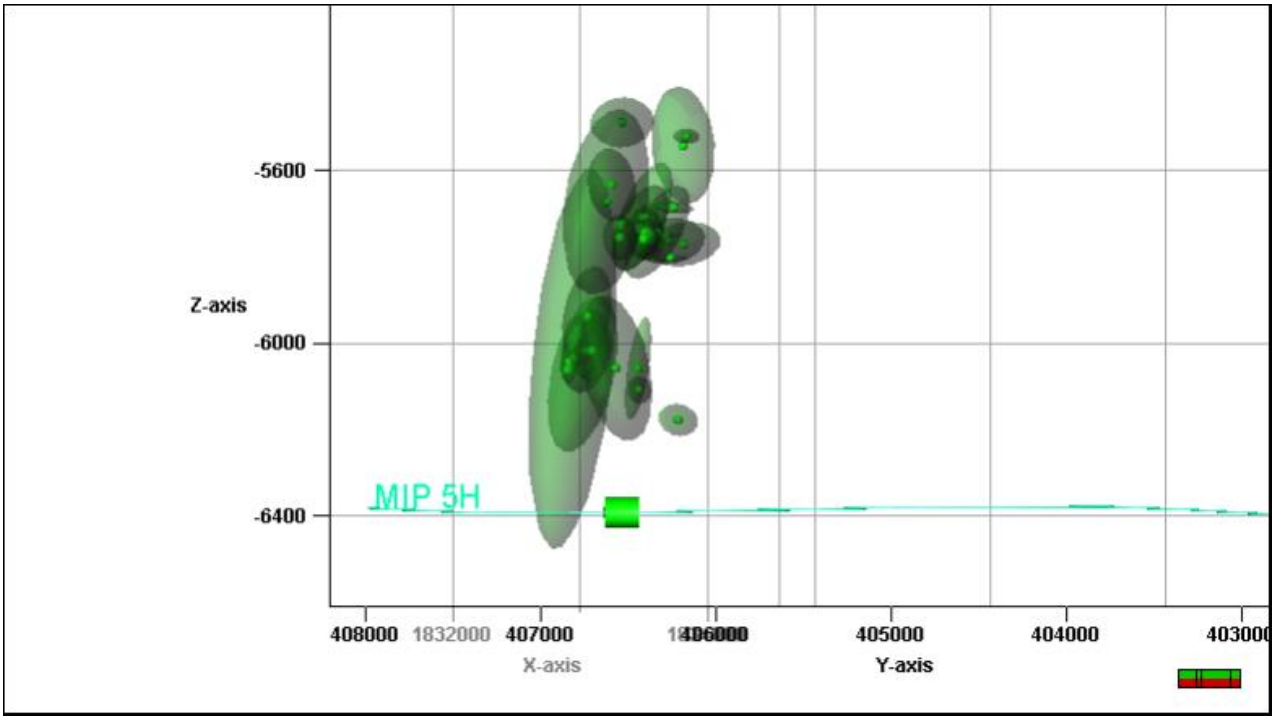



**Figure 5-139 - MIP 5H Stage 6 event location uncertainty ellipsoids – side view**

### 5.28.1 MIP 5H Stage 6 On-Site Notes and Observations

## 5.29 MIP 5H Stage 7

The MIP 5H Stage 7 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

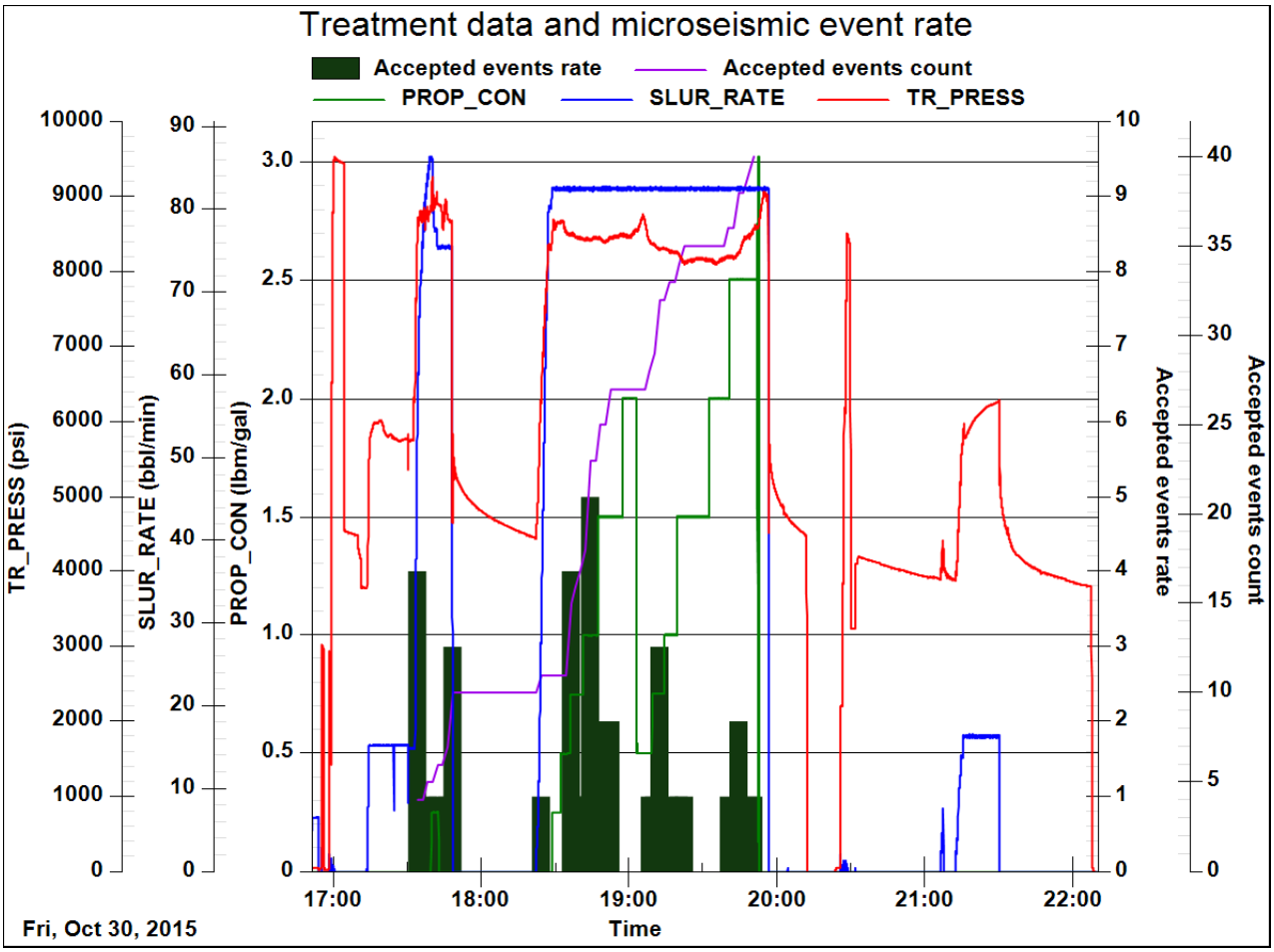



**Figure 5-140 - MIP 5H Stage 7 treatment data and microseismic event rate**

**Table 5.85 - MIP 5H Stage 7 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 355573 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 358573 |
| 100 Mesh (lbm) | 140000 | 140420 |
| 40/70 White (lbm) | 260000 | 261120 |
| Total proppants (lbm) | 400000 | 401540 |

**Table 5.86 - MIP 5H Stage 7 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 78.8 |
| Average pressure (psi) | 8330 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6041 |
| Maximum PPA (lbm/gal) | 3.022 |

**Table 5.87 - MIP 5H Stage 7 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 83 |
| MS length (ft) | 1091 |
| MS height (ft) | 643 |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 7 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

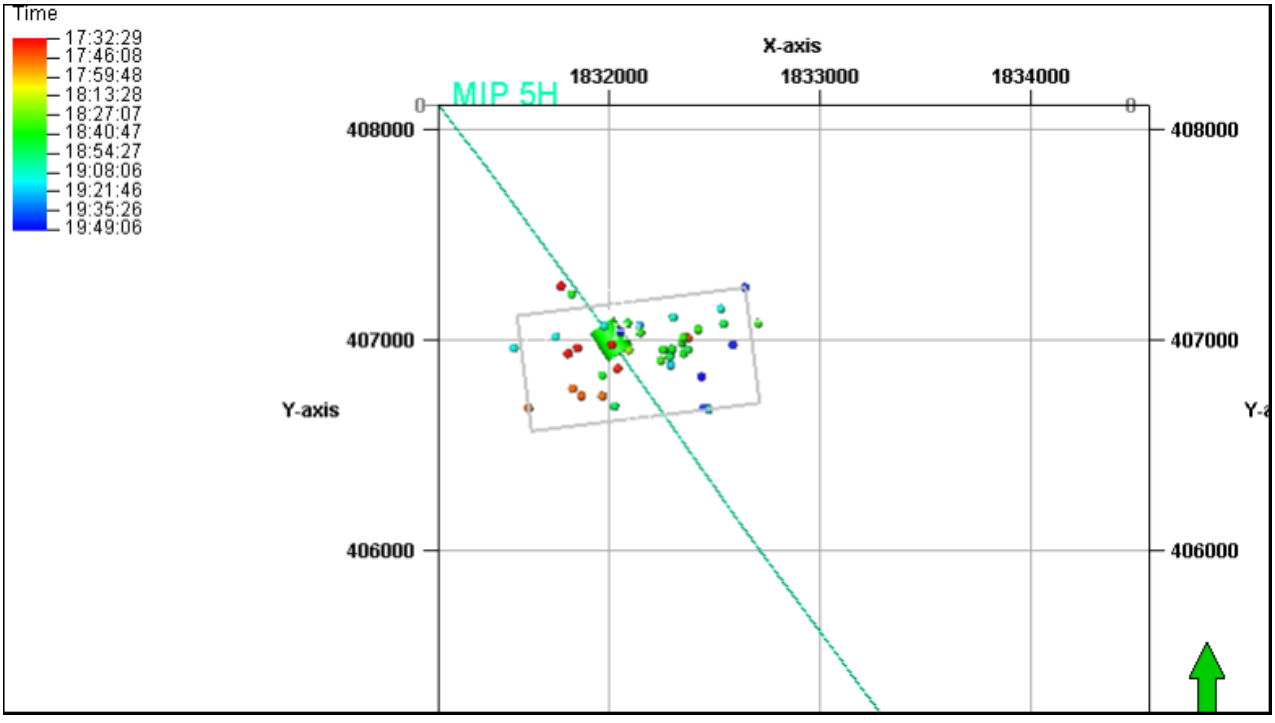



**Figure 5-141 - MIP 5H Stage 7 map view (length and width)**

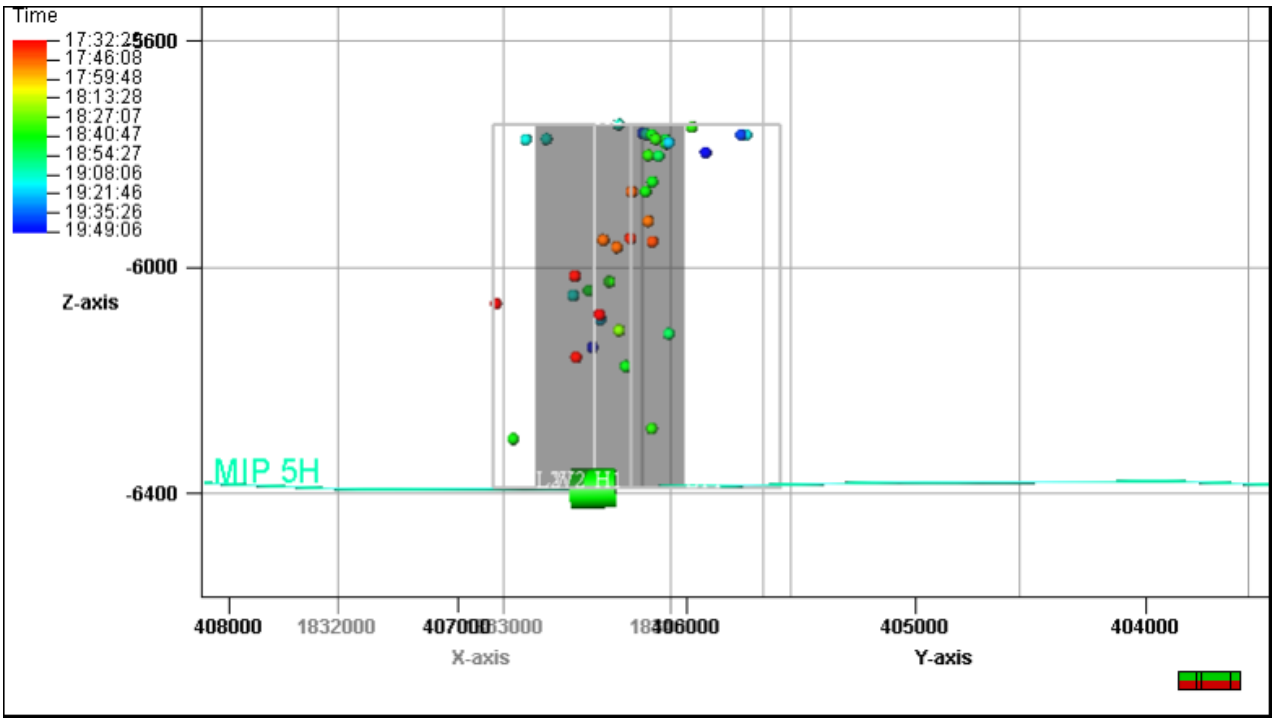



**Figure 5-142 - MIP 5H Stage 7 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 7 are shown below in map and transverse views.

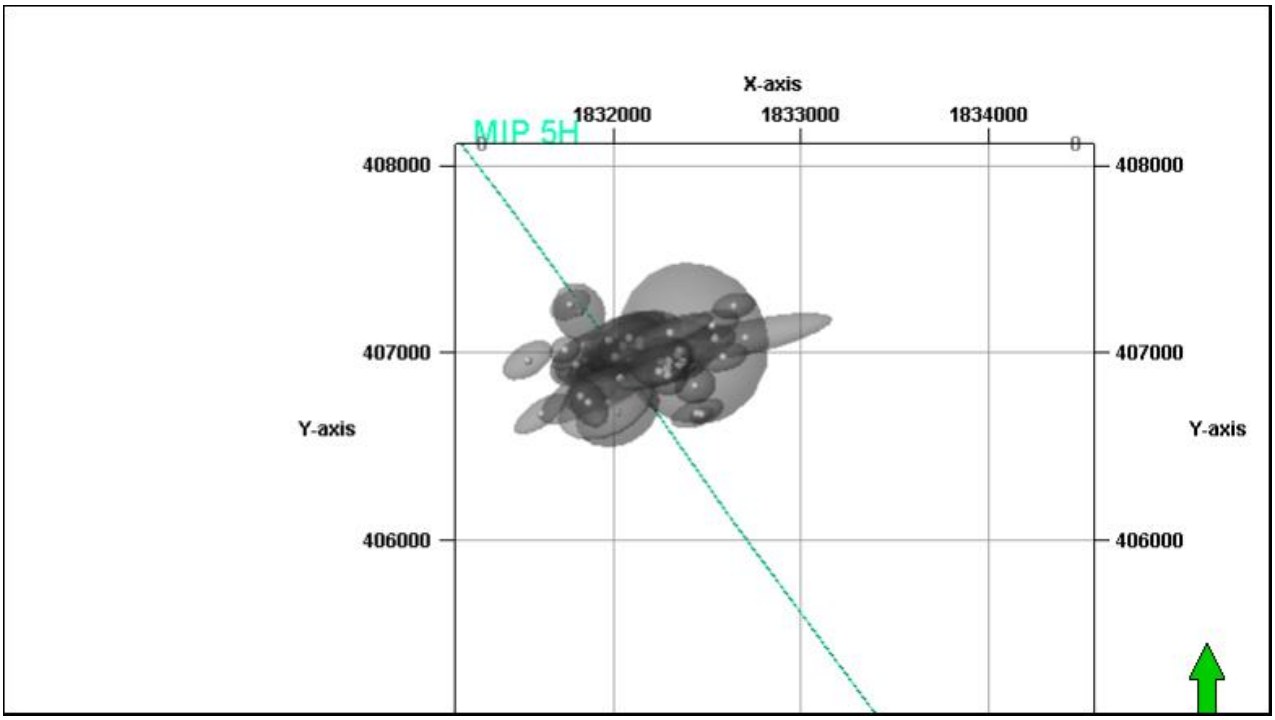



**Figure 5-143 - MIP 5H Stage 7 event location uncertainty ellipsoids – map view**

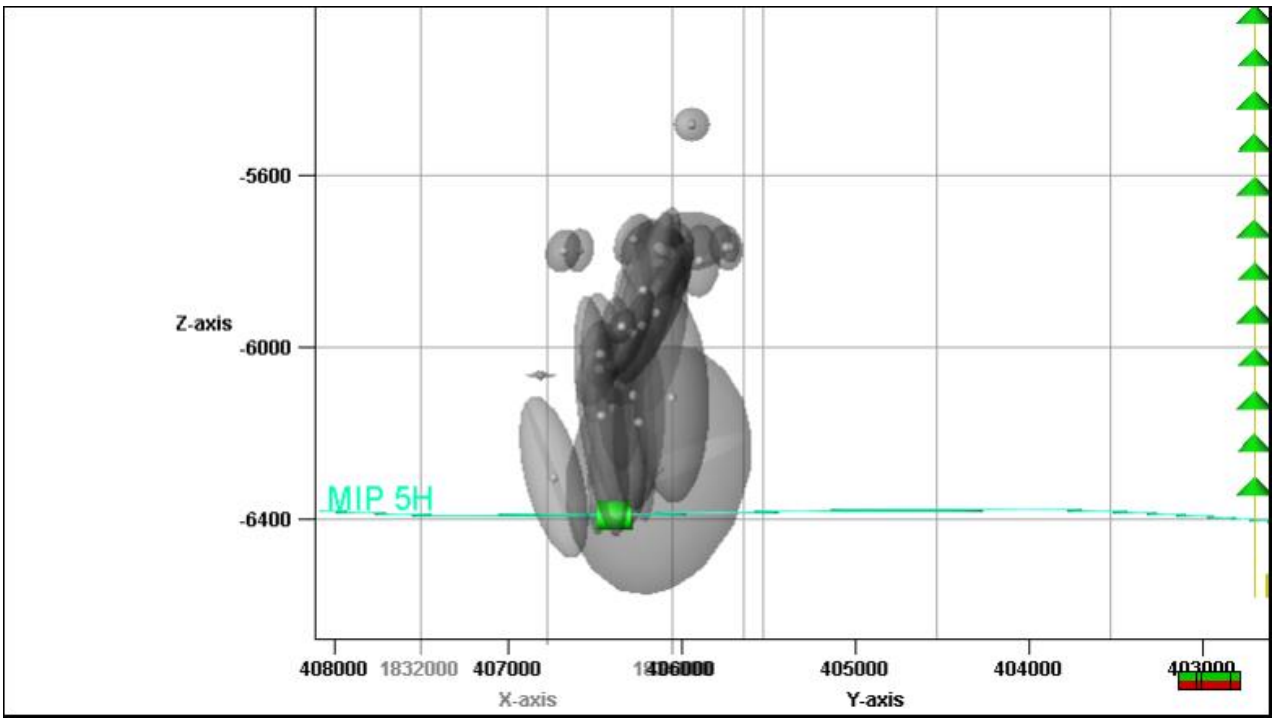



**Figure 5-144 - MIP 5H Stage 7 event location uncertainty ellipsoids – side view**

### 5.29.1 MIP 5H Stage 7 On-Site Notes and Observations

## 5.30 MIP 5H Stage 8

The MIP 5H Stage 8 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

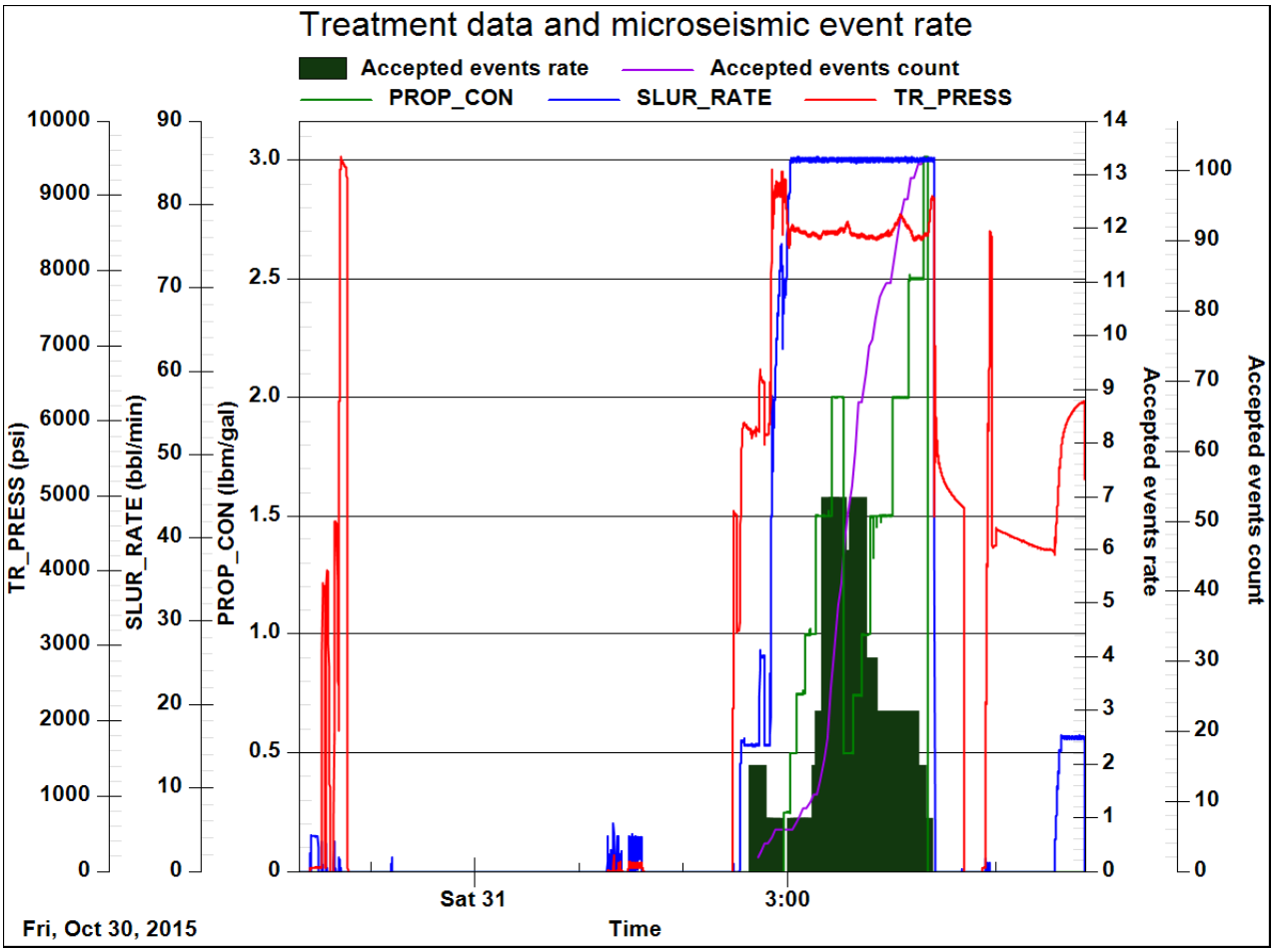



**Figure 5-145 - MIP 5H Stage 8 treatment data and microseismic event rate**

**Table 5.88 - MIP 5H Stage 8 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 320484 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 2940 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 323424 |
| 100 Mesh (lbm) | 140000 | 141540 |
| 40/70 White (lbm) | 260000 | 258640 |
| Total proppants (lbm) | 400000 | 400180 |

**Table 5.89 - MIP 5H Stage 8 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 81.2 |
| Average pressure (psi) | 8455 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6156 |
| Maximum PPA (lbm/gal) | 3.015 |

**Table 5.90 - MIP 5H Stage 8 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 71 |
| MS length (ft) | 1137 |
| MS height (ft) | 661 |
| MS volume (million ft3) | 29.2 |

The microseismic data from MIP 5H Stage 8 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

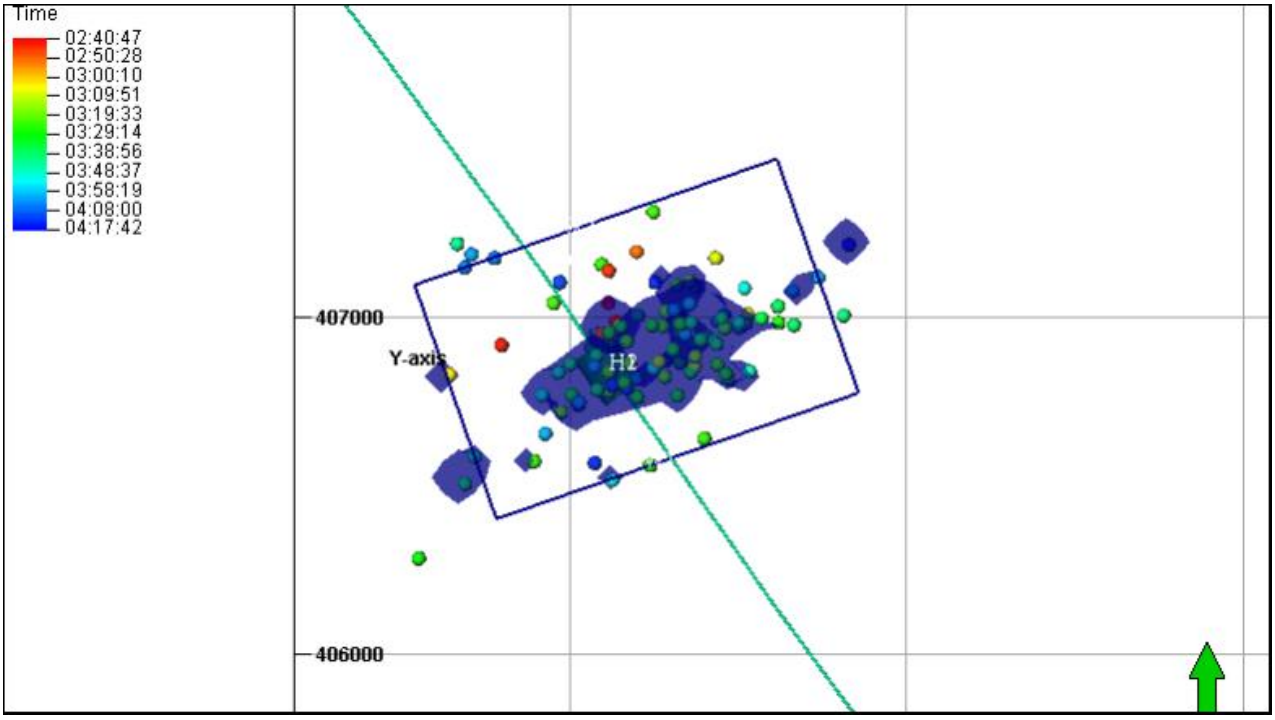



**Figure 5-146 - MIP 5H Stage 8 map view (length and width)**

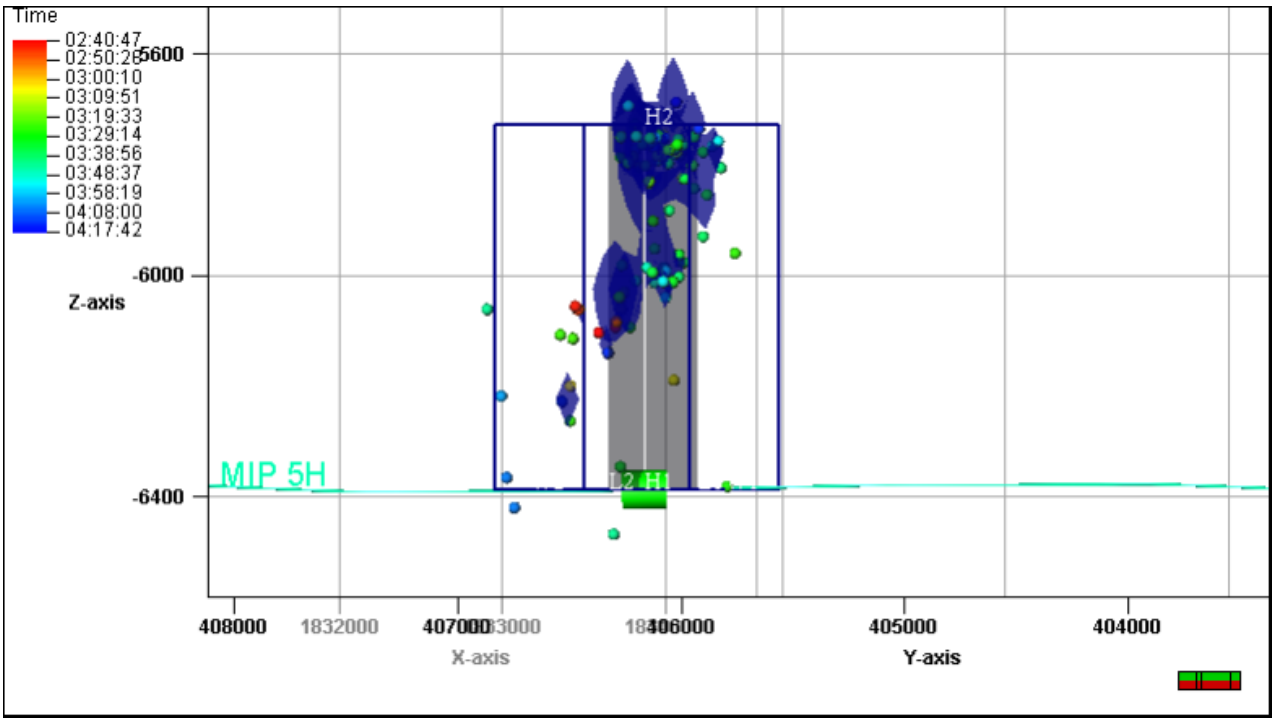



**Figure 5-147 - MIP 5H Stage 8 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 8 are shown below in map and transverse views.

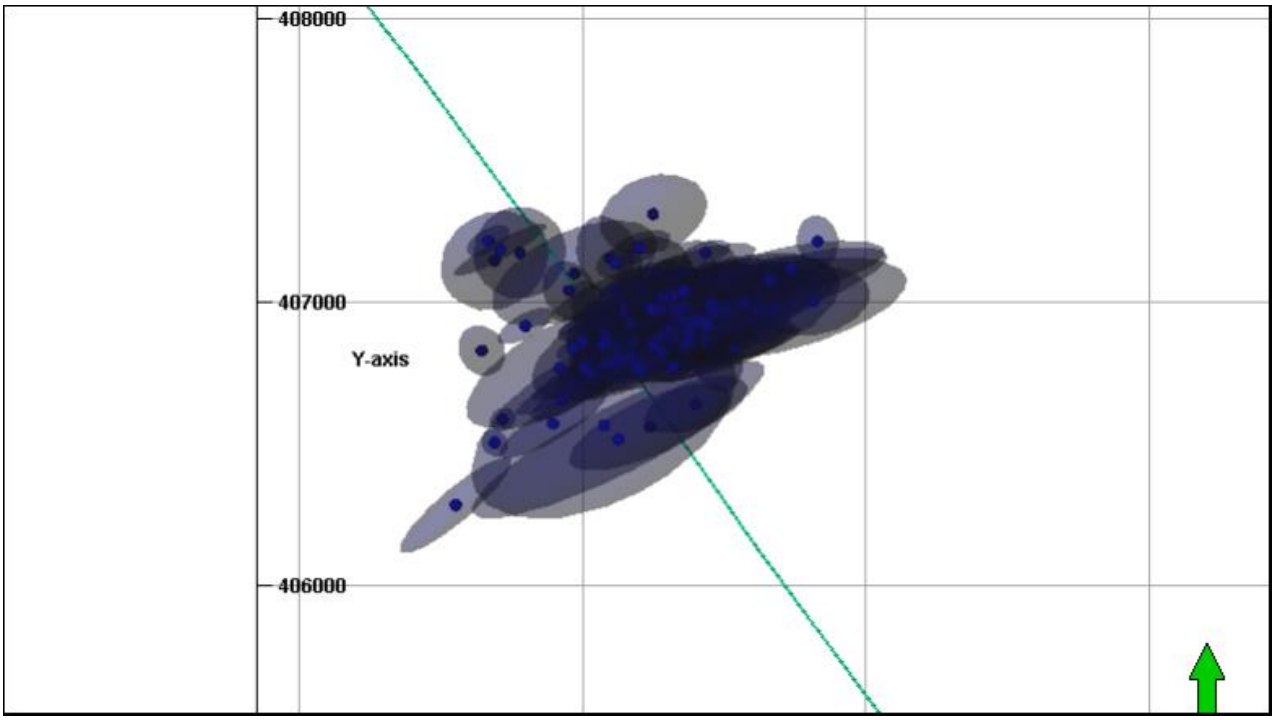



**Figure 5-148 - MIP 5H Stage 8 event location uncertainty ellipsoids – map view**

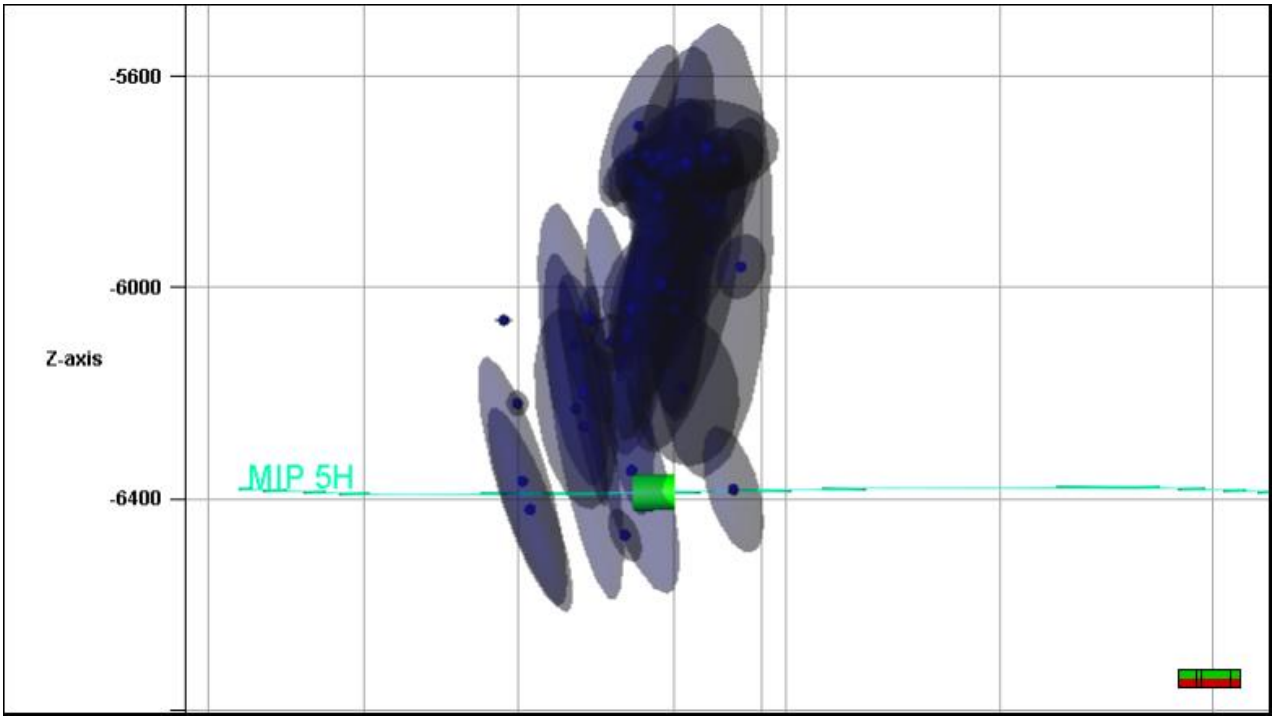



**Figure 5-149 - MIP 5H Stage 8 event location uncertainty ellipsoids – side view**

### 5.30.1 MIP 5H Stage 8 On-Site Notes and Observations

## 5.31 MIP 5H Stage 9

The MIP 5H Stage 9 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

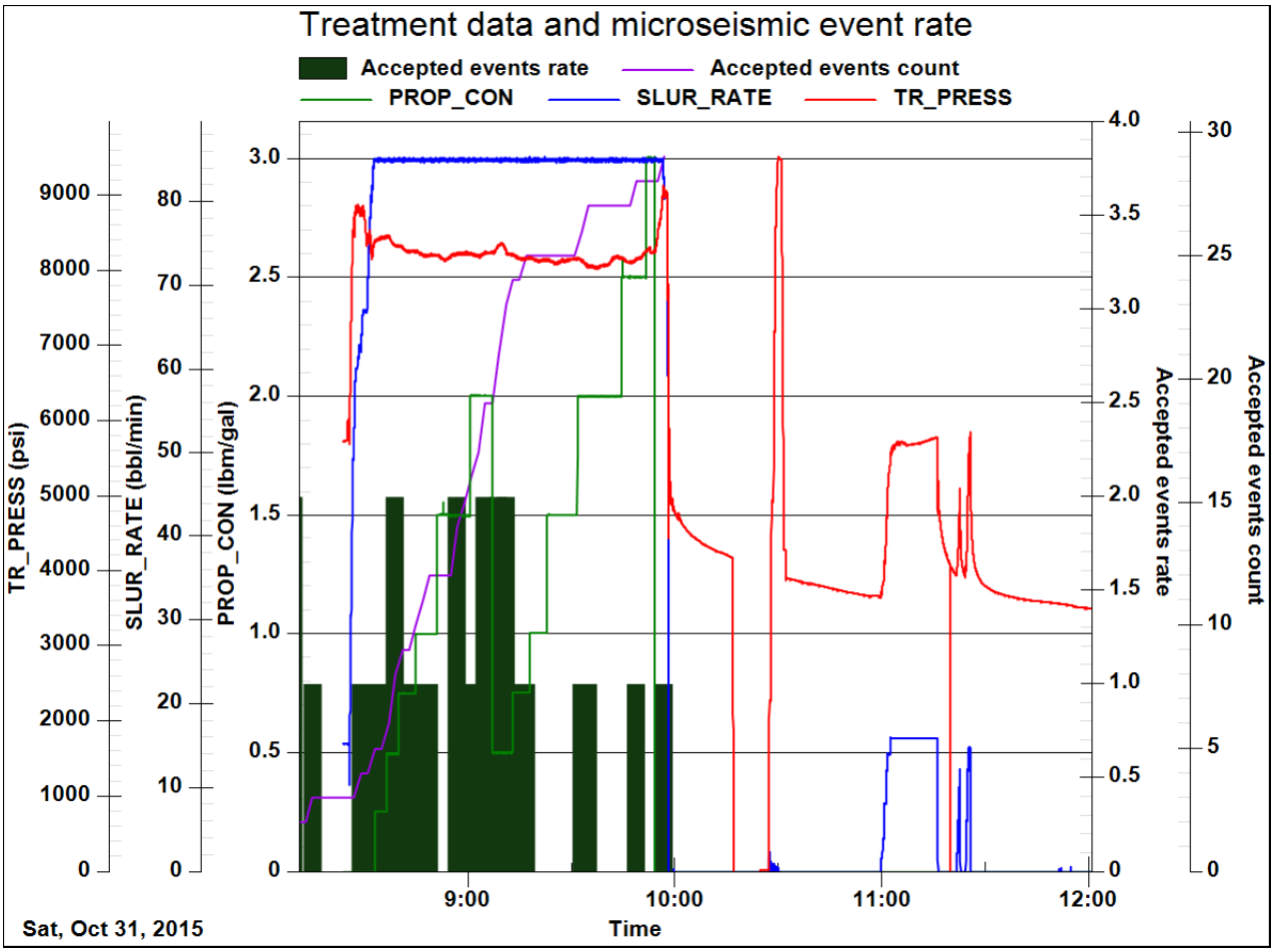



**Figure 5-150 - MIP 5H Stage 9 treatment data and microseismic event rate**

**Table 5.91 - MIP 5H Stage 9 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 311771 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 5618 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 317389 |
| 100 Mesh (lbm) | 140000 | 140760 |
| 40/70 White (lbm) | 260000 | 257860 |
| Total proppants (lbm) | 400000 | 398620 |

**Table 5.92 - MIP 5H Stage 9 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 84.7 |
| Average pressure (psi) | 8217 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5312 |
| Maximum PPA (lbm/gal) | 3.007 |

**Table 5.93 - MIP 5H Stage 9 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 61 |
| MS length (ft) | 790 |
| MS height (ft) | 743 |
| MS volume (million ft3) | N/A |

The microseismic data from MIP 5H Stage 9 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

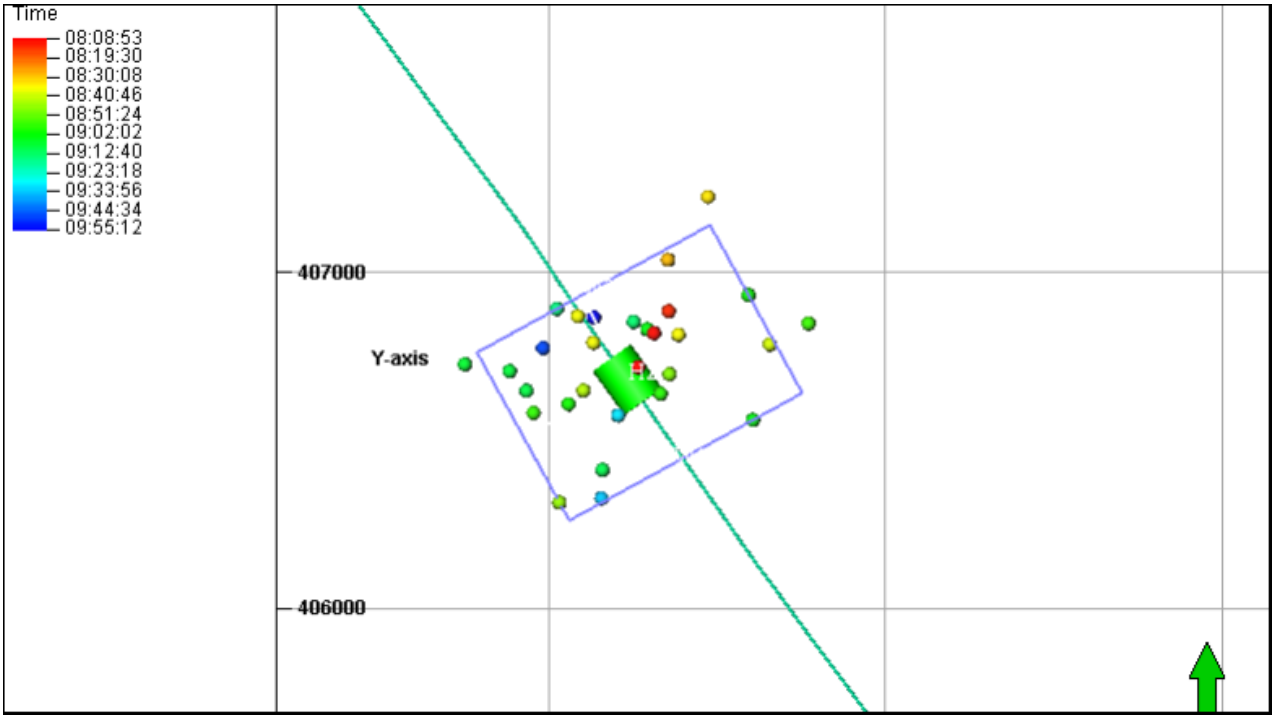



**Figure 5-151 - MIP 5H Stage 9 map view (length and width)**

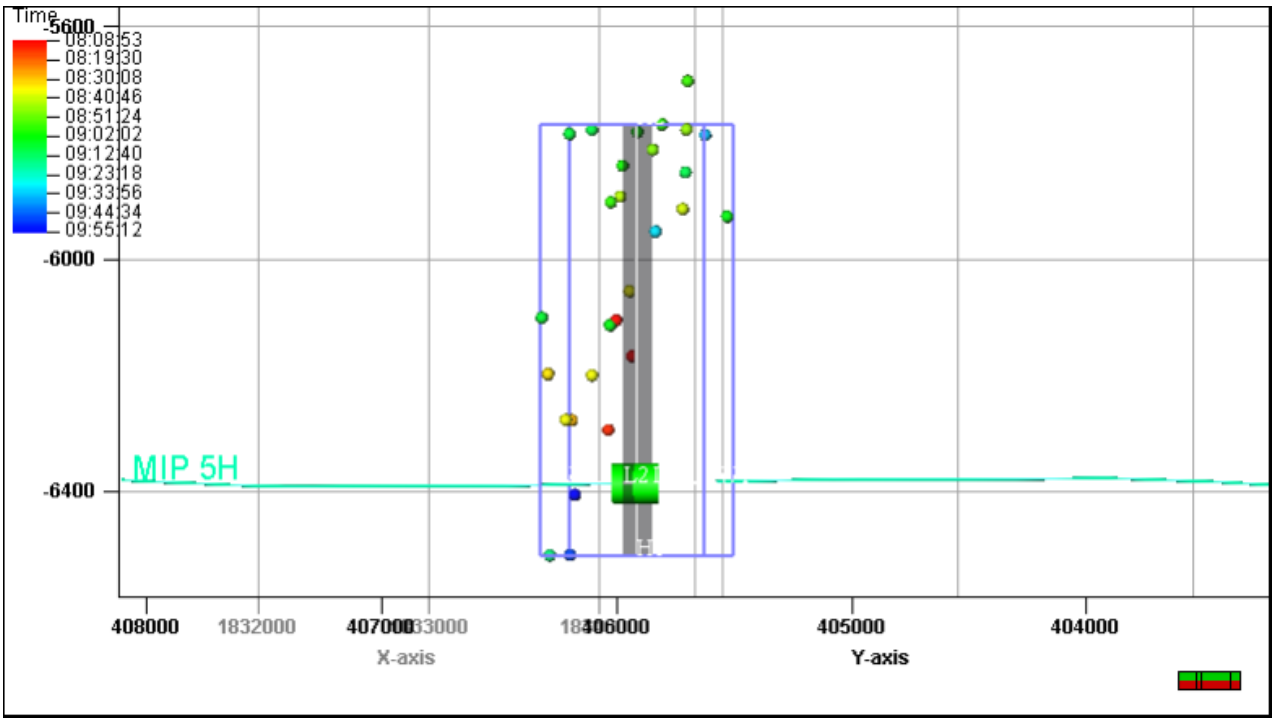



**Figure 5-152 - MIP 5H Stage 9 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 9 are shown below in map and transverse views.

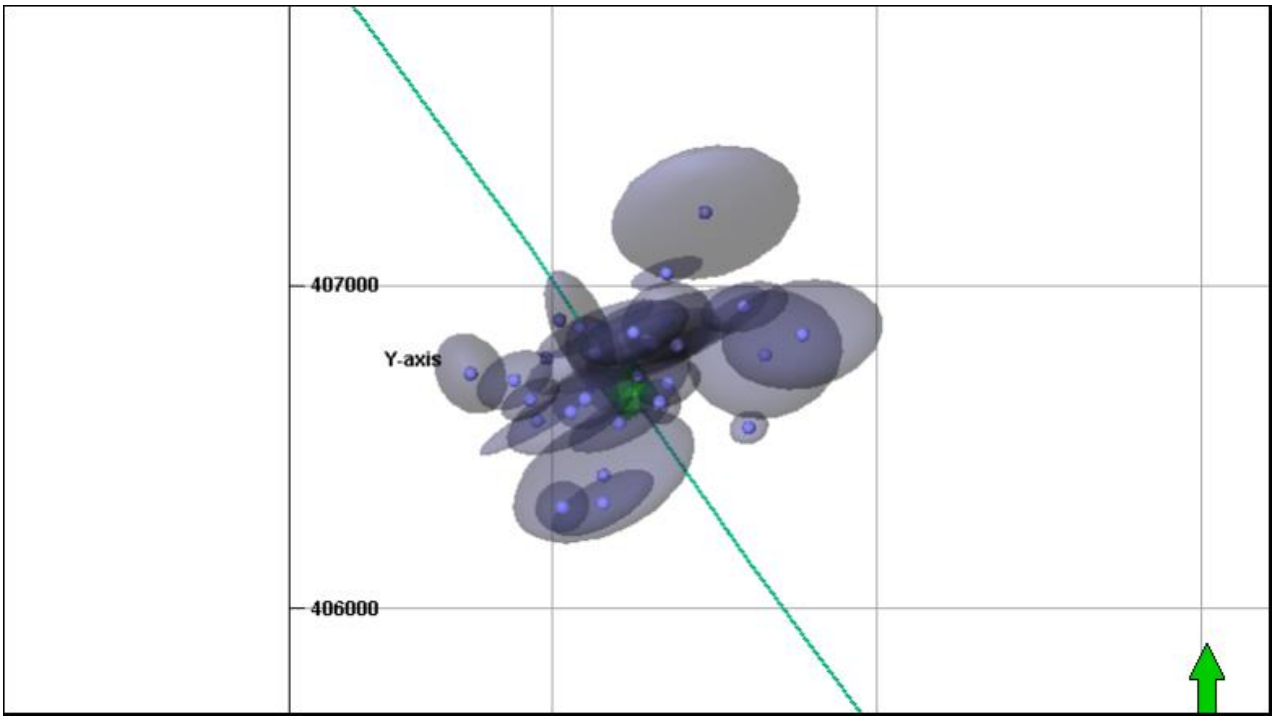



**Figure 5-153 - MIP 5H Stage 9 event location uncertainty ellipsoids – map view**

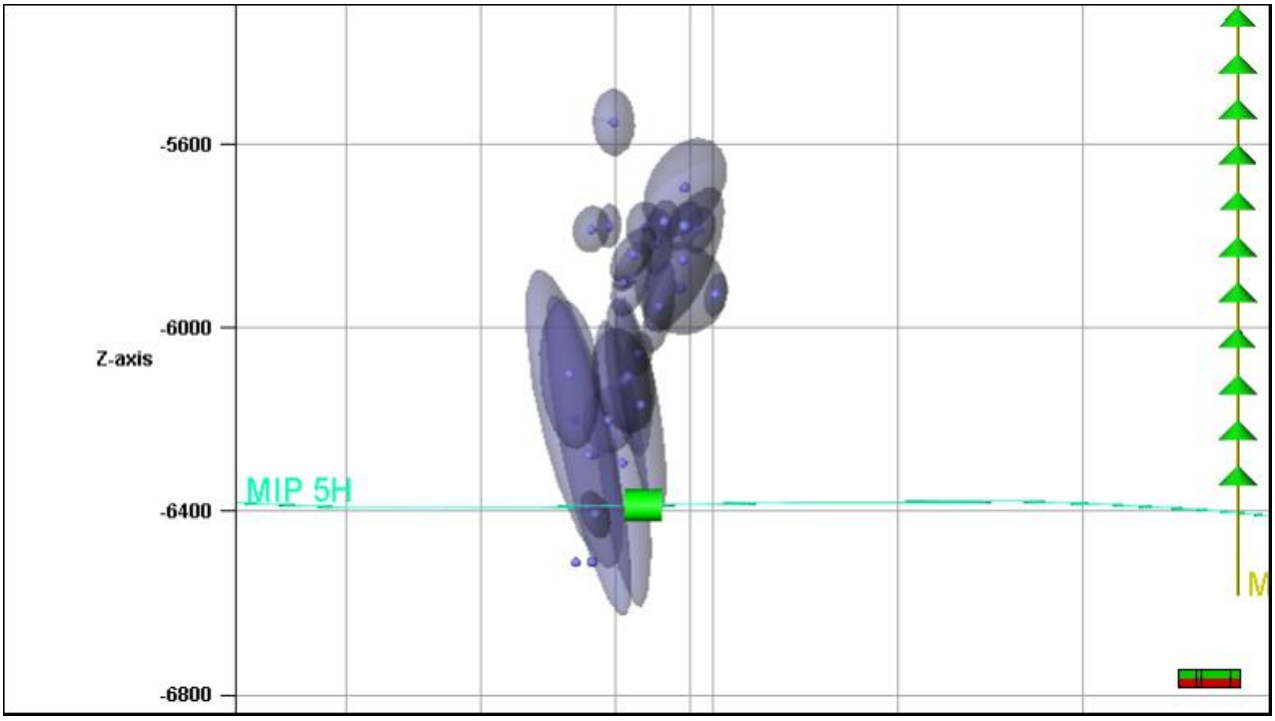



**Figure 5-154 - MIP 5H Stage 9 event location uncertainty ellipsoids – side view**

### 5.31.1 MIP 5H Stage 9 On-Site Notes and Observations

## 5.32 MIP 5H Stage 10

The MIP 5H Stage 10 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

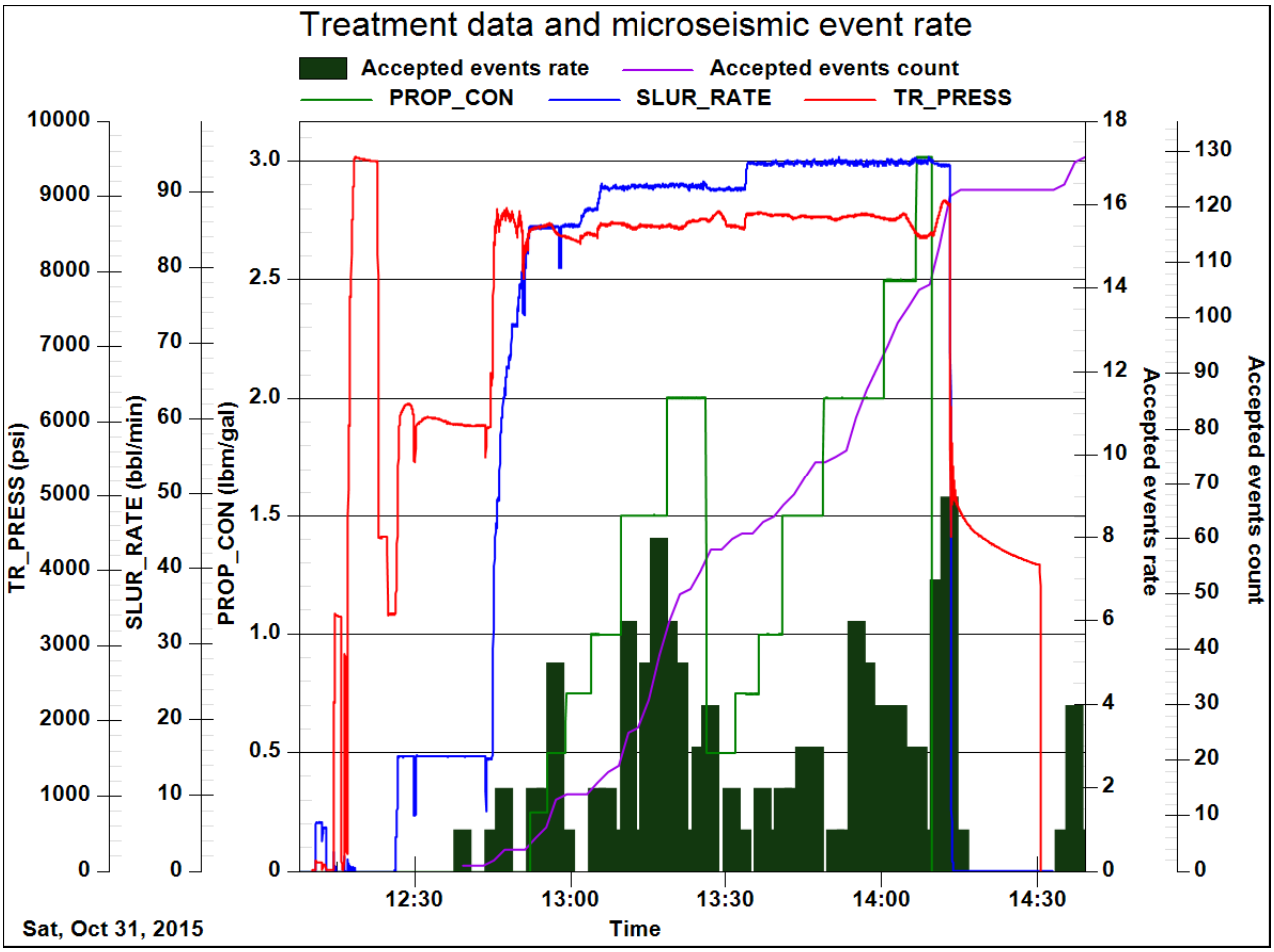



**Figure 5-155 - MIP 5H Stage 10 treatment data and microseismic event rate**

**Table 5.94 - MIP 5H Stage 10 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 321618 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 2931 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 324549 |
| 100 Mesh (lbm) | 140000 | 145440 |
| 40/70 White (lbm) | 260000 | 253440 |
| Total proppants (lbm) | 400000 | 398880 |

**Table 5.95 - MIP 5H Stage 10 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 91.2 |
| Average pressure (psi) | 8644 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5401 |
| Maximum PPA (lbm/gal) | 3.018 |

**Table 5.96 - MIP 5H Stage 10 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 75 |
| MS length (ft) | 1565 |
| MS height (ft) | 604 |
| MS volume (million ft3) | 26.4 |

The microseismic data from MIP 5H Stage 10 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

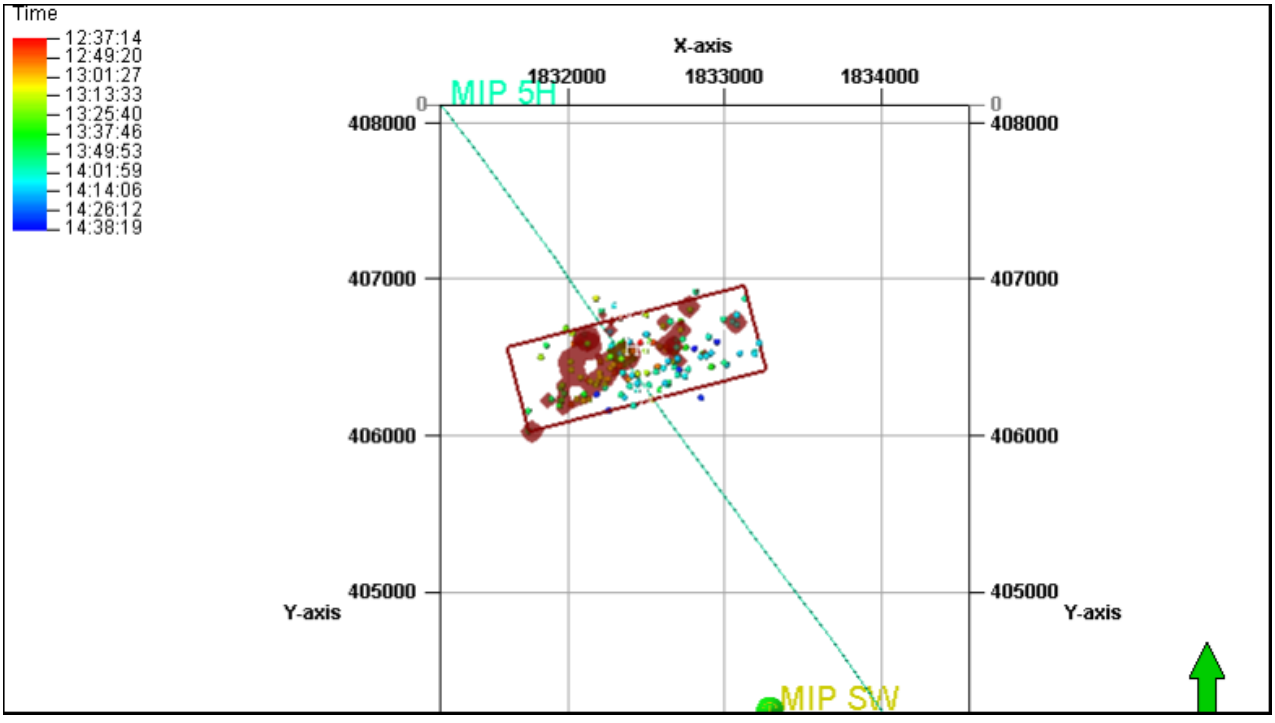



**Figure 5-156 - MIP 5H Stage 10 map view (length and width)**

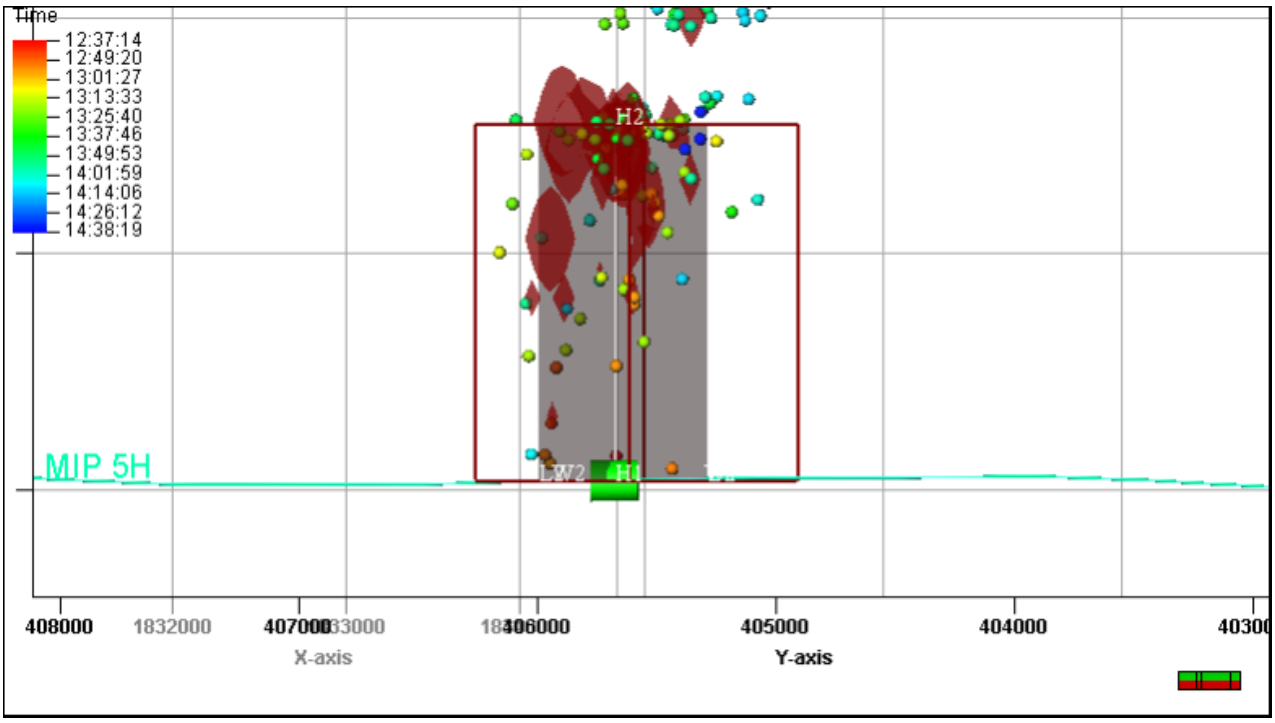



**Figure 5-157 - MIP 5H Stage 10 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 10 are shown below in map and transverse views.

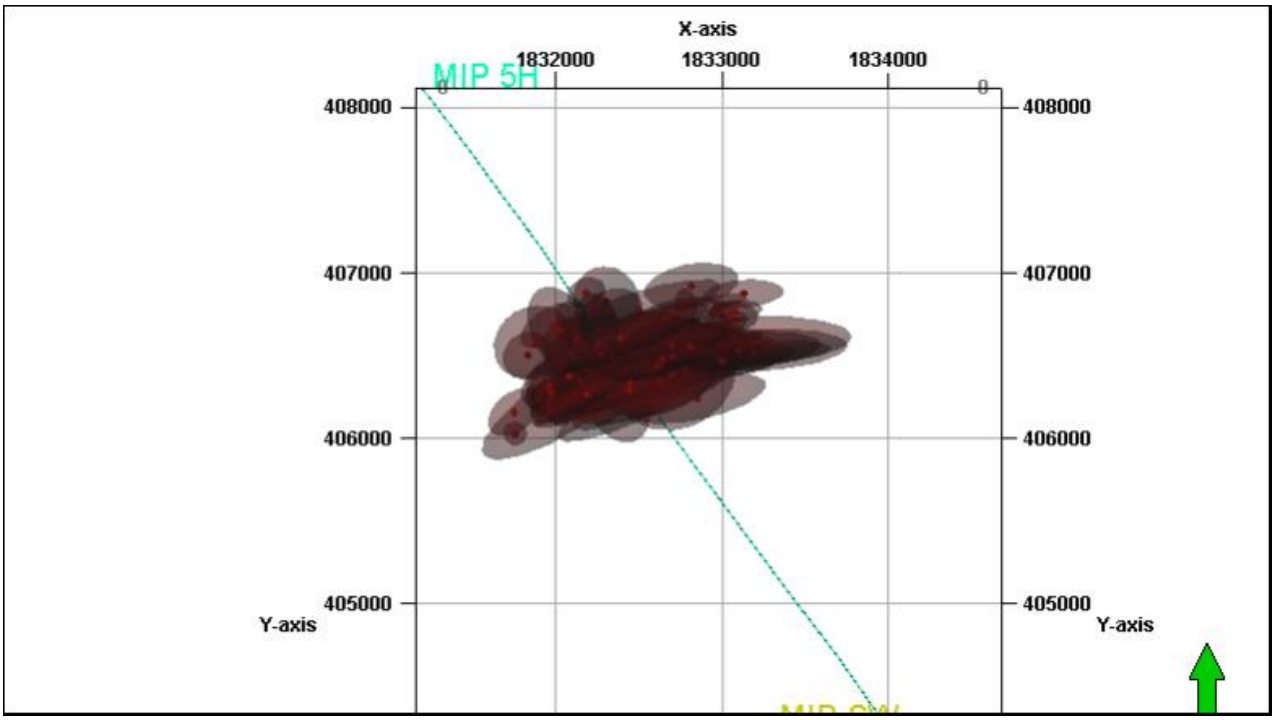



**Figure 5-158 - MIP 5H Stage 10 event location uncertainty ellipsoids – map view**

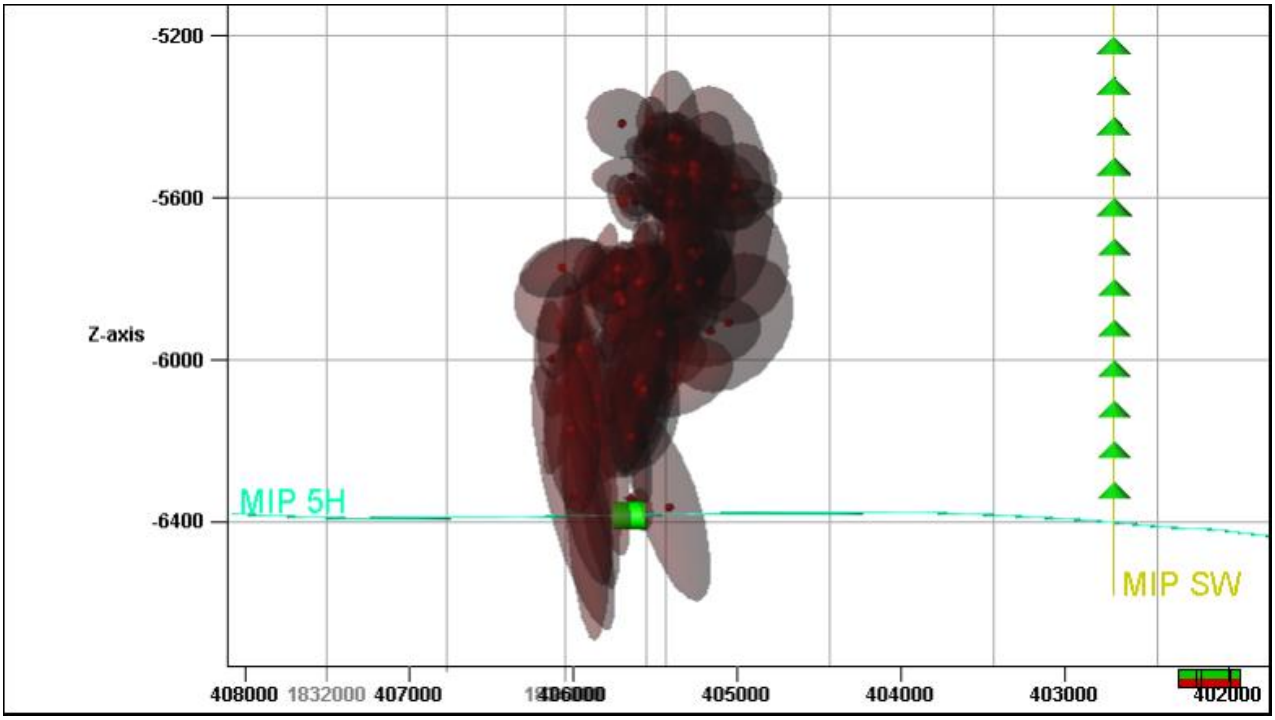



**Figure 5-159 - MIP 5H Stage 10 event location uncertainty ellipsoids – side view**

### 5.32.1 MIP 5H Stage 10 On-Site Notes and Observations

## 5.33 MIP 5H Stage 11

The MIP 5H Stage 11 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

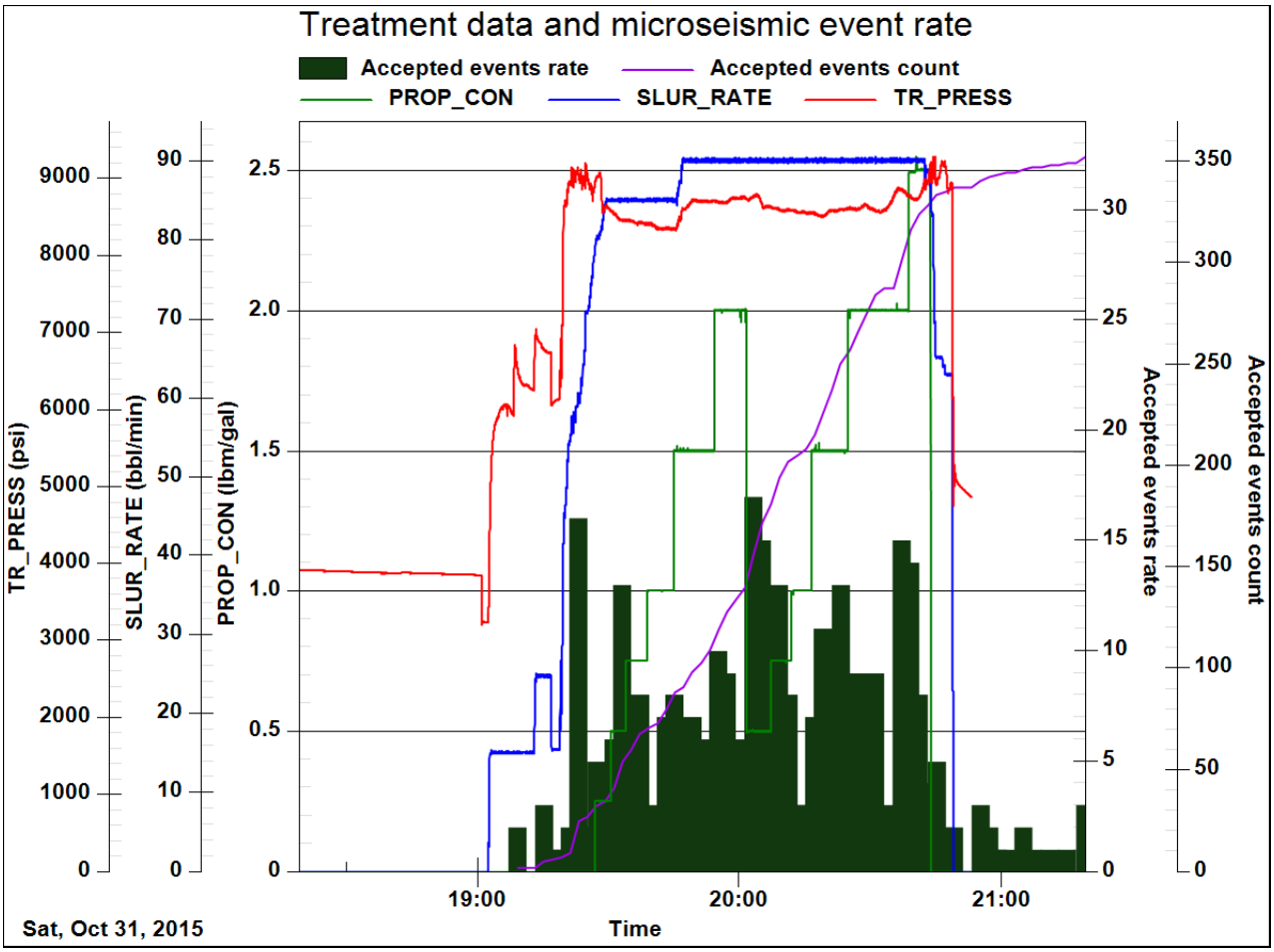



**Figure 5-160 - MIP 5H Stage 11 treatment data and microseismic event rate**

**Table 5.97 - MIP 5H Stage 11 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 312561 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 315561 |
| 100 Mesh (lbm) | 140000 | 139560 |
| 40/70 White (lbm) | 260000 | 218620 |
| Total proppants (lbm) | 400000 | 358180 |

**Table 5.98 - MIP 5H Stage 11 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 83.7 |
| Average pressure (psi) | 8566 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5408 |
| Maximum PPA (lbm/gal) | 2.547 |

**Table 5.99 - MIP 5H Stage 11 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 71 |
| MS length (ft) | 1204 |
| MS height (ft) | 727 |
| MS volume (million ft3) | 58.9 |

The microseismic data from MIP 5H Stage 11 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

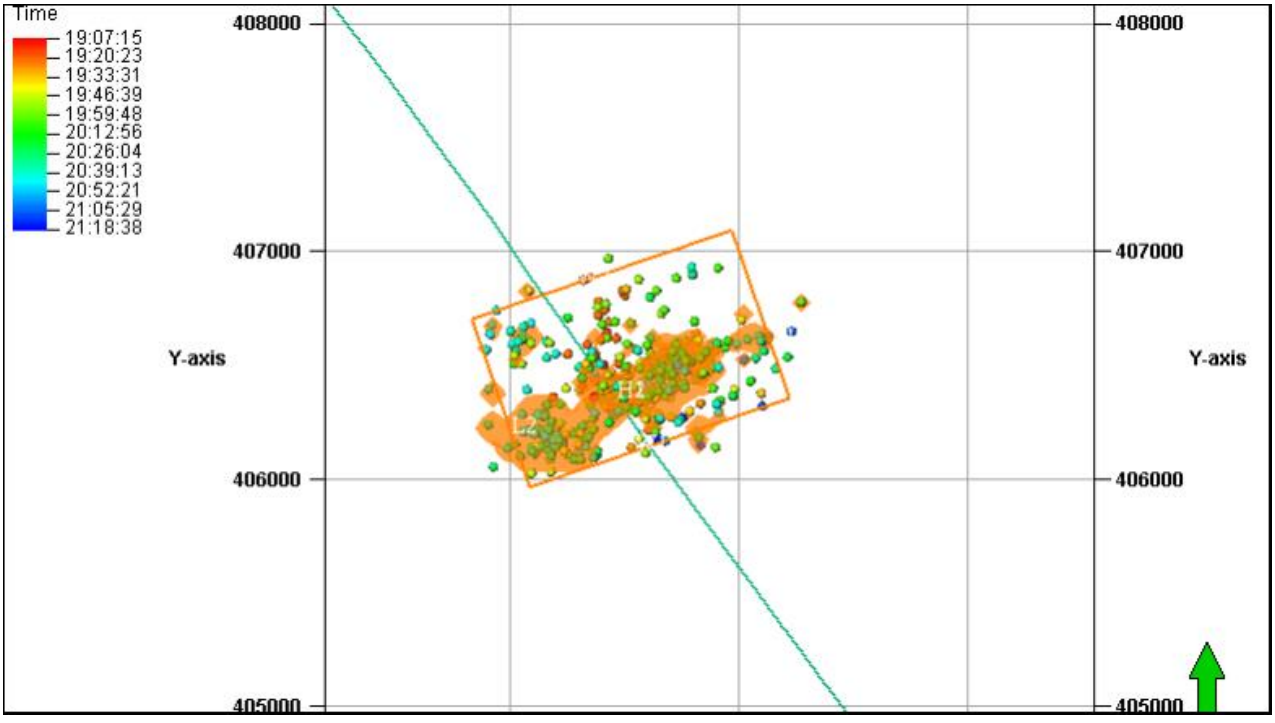



**Figure 5-161 - MIP 5H Stage 11 map view (length and width)**

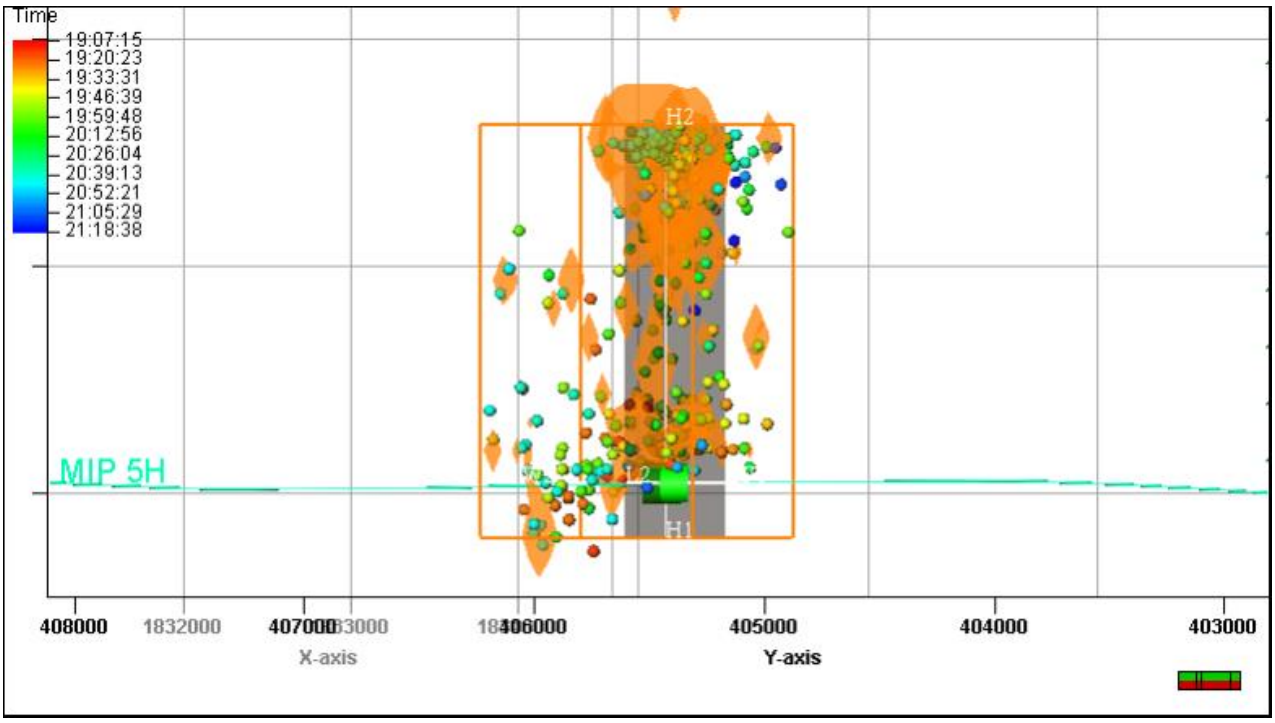



**Figure 5-162 - MIP 5H Stage 11 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 11 are shown below in map and transverse views.

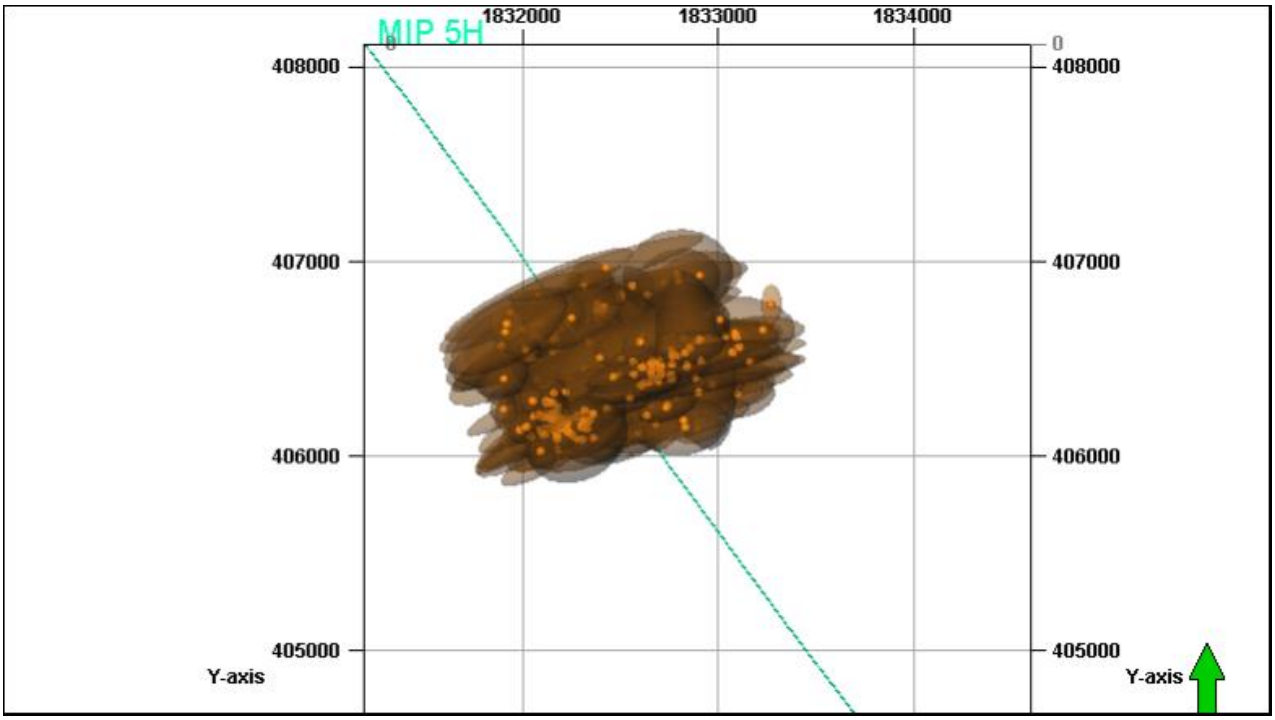



**Figure 5-163 - MIP 5H Stage 11 event location uncertainty ellipsoids – map view**

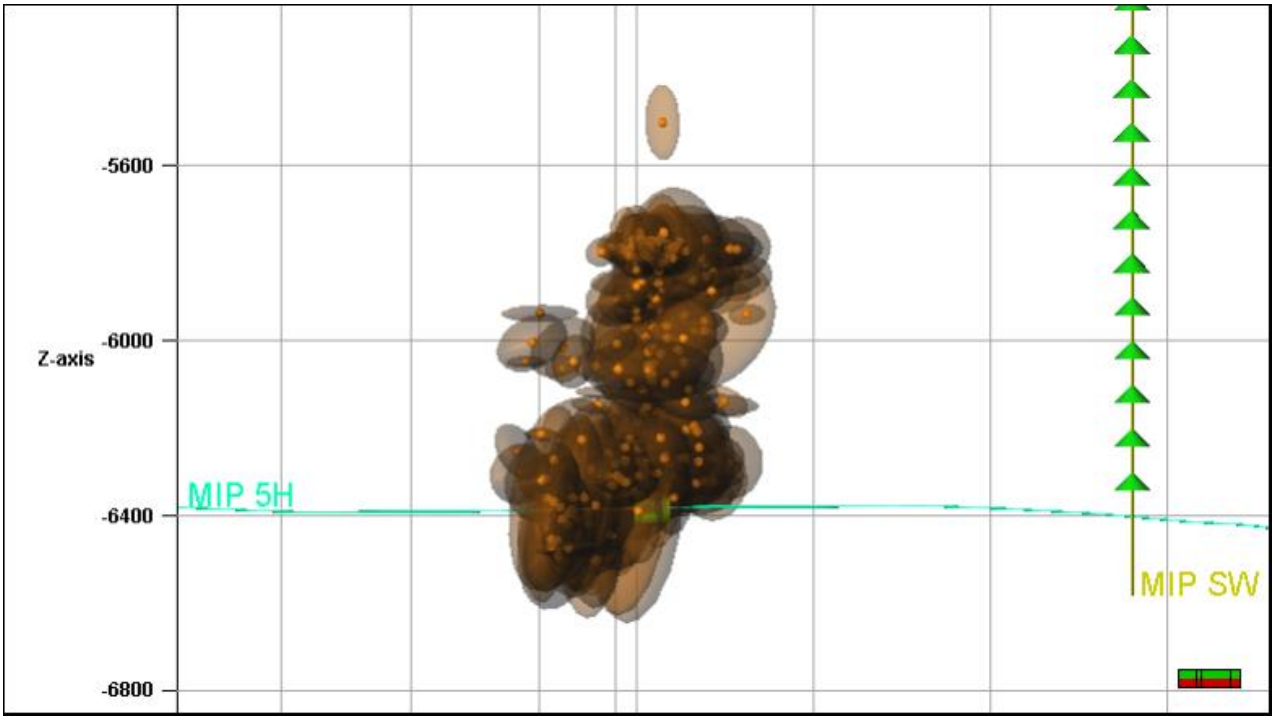



**Figure 5-164 - MIP 5H Stage 11 event location uncertainty ellipsoids – side view**

### 5.33.1 MIP 5H Stage 11 On-Site Notes and Observations

## 5.34 MIP 5H Stage 12

The MIP 5H Stage 12 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

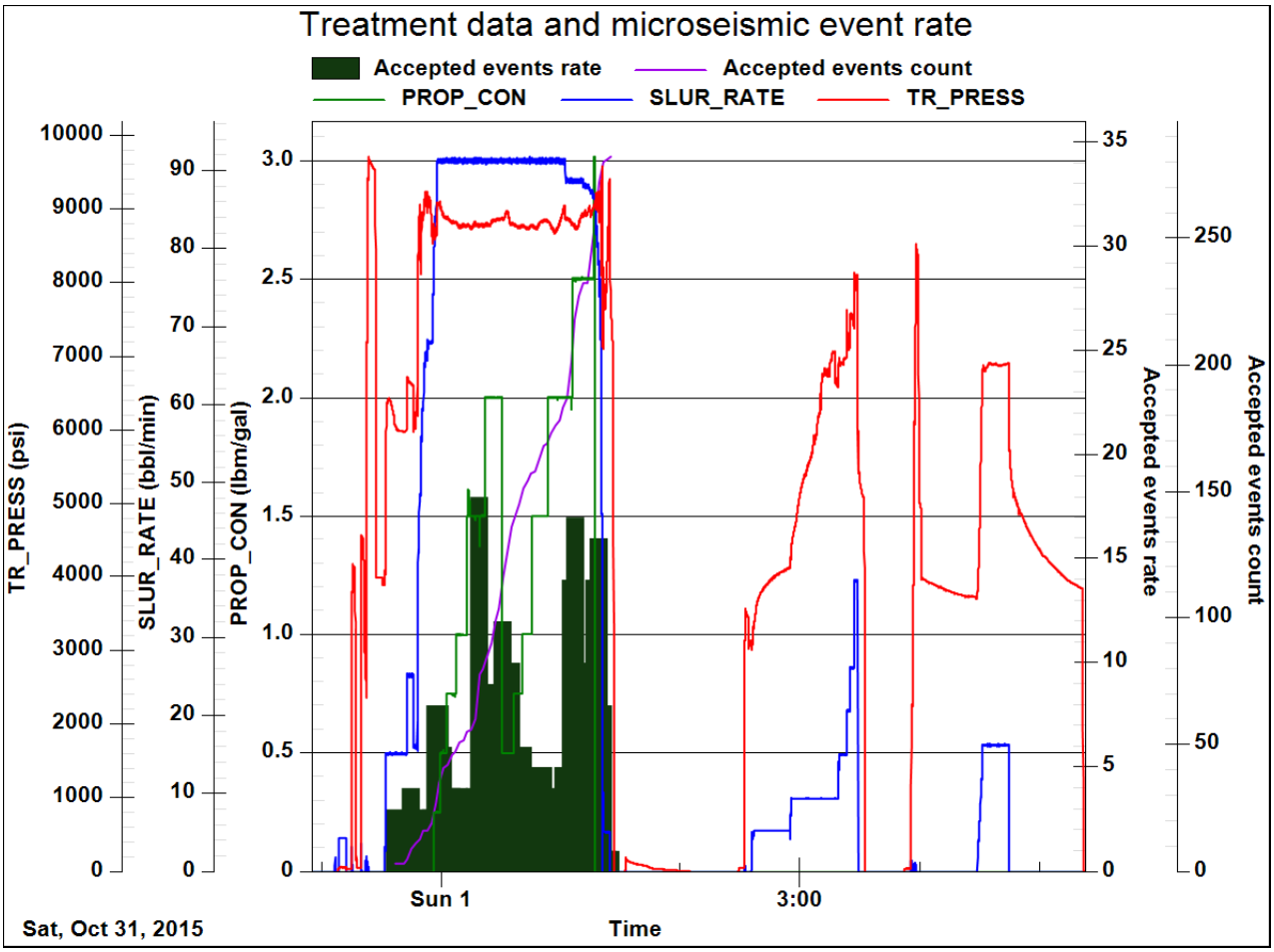



**Figure 5-165 - MIP 5H Stage 12 treatment data and microseismic event rate**

**Table 5.100 - MIP 5H Stage 12 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 329445 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 332445 |
| 100 Mesh (lbm) | 140000 | 145260 |
| 40/70 White (lbm) | 260000 | 258120 |
| Total proppants (lbm) | 400000 | 403380 |

**Table 5.101 - MIP 5H Stage 12 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 85.9 |
| Average pressure (psi) | 8747 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 0 |
| Maximum PPA (lbm/gal) | 3.016 |

**Table 5.102 - MIP 5H Stage 12 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 86 |
| MS length (ft) | 1147 |
| MS height (ft) | 678 |
| MS volume (million ft3) | 47.1 |

The microseismic data from MIP 5H Stage 12 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

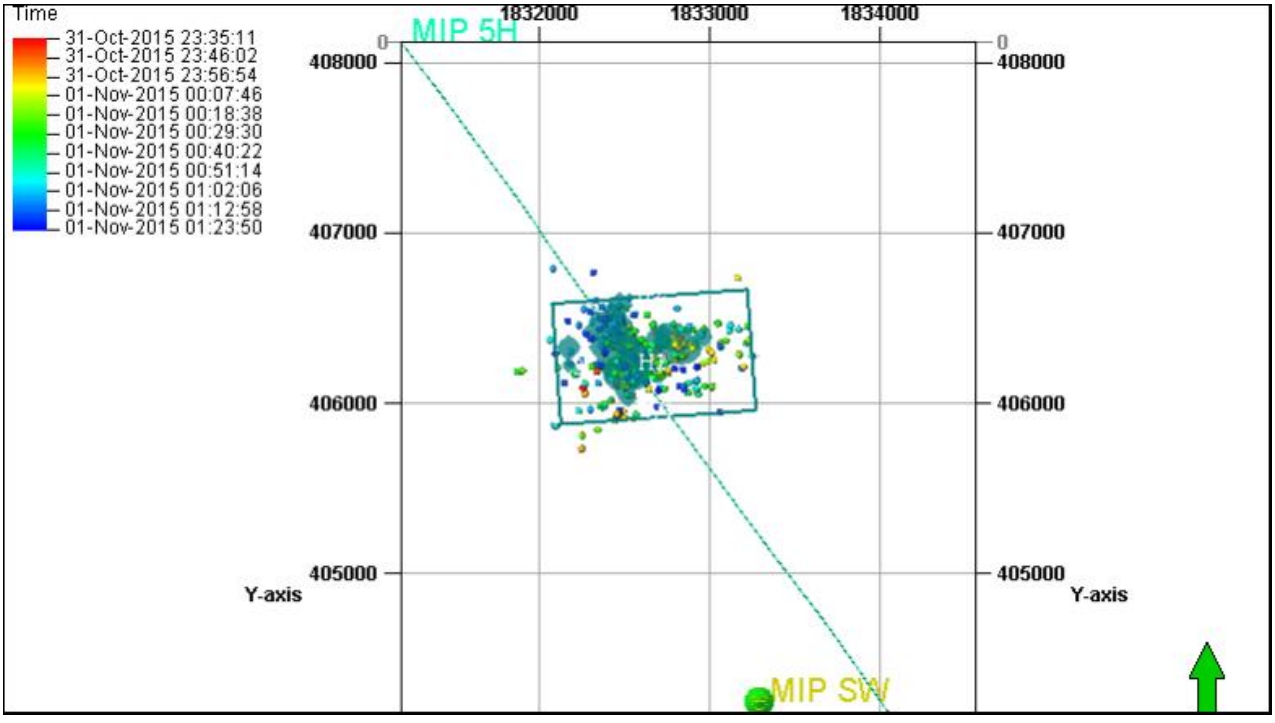



**Figure 5-166 - MIP 5H Stage 12 map view (length and width)**

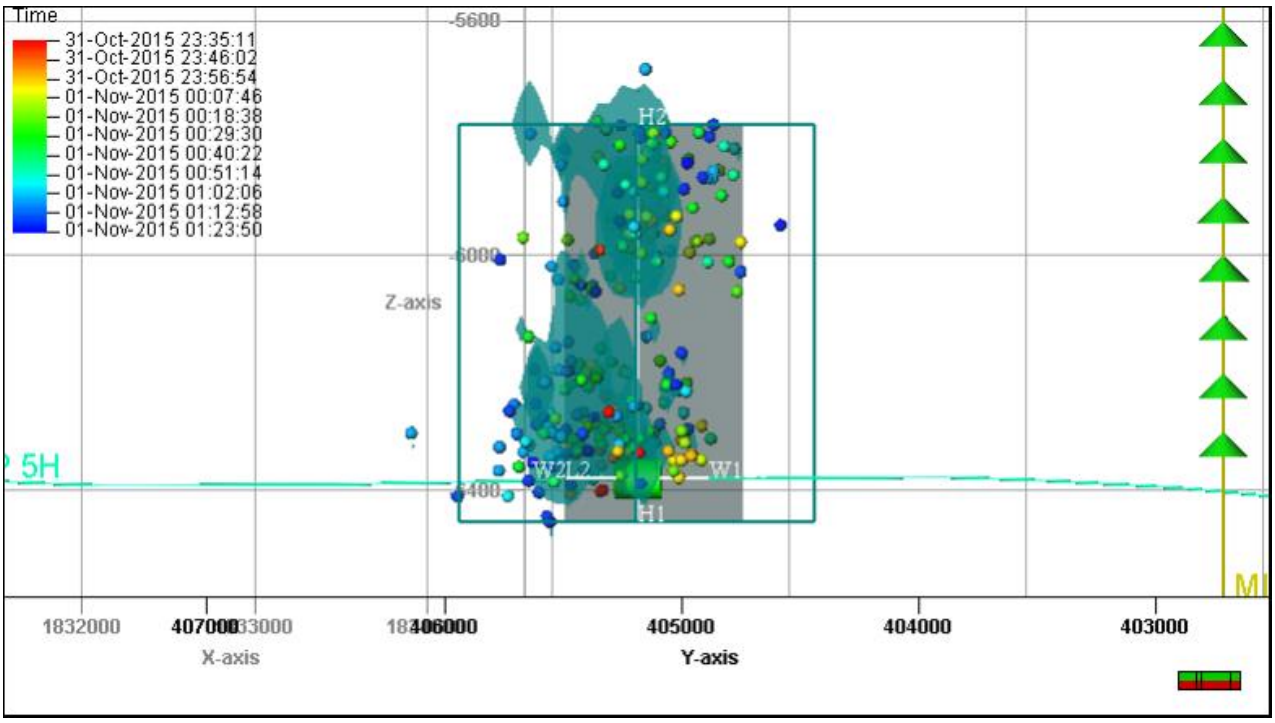



**Figure 5-167 - MIP 5H Stage 12 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 12 are shown below in map and transverse views.

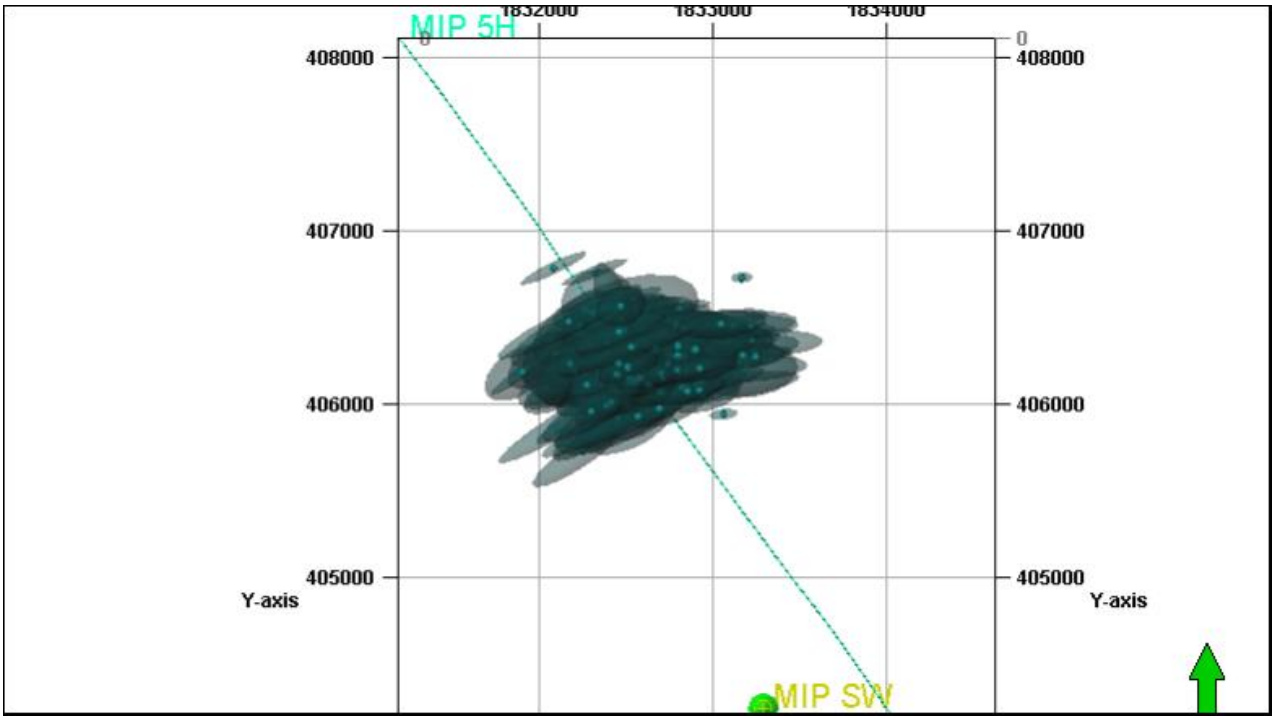



**Figure 5-168 - MIP 5H Stage 12 event location uncertainty ellipsoids – map view**

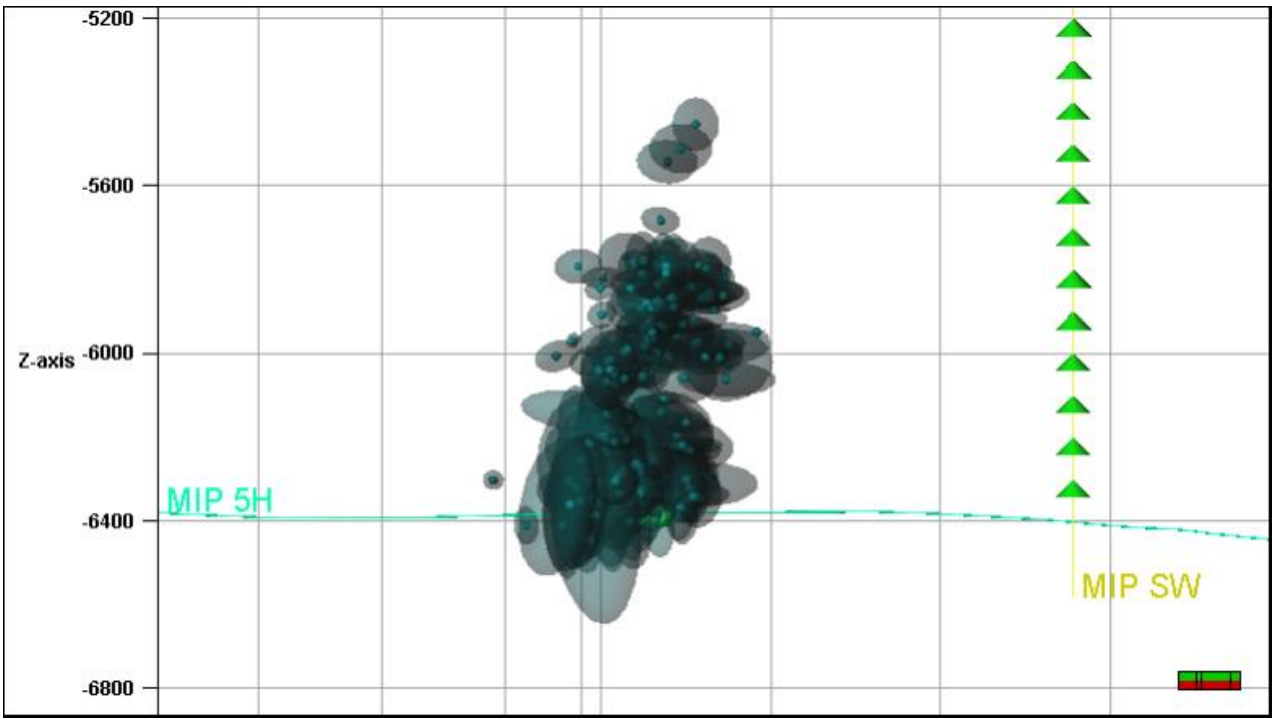



**Figure 5-169 - MIP 5H Stage 12 event location uncertainty ellipsoids – side view**

### 5.34.1 MIP 5H Stage 12 On-Site Notes and Observations

## 5.35 MIP 5H Stage 13

The MIP 5H Stage 13 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

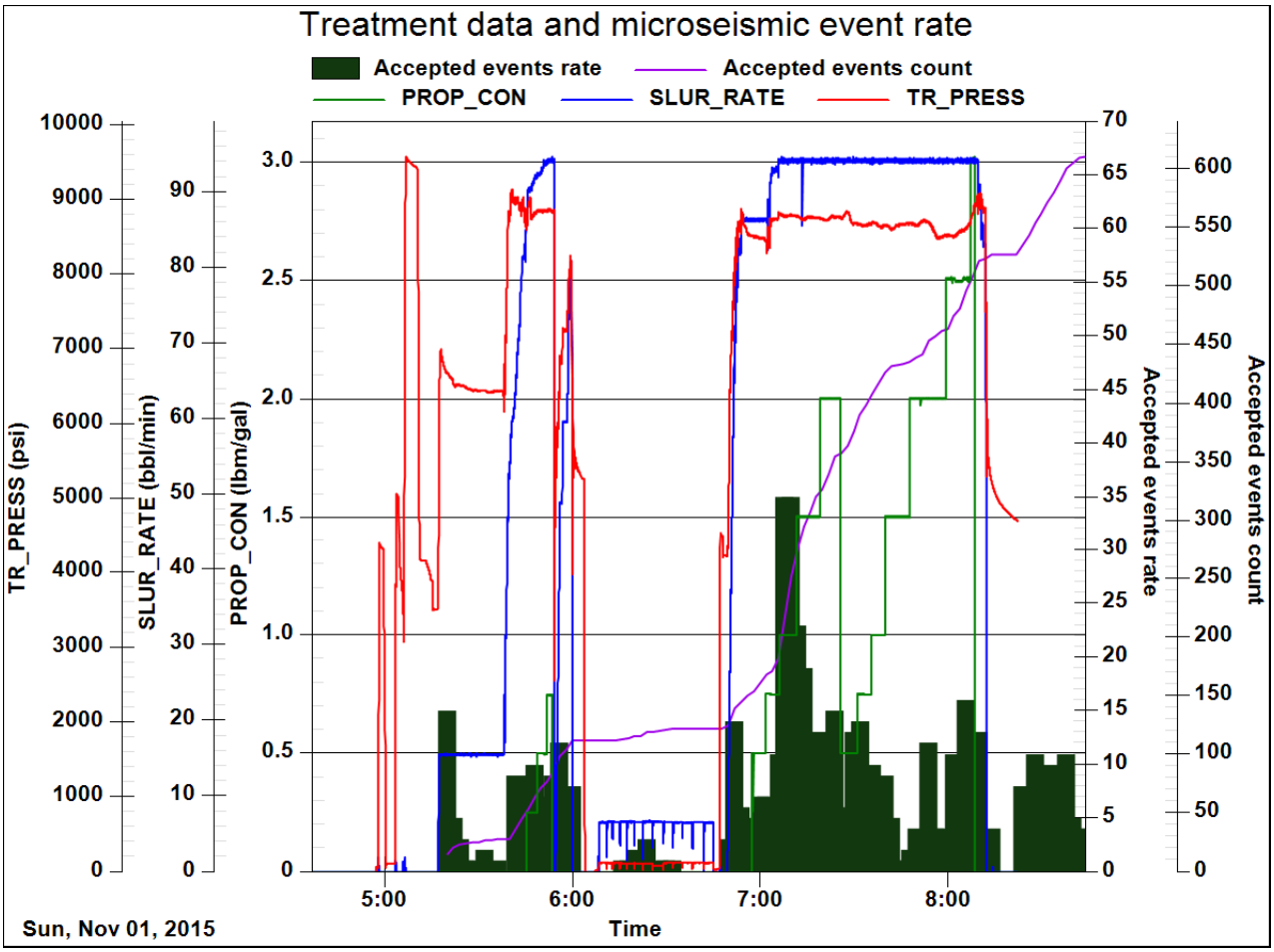



**Figure 5-170 - MIP 5H Stage 13 treatment data and microseismic event rate**

**Table 5.103 - MIP 5H Stage 13 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 369186 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 372186 |
| 100 Mesh (lbm) | 140000 | 142780 |
| 40/70 White (lbm) | 260000 | 251802 |
| Total proppants (lbm) | 400000 | 394582 |

**Table 5.104 - MIP 5H Stage 13 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 92.8 |
| Average pressure (psi) | 8672 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5898 |
| Maximum PPA (lbm/gal) | 3.022 |

**Table 5.105 - MIP 5H Stage 13 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 59 |
| MS length (ft) | 1447 |
| MS height (ft) | 687 |
| MS volume (million ft3) | 90.6 |

The microseismic data from MIP 5H Stage 13 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

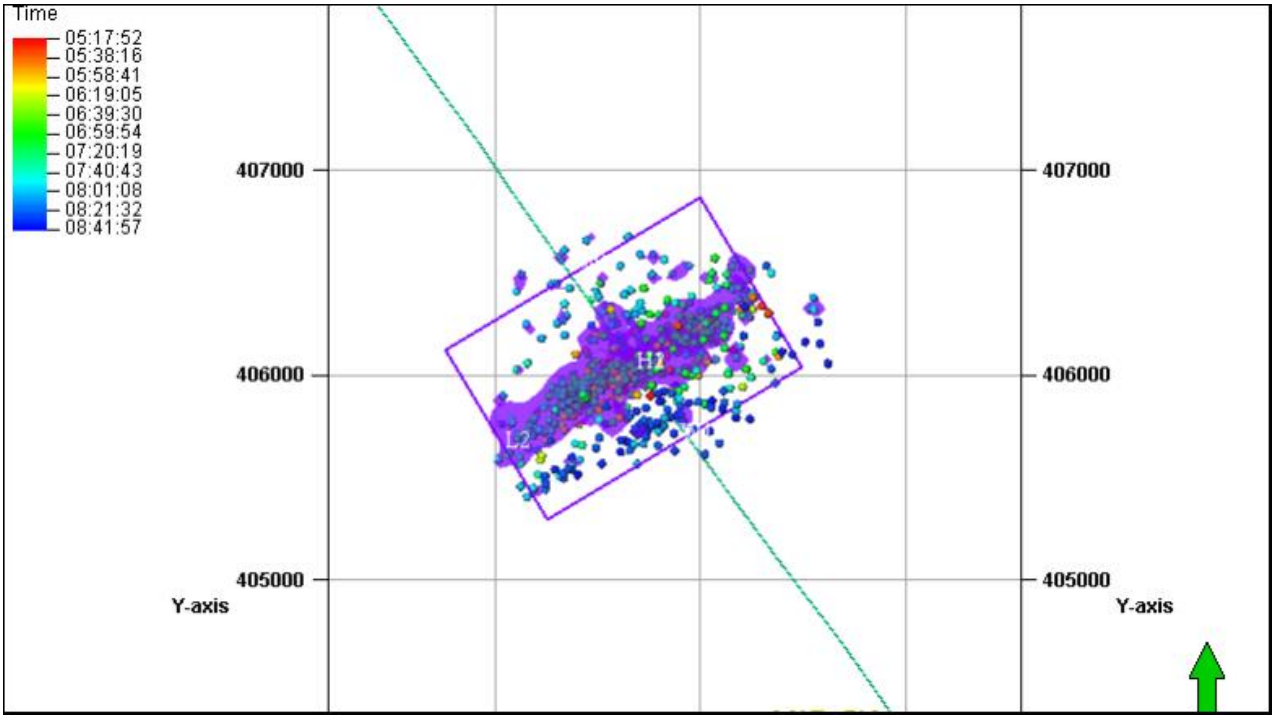



**Figure 5-171 - MIP 5H Stage 13 map view (length and width)**

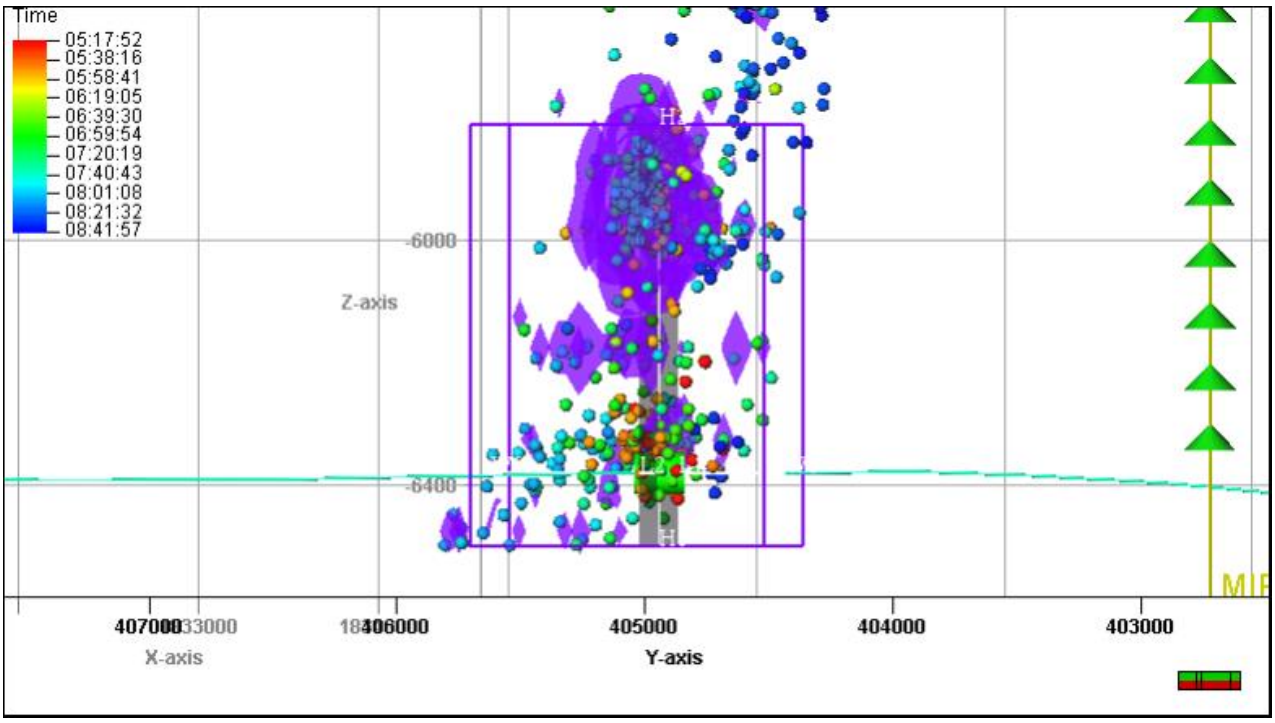



**Figure 5-172 - MIP 5H Stage 13 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 13 are shown below in map and transverse views.

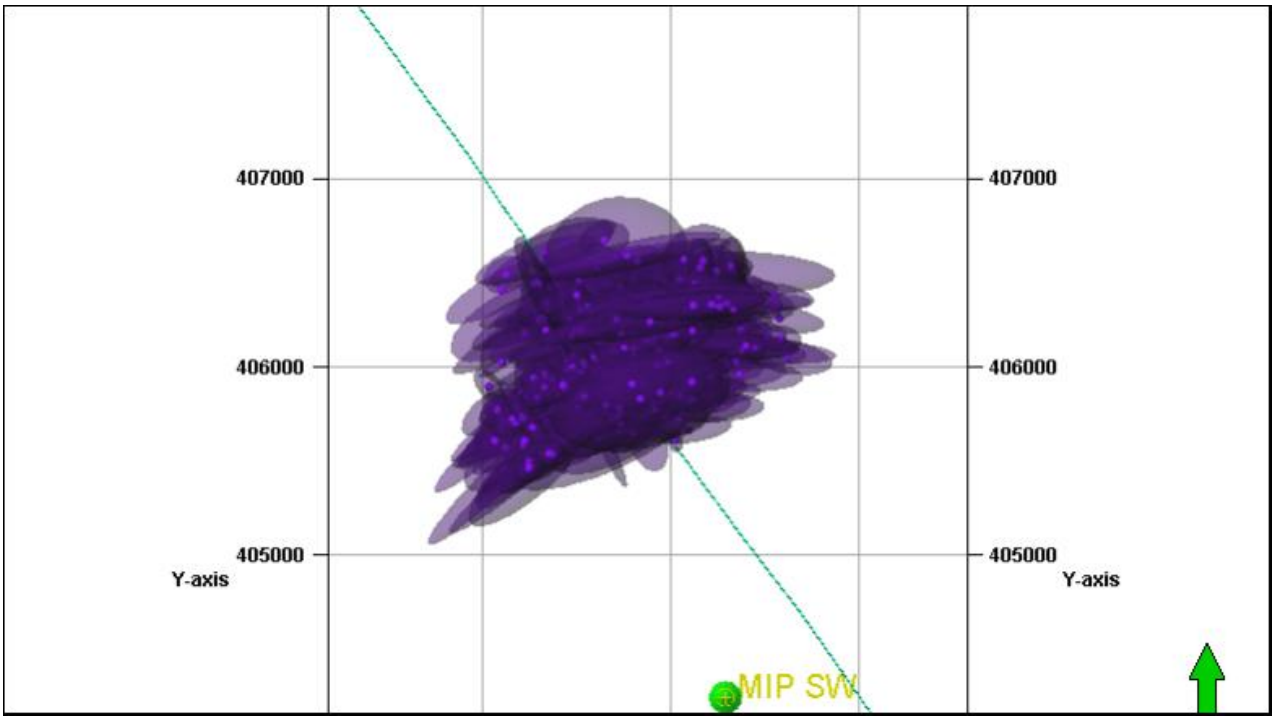



**Figure 5-173 - MIP 5H Stage 13 event location uncertainty ellipsoids – map view**

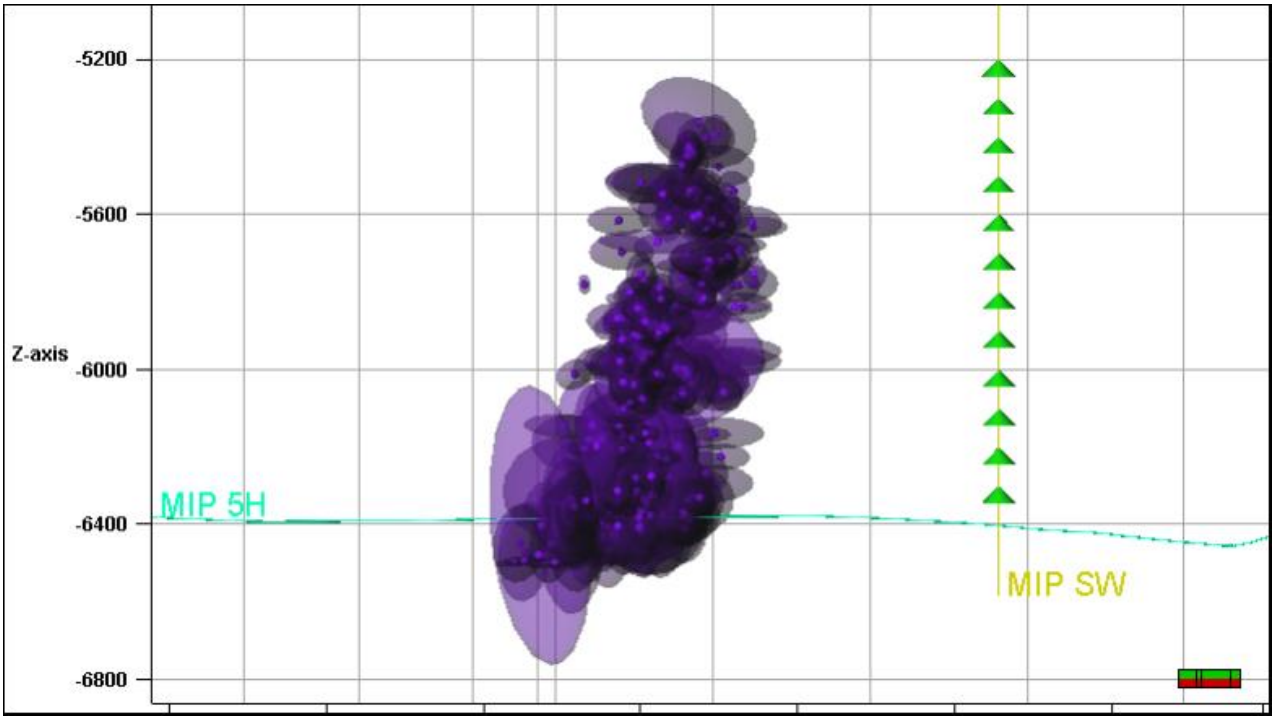



**Figure 5-174 - MIP 5H Stage 13 event location uncertainty ellipsoids – side view**

### 5.35.1 MIP 5H Stage 13 On-Site Notes and Observations

## 5.36 MIP 5H Stage 14

The MIP 5H Stage 14 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

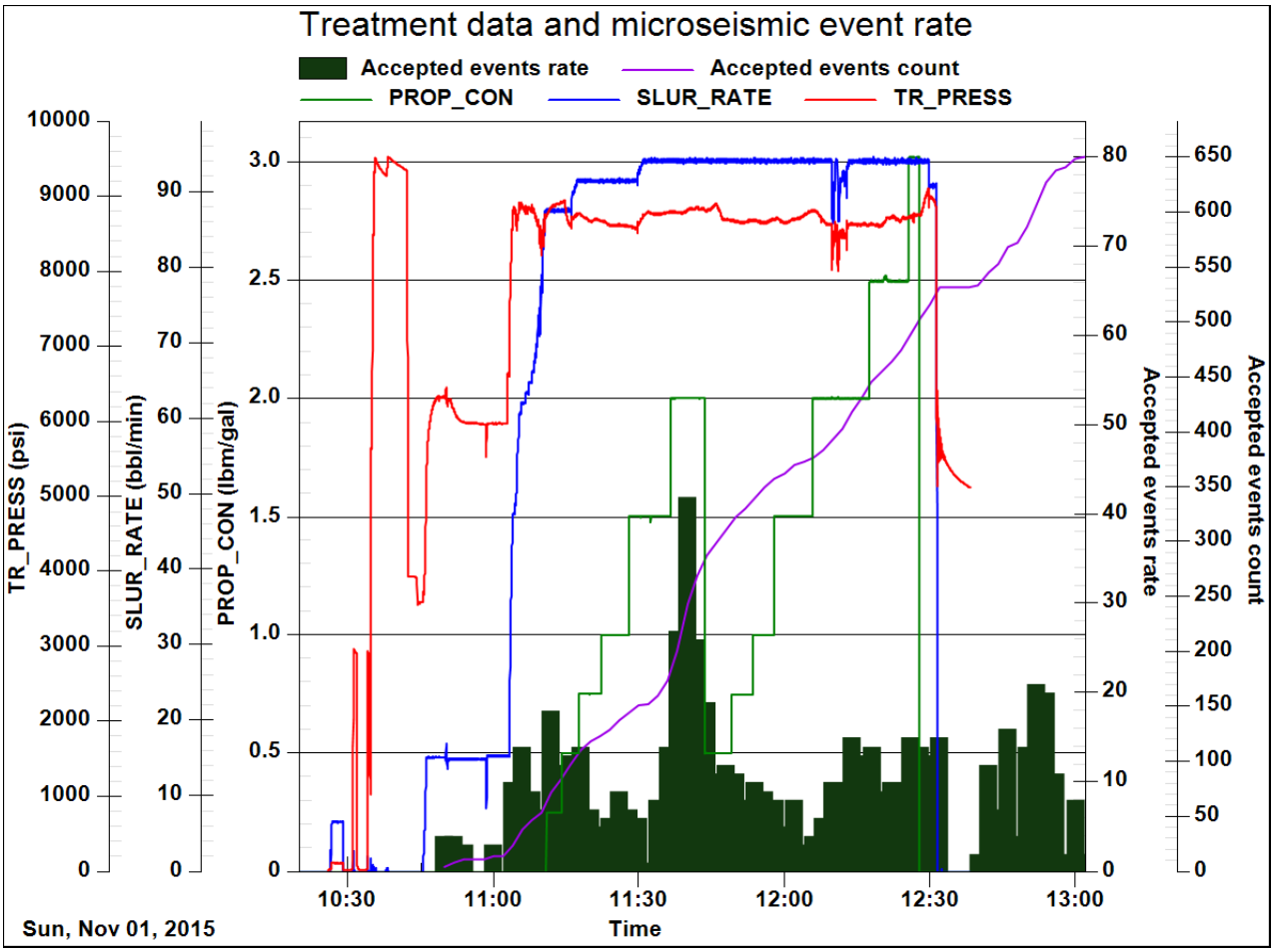



**Figure 5-175 - MIP 5H Stage 14 treatment data and microseismic event rate**

**Table 5.106 - MIP 5H Stage 14 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 324276 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 1448 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 325724 |
| 100 Mesh (lbm) | 140000 | 139480 |
| 40/70 White (lbm) | 260000 | 260620 |
| Total proppants (lbm) | 400000 | 400100 |

**Table 5.107 - MIP 5H Stage 14 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 92.7 |
| Average pressure (psi) | 8702 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5820 |
| Maximum PPA (lbm/gal) | 3.02 |

**Table 5.108 - MIP 5H Stage 14 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 60 |
| MS length (ft) | 1488 |
| MS height (ft) | 588 |
| MS volume (million ft3) | 85.3 |

The microseismic data from MIP 5H Stage 14 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

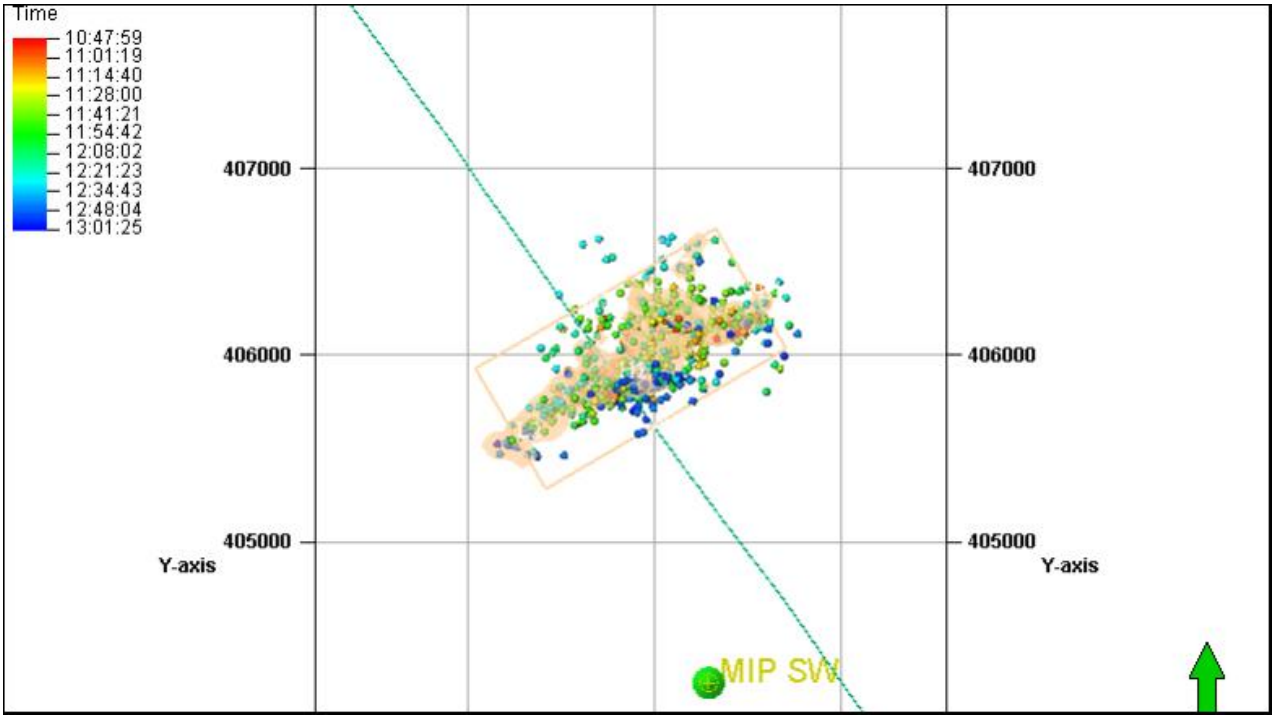



**Figure 5-176 - MIP 5H Stage 14 map view (length and width)**

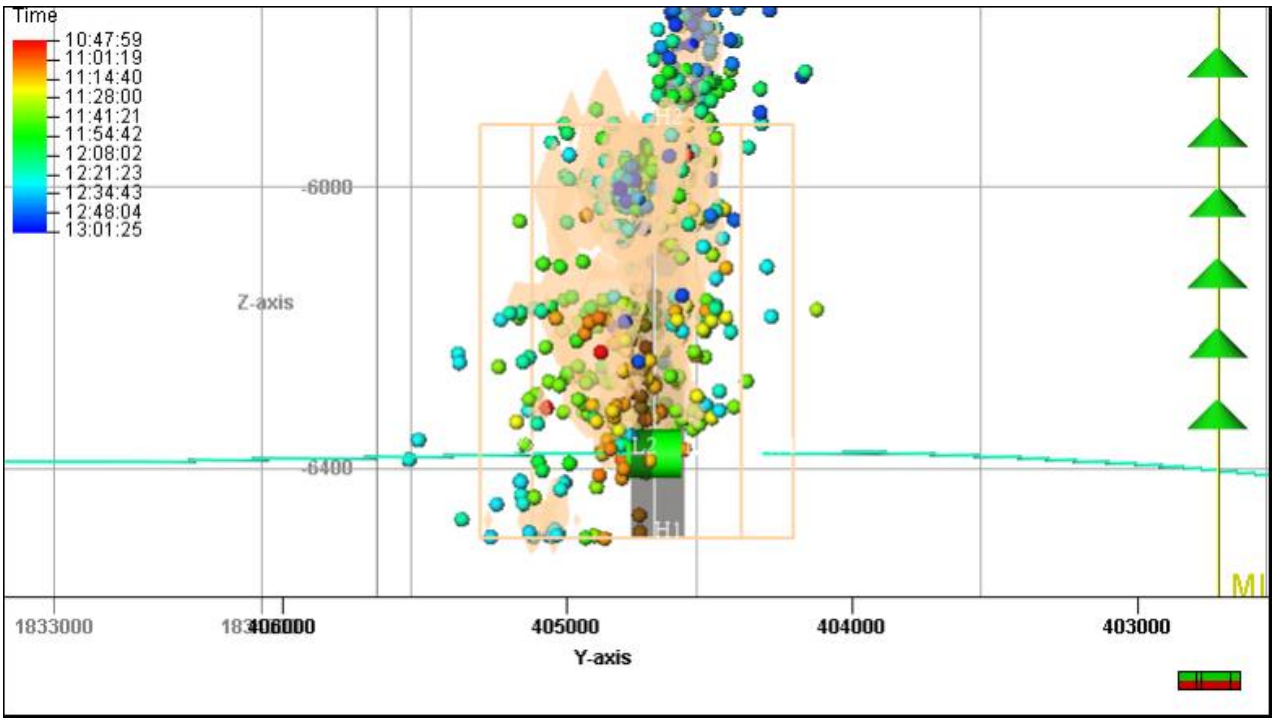



**Figure 5-177 - MIP 5H Stage 14 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 14 are shown below in map and transverse views.

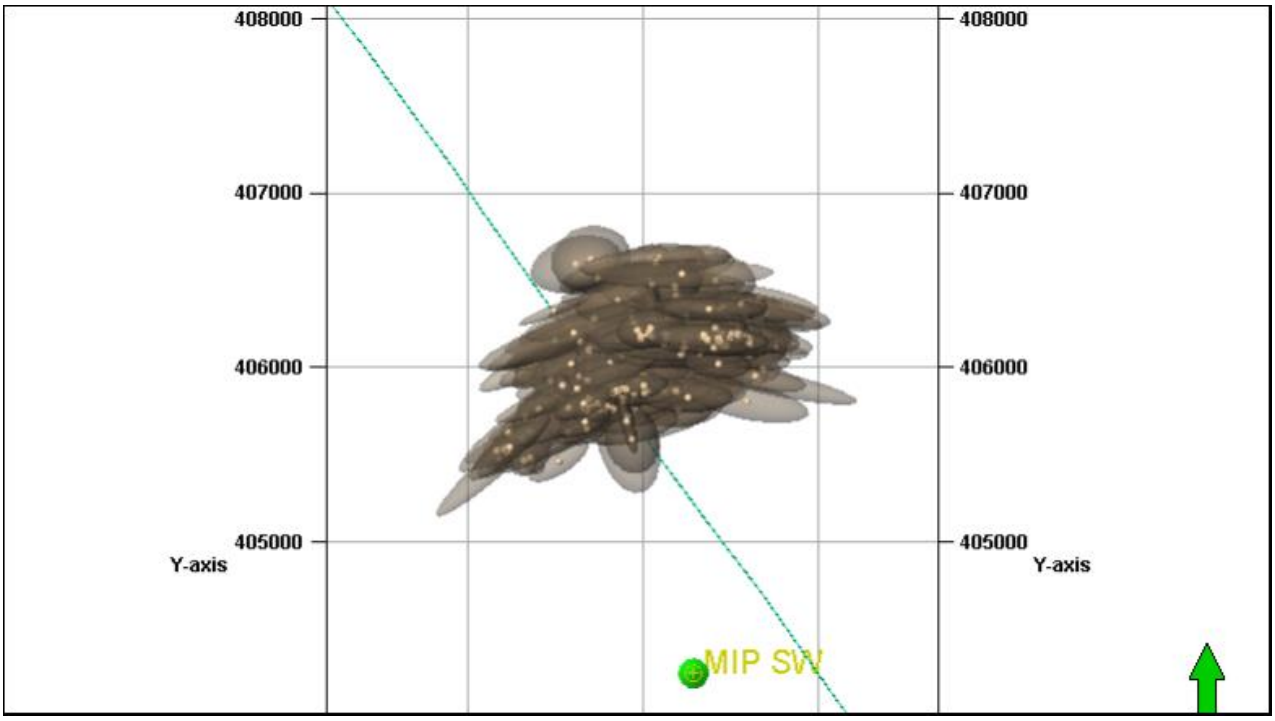



**Figure 5-178 - MIP 5H Stage 14 event location uncertainty ellipsoids – map view**

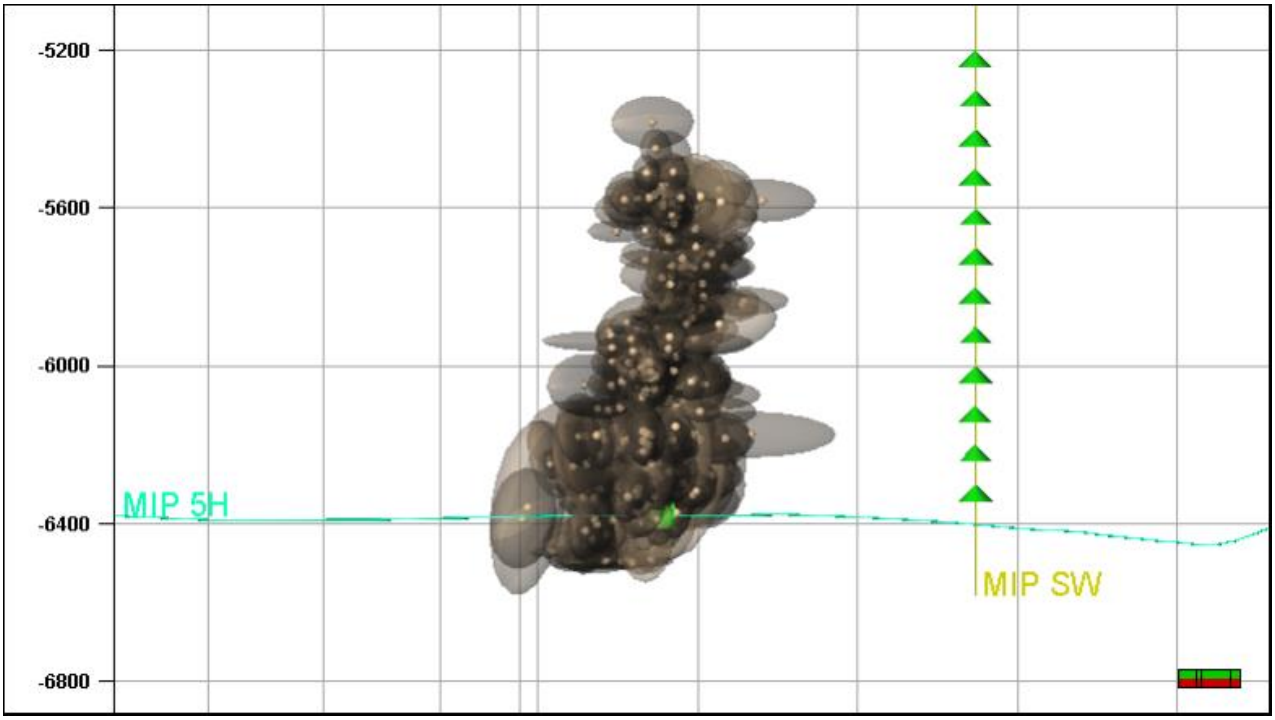



**Figure 5-179 - MIP 5H Stage 14 event location uncertainty ellipsoids – side view**

### 5.36.1 MIP 5H Stage 14 On-Site Notes and Observations

## 5.37 MIP 5H Stage 15

The MIP 5H Stage 15 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

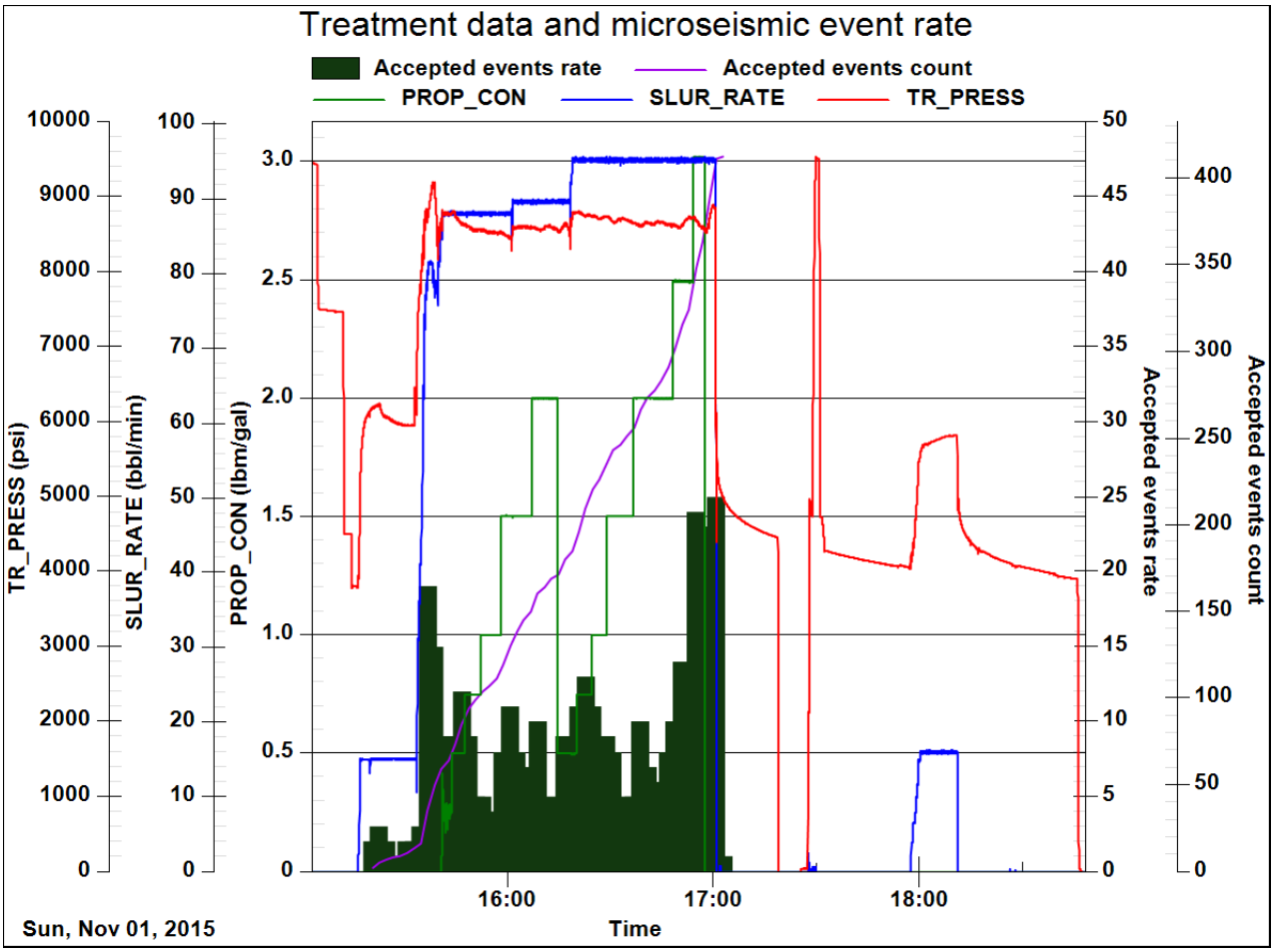



**Figure 5-180 - MIP 5H Stage 15 treatment data and microseismic event rate**

**Table 5.109 - MIP 5H Stage 15 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 319709 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 2607 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 322316 |
| 100 Mesh (lbm) | 140000 | 140060 |
| 40/70 White (lbm) | 260000 | 263100 |
| Total proppants (lbm) | 400000 | 403160 |

**Table 5.110 - MIP 5H Stage 15 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 93.7 |
| Average pressure (psi) | 8648 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5403 |
| Maximum PPA (lbm/gal) | 3.02 |

**Table 5.111 - MIP 5H Stage 15 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 59 |
| MS length (ft) | 1660 |
| MS height (ft) | 480 |
| MS volume (million ft3) | 24.7 |

The microseismic data from MIP 5H Stage 15 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

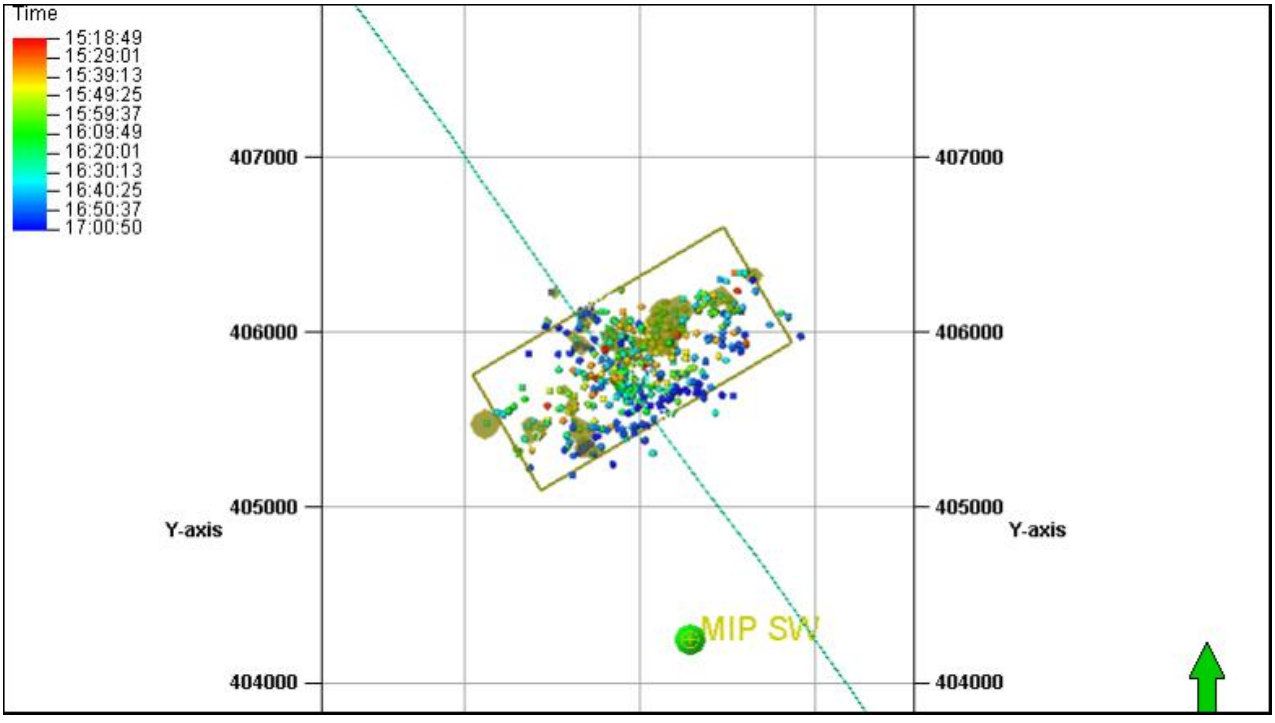



**Figure 5-181 - MIP 5H Stage 15 map view (length and width)**

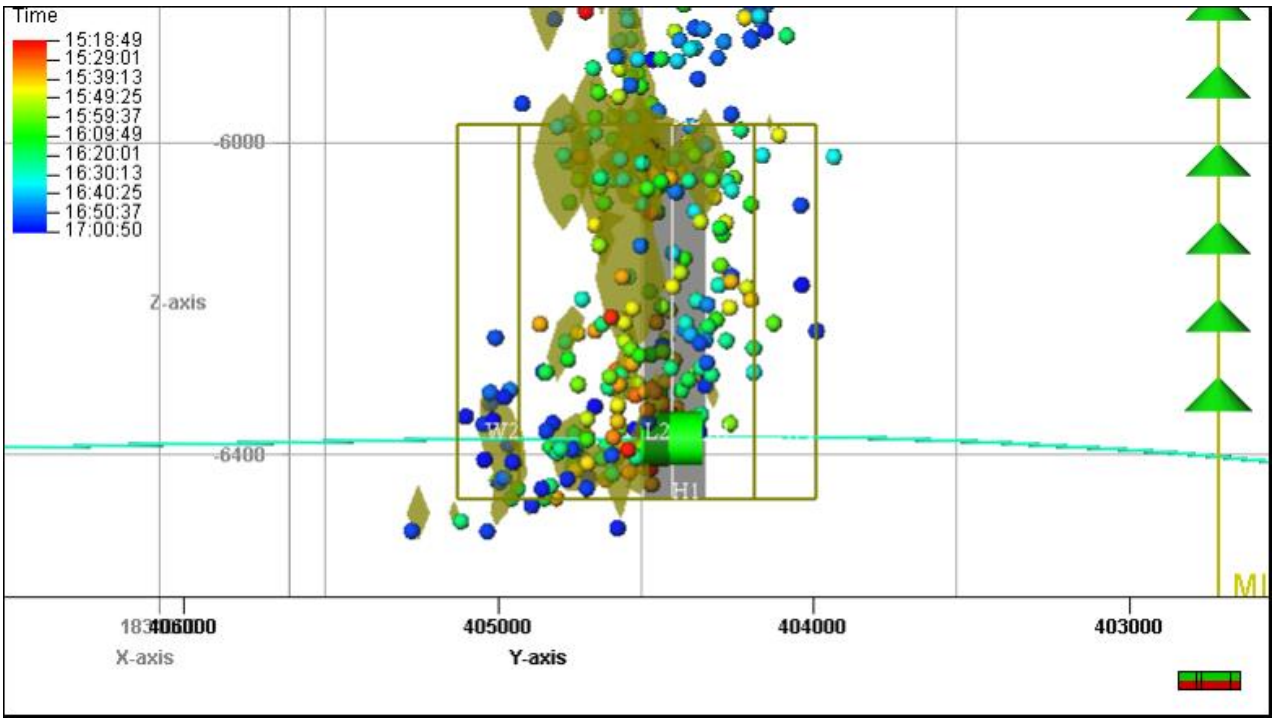



**Figure 5-182 - MIP 5H Stage 15 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 15 are shown below in map and transverse views.

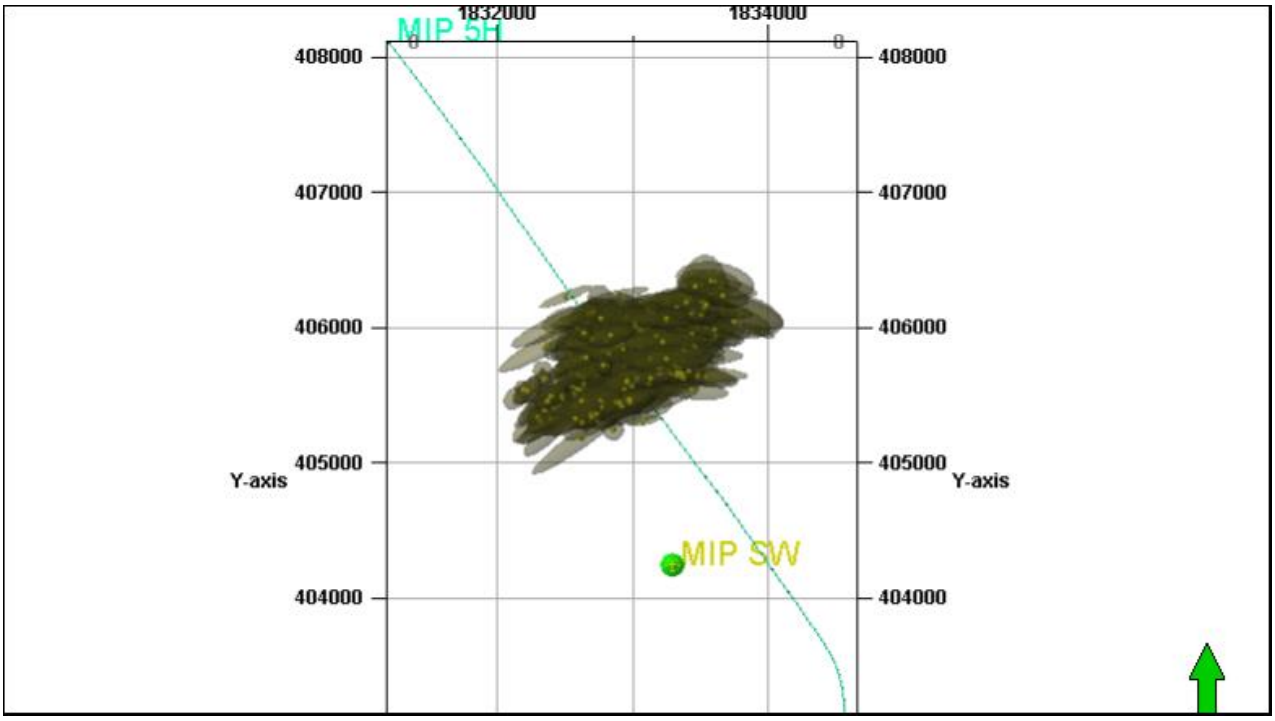



**Figure 5-183 - MIP 5H Stage 15 event location uncertainty ellipsoids – map view**

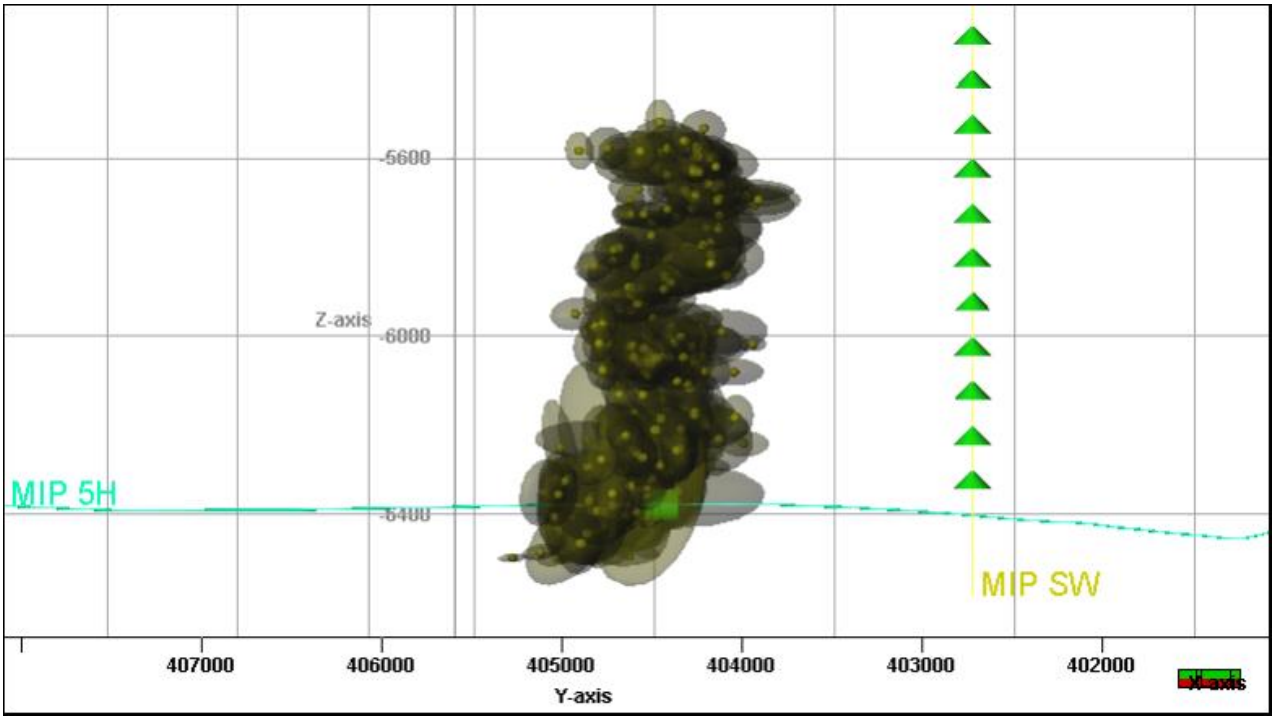



**Figure 5-184 - MIP 5H Stage 15 event location uncertainty ellipsoids – side view**

### 5.37.1 MIP 5H Stage 15 On-Site Notes and Observations

## 5.38 MIP 5H Stage 16

The MIP 5H Stage 16 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

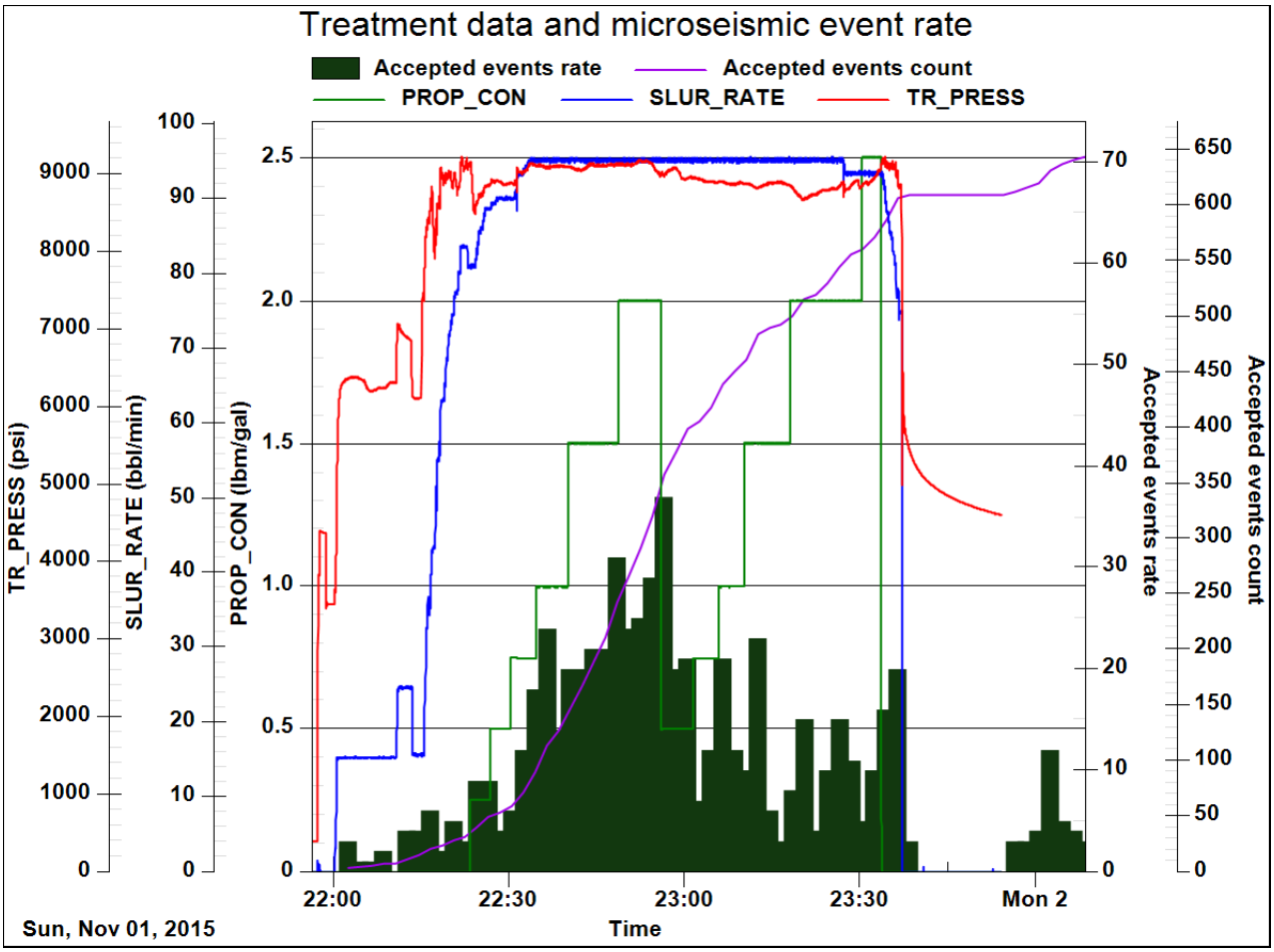



**Figure 5-185 - MIP 5H Stage 16 treatment data and microseismic event rate**

**Table 5.112 - MIP 5H Stage 16 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 303131 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 306131 |
| 100 Mesh (lbm) | 140000 | 140660 |
| 40/70 White (lbm) | 260000 | 206440 |
| Total proppants (lbm) | 400000 | 347100 |

**Table 5.113 - MIP 5H Stage 16 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 89.6 |
| Average pressure (psi) | 8861 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5983 |
| Maximum PPA (lbm/gal) | 2.504 |

**Table 5.114 - MIP 5H Stage 16 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 61 |
| MS length (ft) | 1354 |
| MS height (ft) | 521 |
| MS volume (million ft3) | 60.4 |

The microseismic data from MIP 5H Stage 16 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

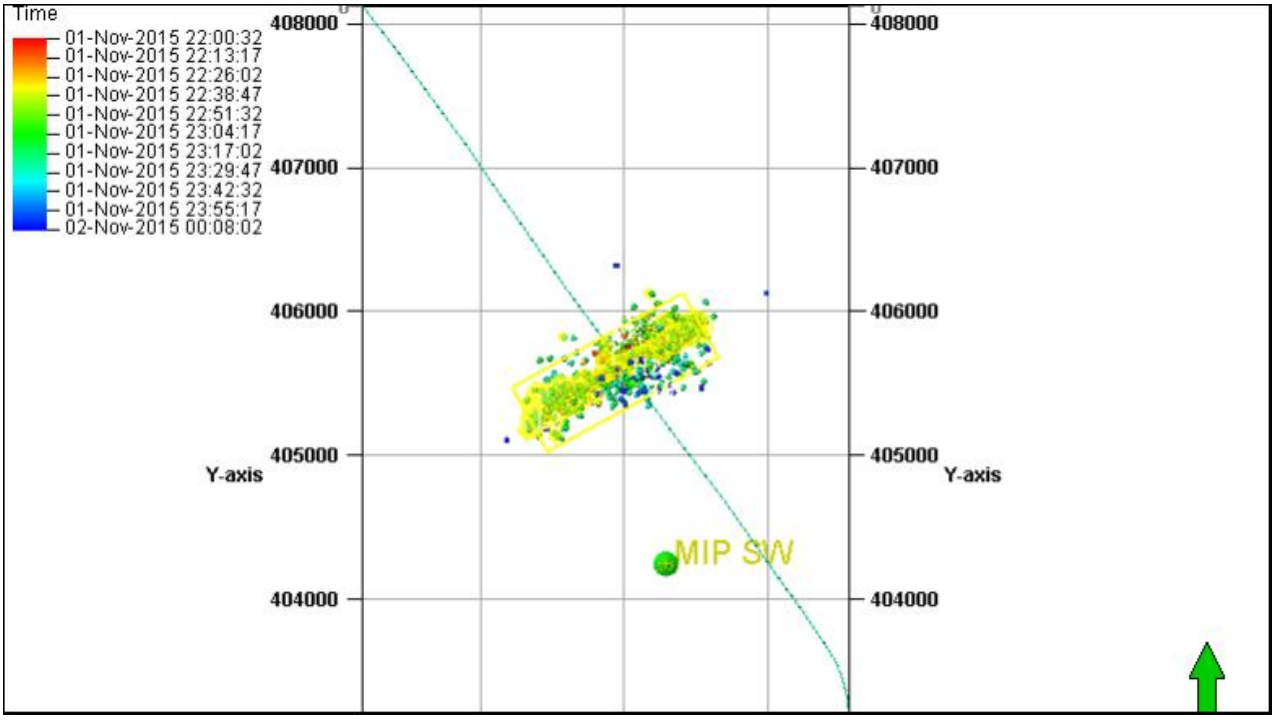



**Figure 5-186 - MIP 5H Stage 16 map view (length and width)**

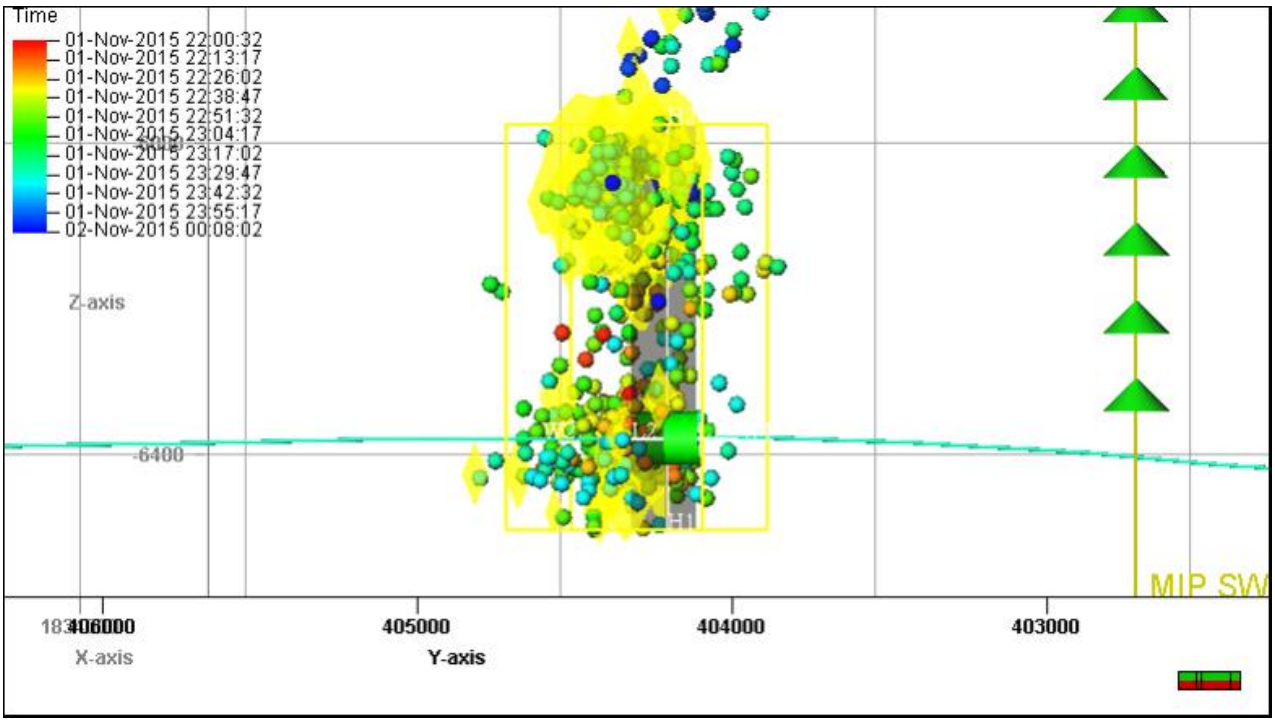



**Figure 5-187 - MIP 5H Stage 16 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 16 are shown below in map and transverse views.

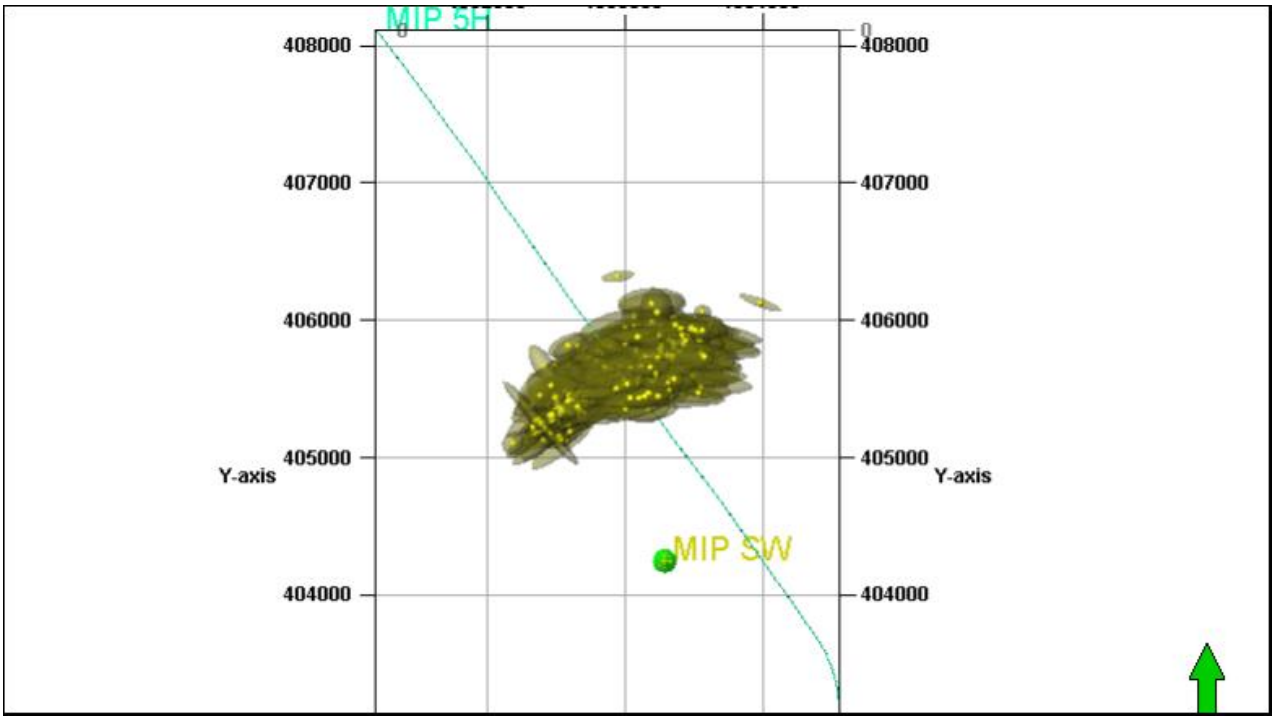



**Figure 5-188 - MIP 5H Stage 16 event location uncertainty ellipsoids – map view**

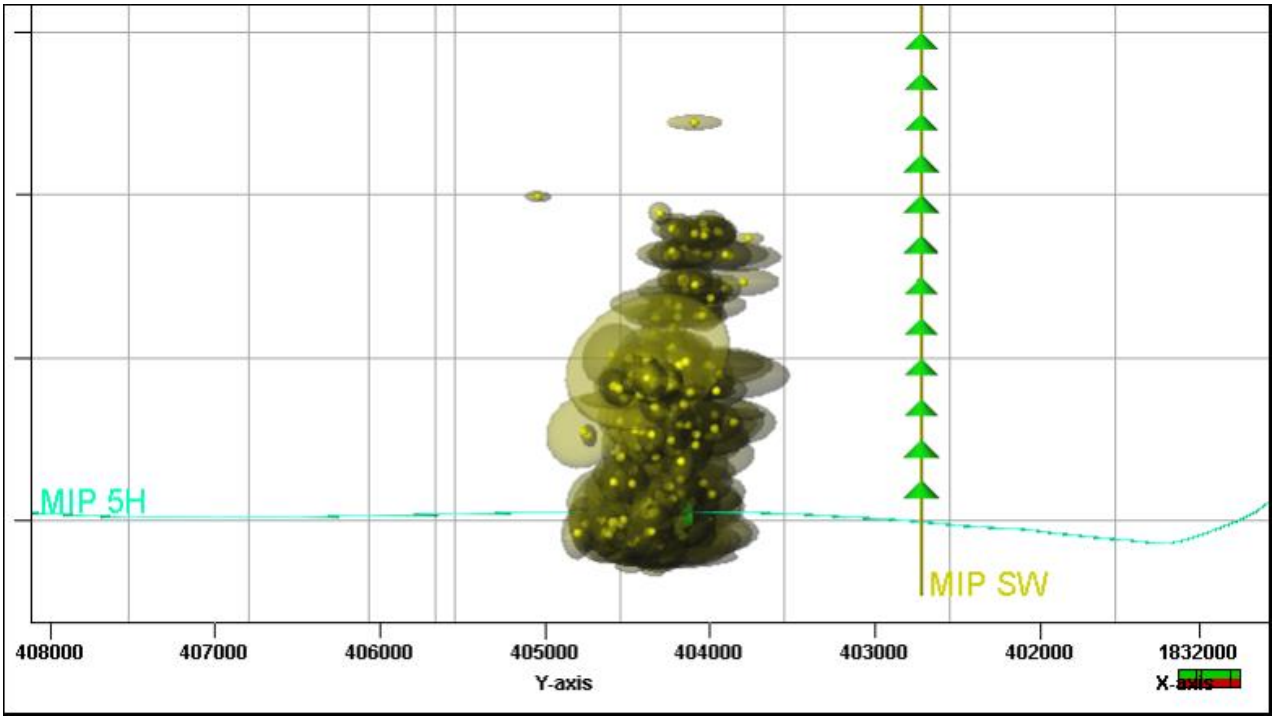



**Figure 5-189 - MIP 5H Stage 16 event location uncertainty ellipsoids – side view**

### 5.38.1 MIP 5H Stage 16 On-Site Notes and Observations

## 5.39 MIP 5H Stage 17

The MIP 5H Stage 17 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

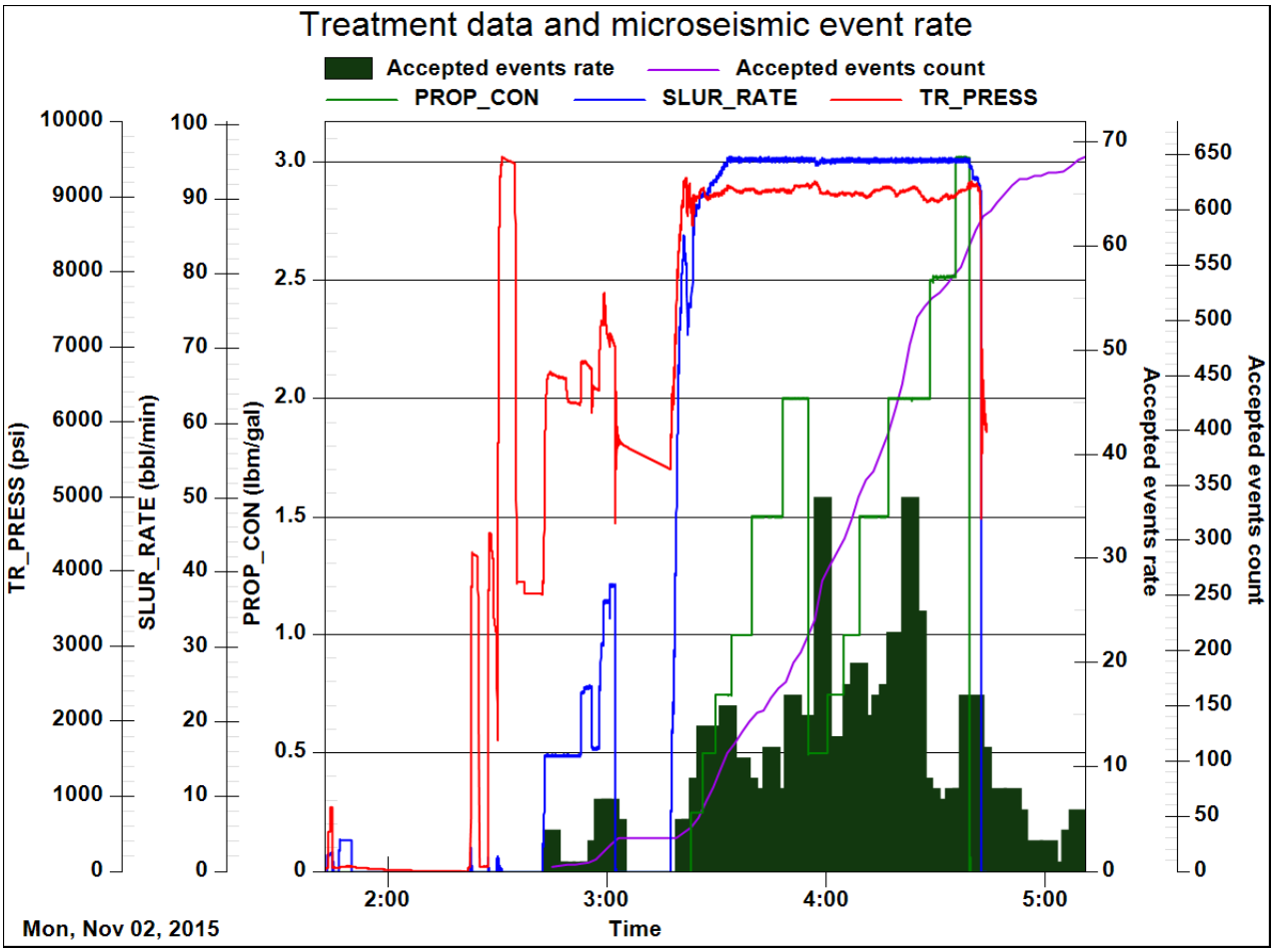



**Figure 5-190 - MIP 5H Stage 17 treatment data and microseismic event rate**

**Table 5.115 - MIP 5H Stage 17 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 325540 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 328540 |
| 100 Mesh (lbm) | 140000 | 138320 |
| 40/70 White (lbm) | 260000 | 262220 |
| Total proppants (lbm) | 400000 | 400540 |

**Table 5.116 - MIP 5H Stage 17 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 90 |
| Average pressure (psi) | 8927 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6465 |
| Maximum PPA (lbm/gal) | 3.022 |

**Table 5.117 - MIP 5H Stage 17 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 57 |
| MS length (ft) | 1155 |
| MS height (ft) | 464 |
| MS volume (million ft3) | 48.4 |

The microseismic data from MIP 5H Stage 17 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

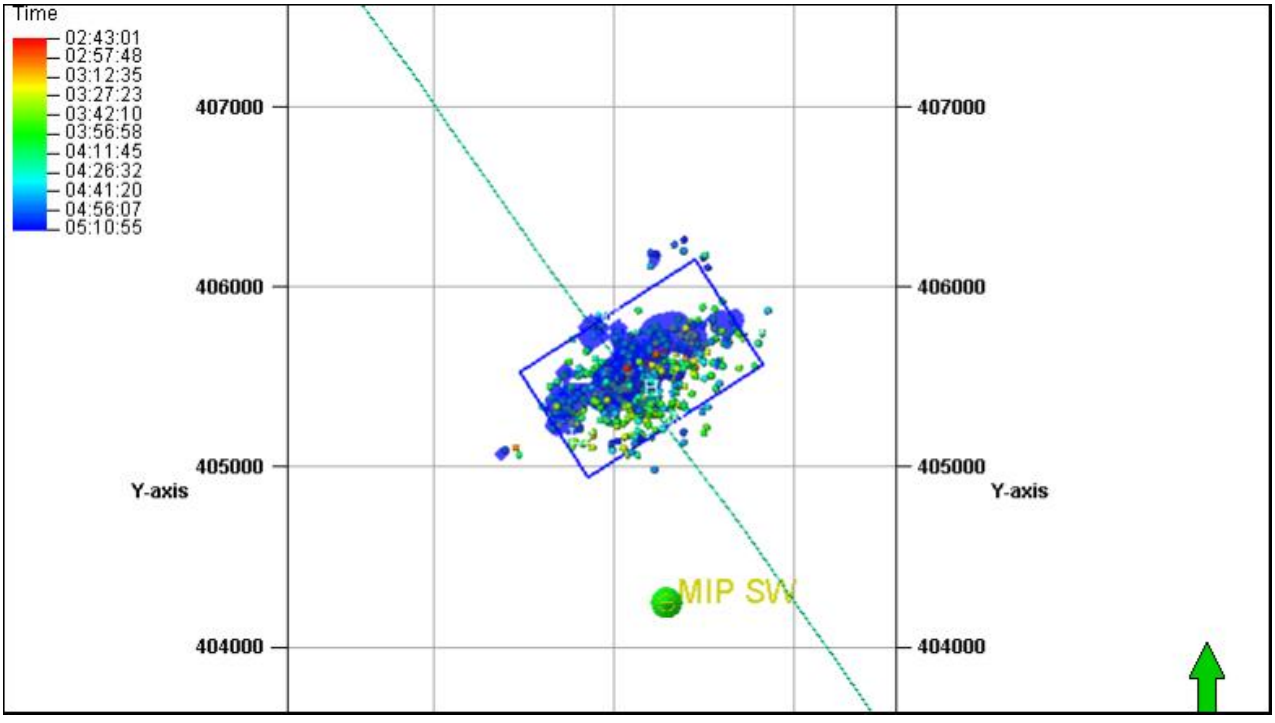



**Figure 5-191 - MIP 5H Stage 17 map view (length and width)**

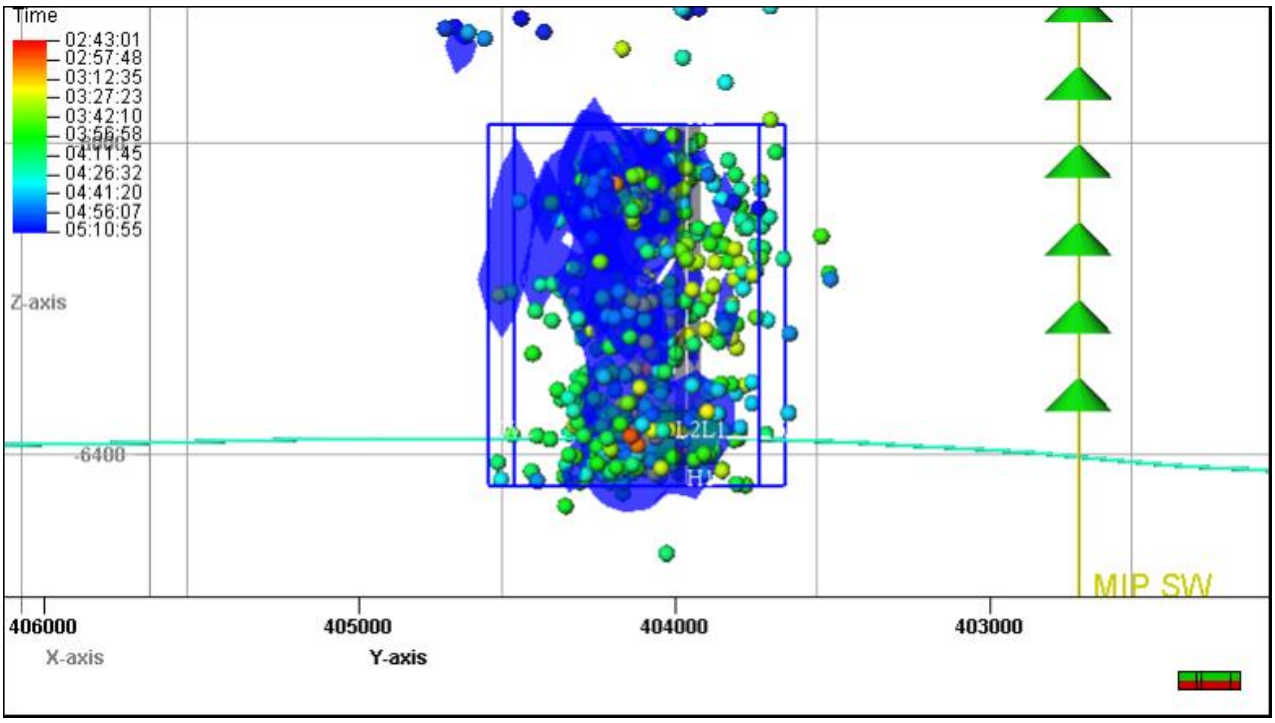



**Figure 5-192 - MIP 5H Stage 17 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 17 are shown below in map and transverse views.

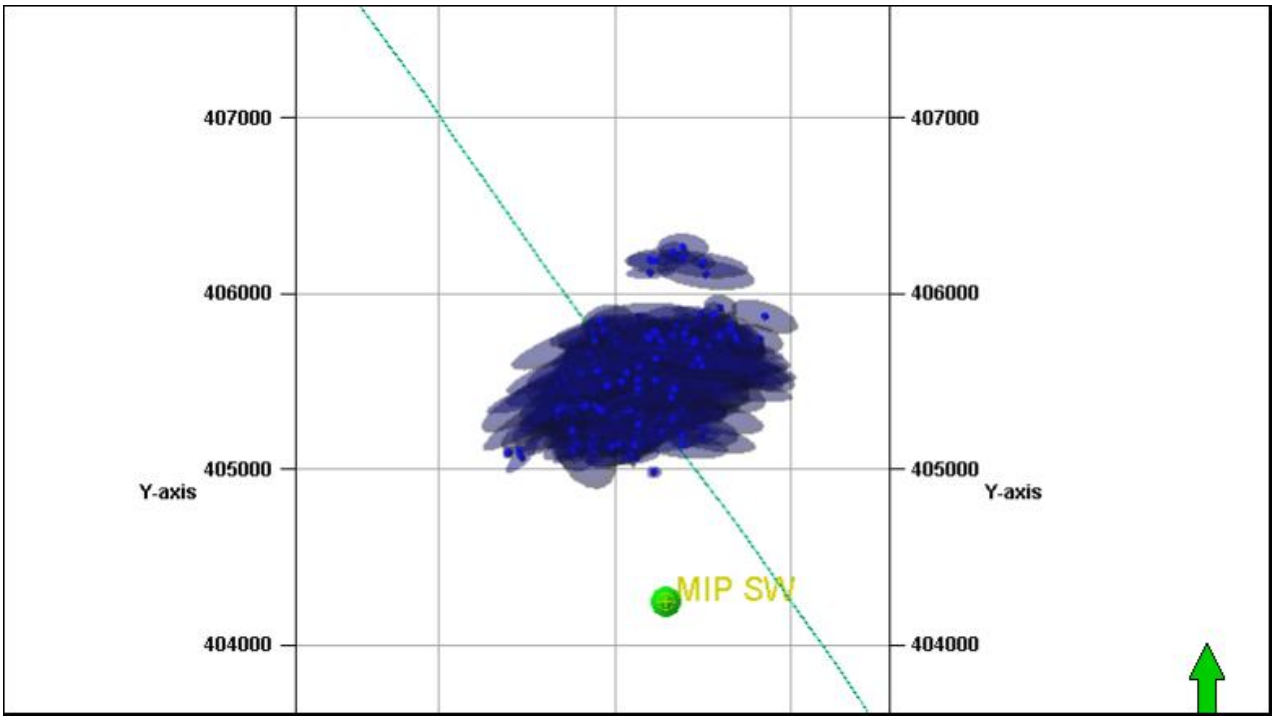



**Figure 5-193 - MIP 5H Stage 17 event location uncertainty ellipsoids – map view**

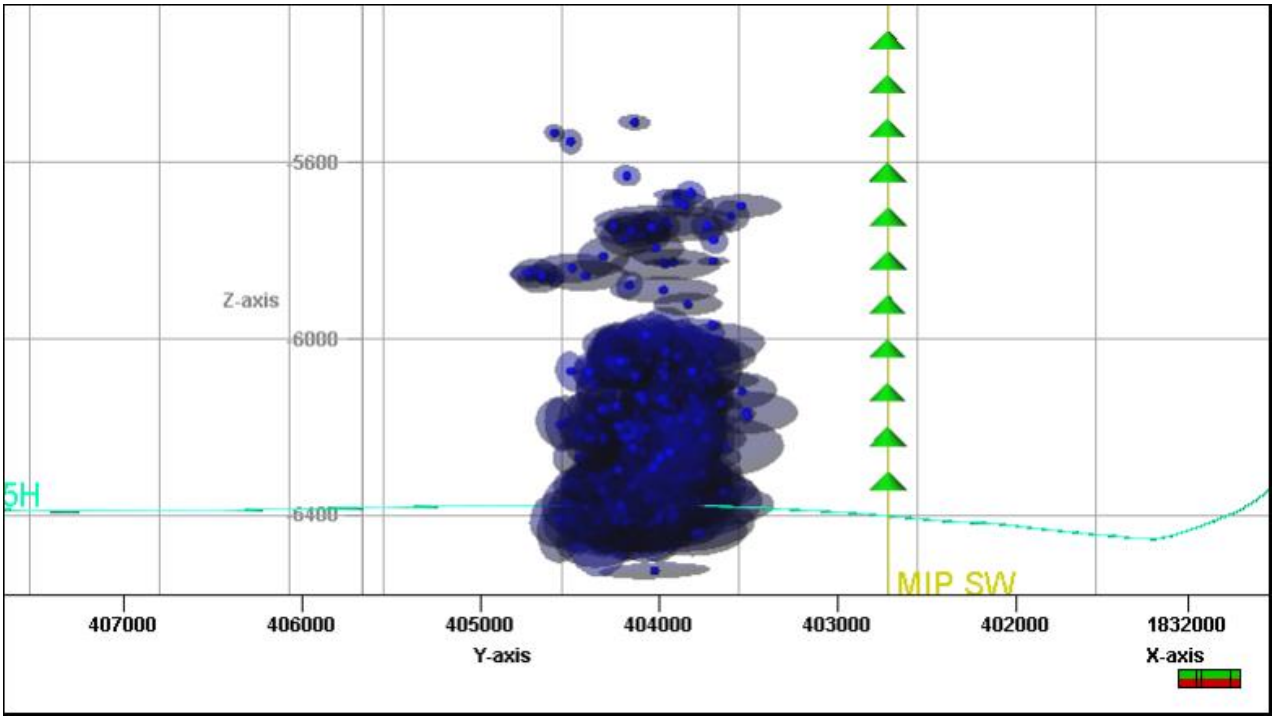



**Figure 5-194 - MIP 5H Stage 17 event location uncertainty ellipsoids – side view**

### 5.39.1 MIP 5H Stage 17 On-Site Notes and Observations

## 5.40 MIP 5H Stage 18

The MIP 5H Stage 18 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

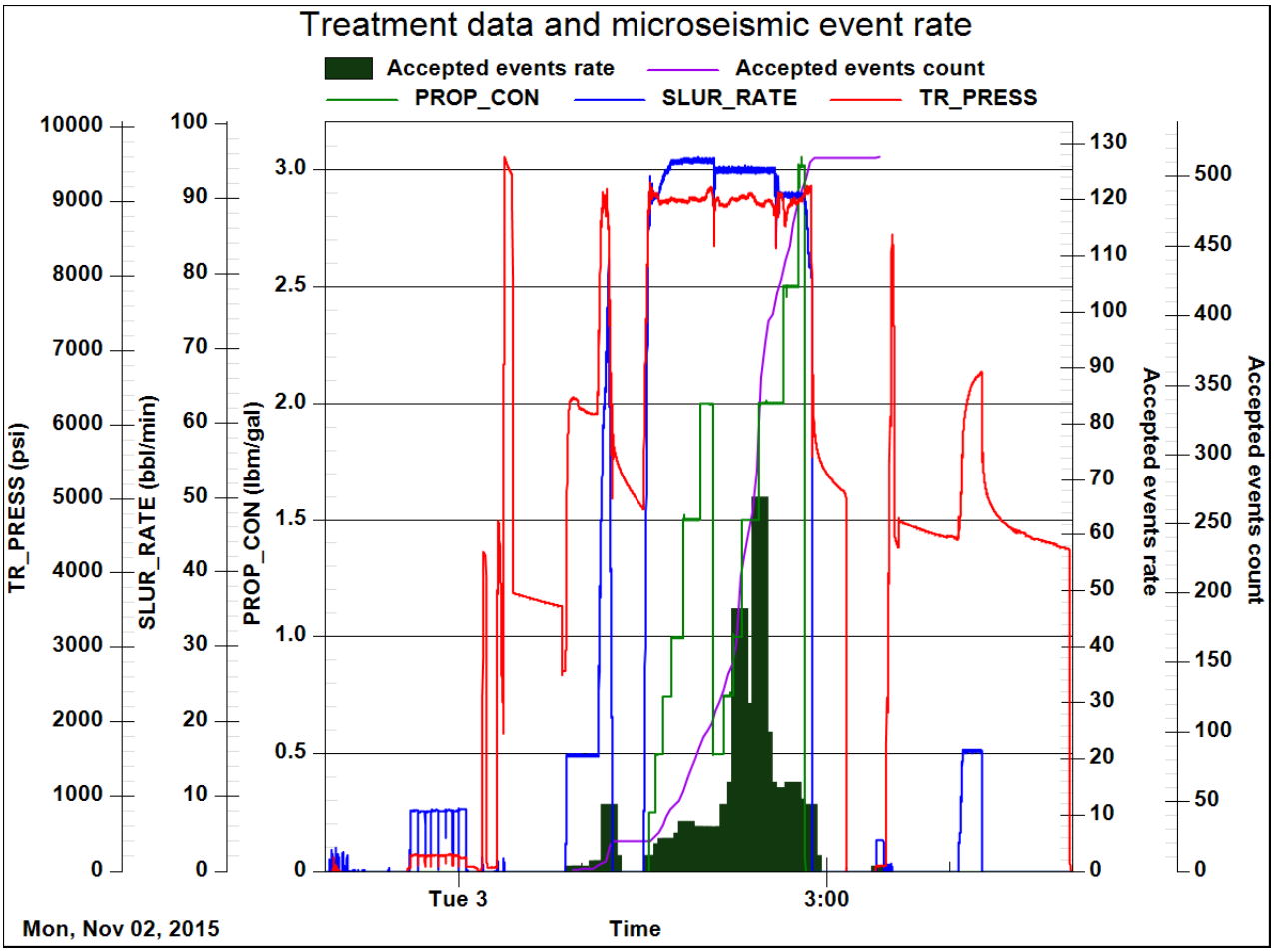



**Figure 5-195 - MIP 5H Stage 18 treatment data and microseismic event rate**

**Table 5.118 - MIP 5H Stage 18 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 319959 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 322959 |
| 100 Mesh (lbm) | 140000 | 137440 |
| 40/70 White (lbm) | 260000 | 259740 |
| Total proppants (lbm) | 400000 | 397180 |

**Table 5.119 - MIP 5H Stage 18 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 88.7 |
| Average pressure (psi) | 8892 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6814 |
| Maximum PPA (lbm/gal) | 3.052 |

**Table 5.120 - MIP 5H Stage 18 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 70 |
| MS length (ft) | 1210 |
| MS height (ft) | 491 |
| MS volume (million ft3) | 37.1 |

The microseismic data from MIP 5H Stage 18 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

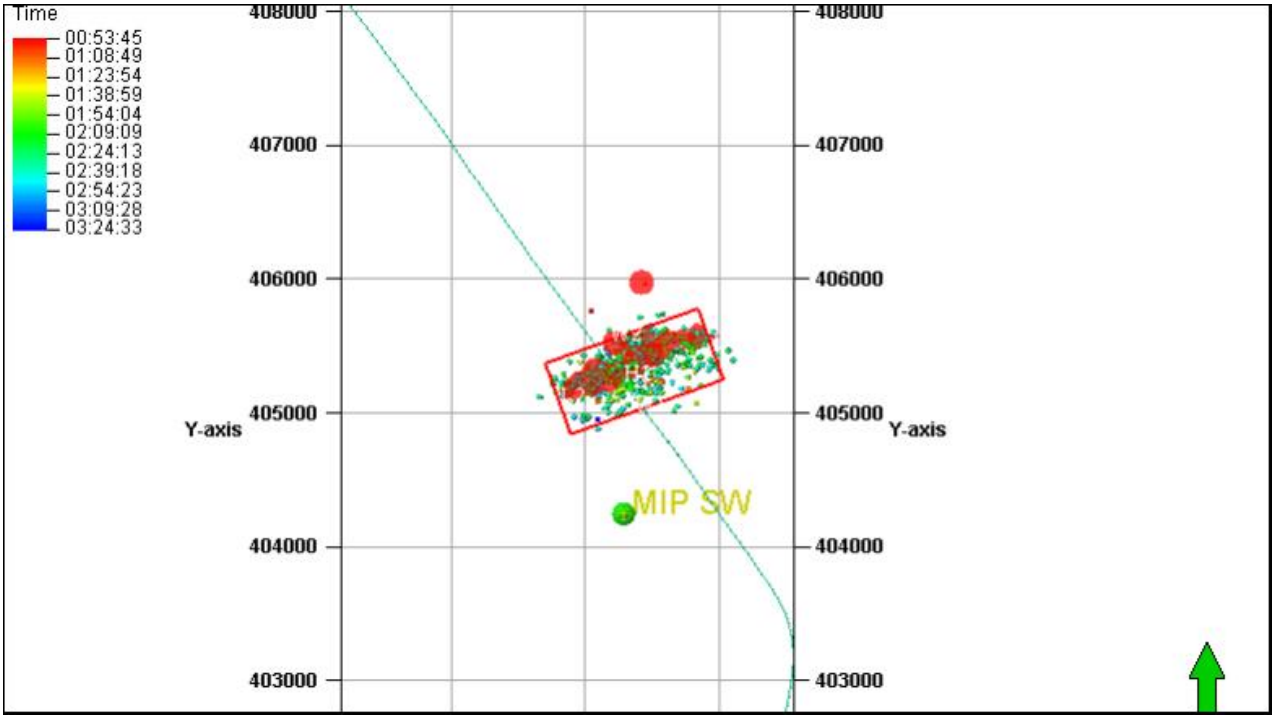



**Figure 5-196 - MIP 5H Stage 18 map view (length and width)**

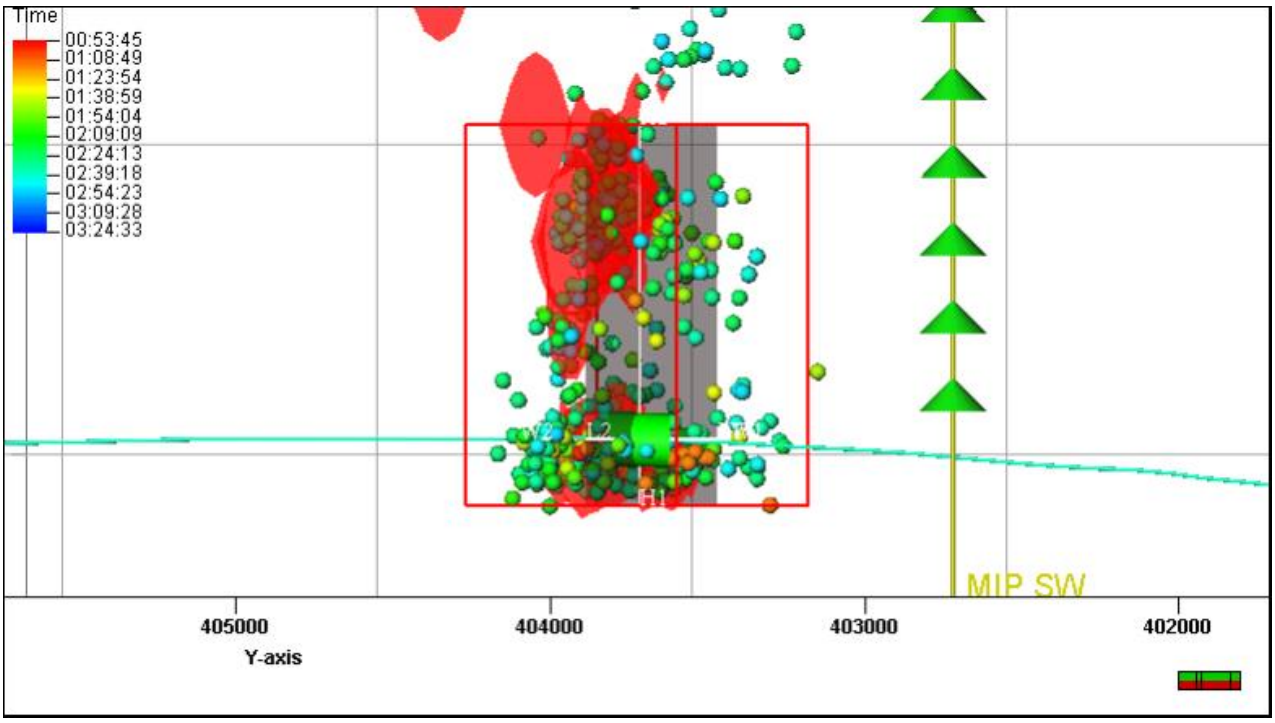



**Figure 5-197 - MIP 5H Stage 18 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 18 are shown below in map and transverse views.

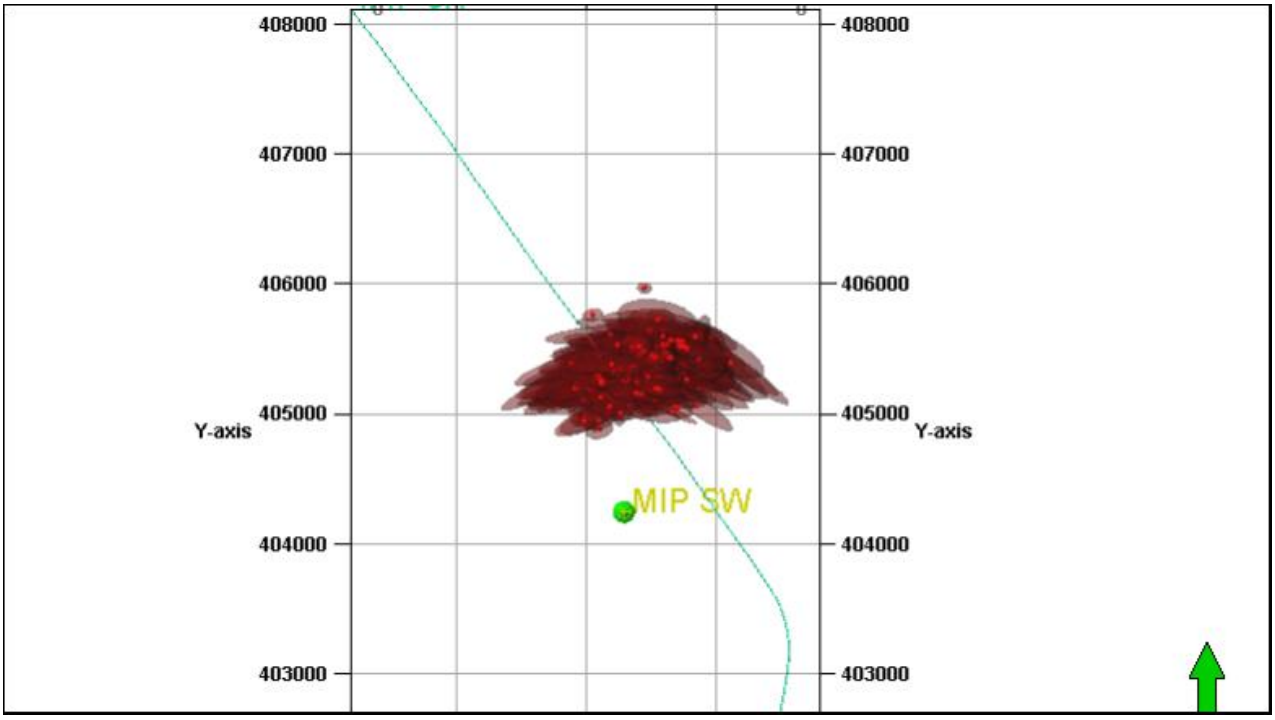



**Figure 5-198 - MIP 5H Stage 18 event location uncertainty ellipsoids – map view**

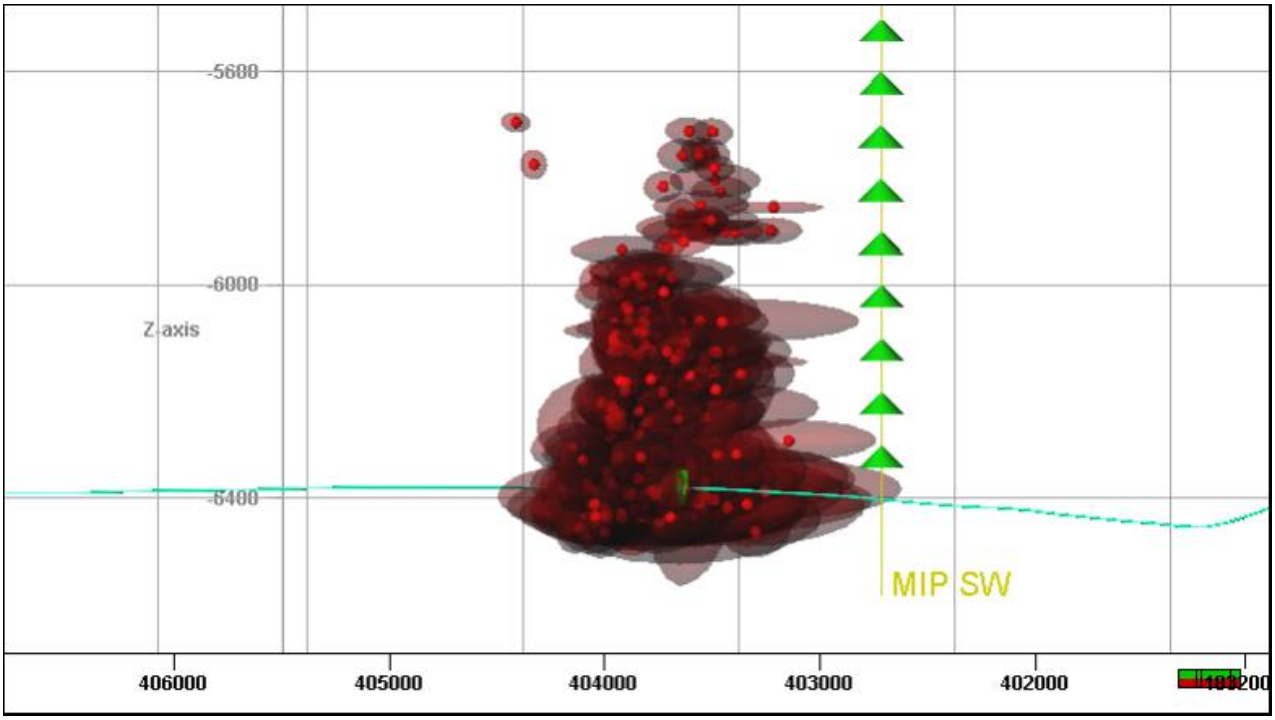



**Figure 5-199 - MIP 5H Stage 18 event location uncertainty ellipsoids – side view**

### 5.40.1 MIP 5H Stage 18 On-Site Notes and Observations

## 5.41 MIP 5H Stage 19

The MIP 5H Stage 19 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

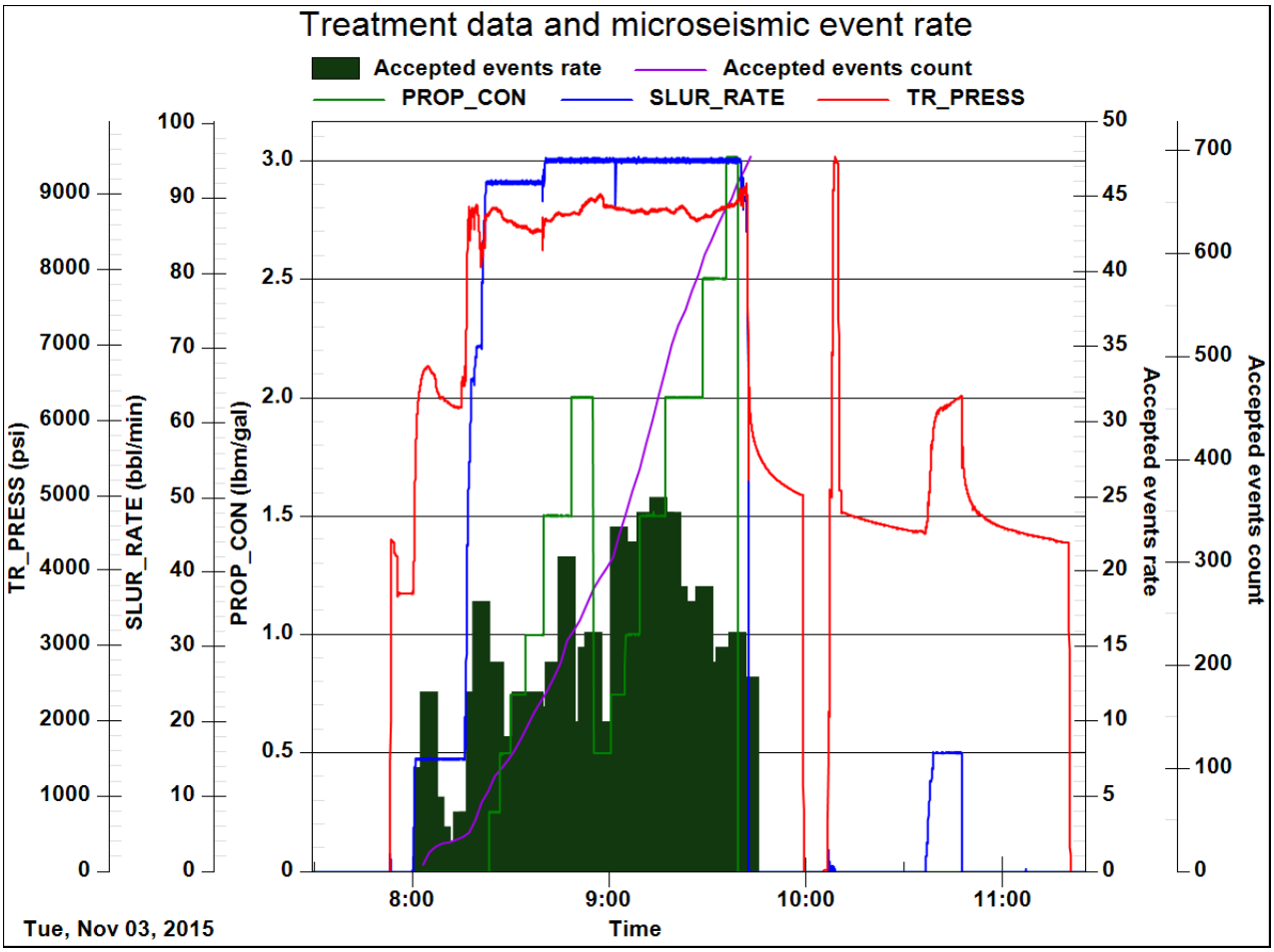



**Figure 5-200 - MIP 5H Stage 19 treatment data and microseismic event rate**

**Table 5.121 - MIP 5H Stage 19 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 322654 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 325654 |
| 100 Mesh (lbm) | 140000 | 140120 |
| 40/70 White (lbm) | 260000 | 260380 |
| Total proppants (lbm) | 400000 | 400500 |

**Table 5.122 - MIP 5H Stage 19 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 93.9 |
| Average pressure (psi) | 8782 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6219 |
| Maximum PPA (lbm/gal) | 3.016 |

**Table 5.123 - MIP 5H Stage 19 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 69 |
| MS length (ft) | 1198 |
| MS height (ft) | 391 |
| MS volume (million ft3) | 57 |

The microseismic data from MIP 5H Stage 19 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

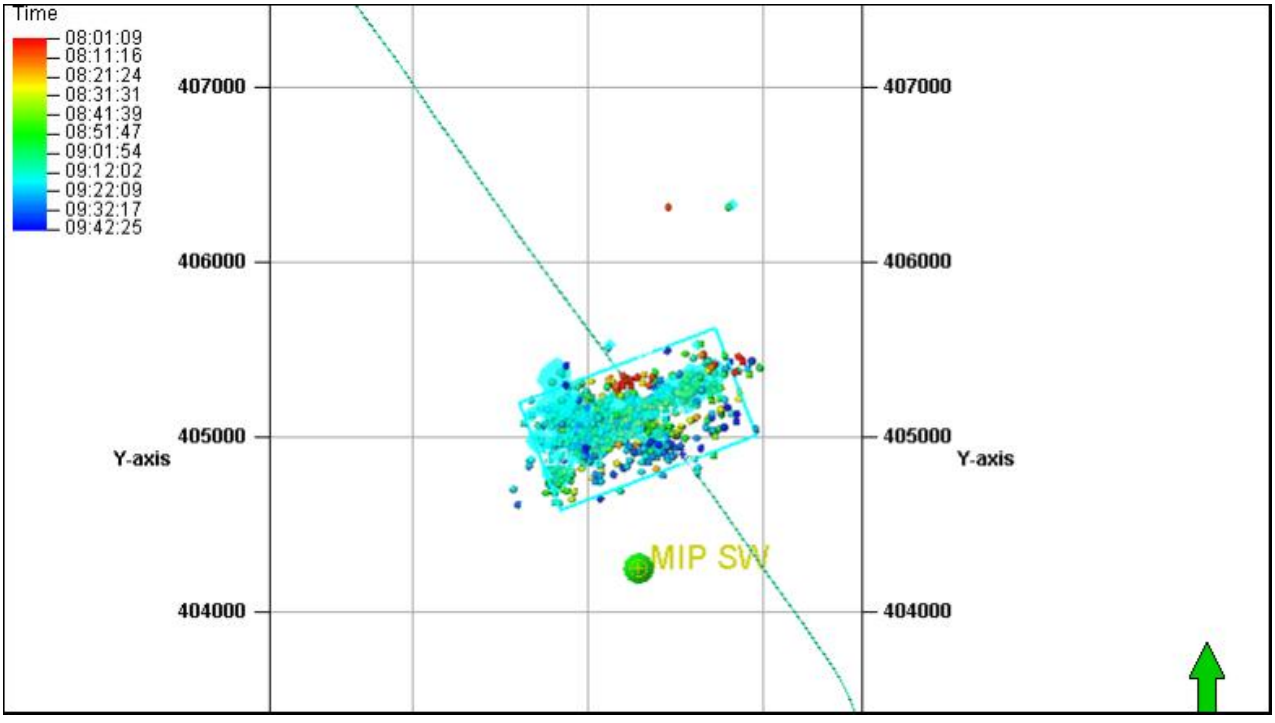



**Figure 5-201 - MIP 5H Stage 19 map view (length and width)**

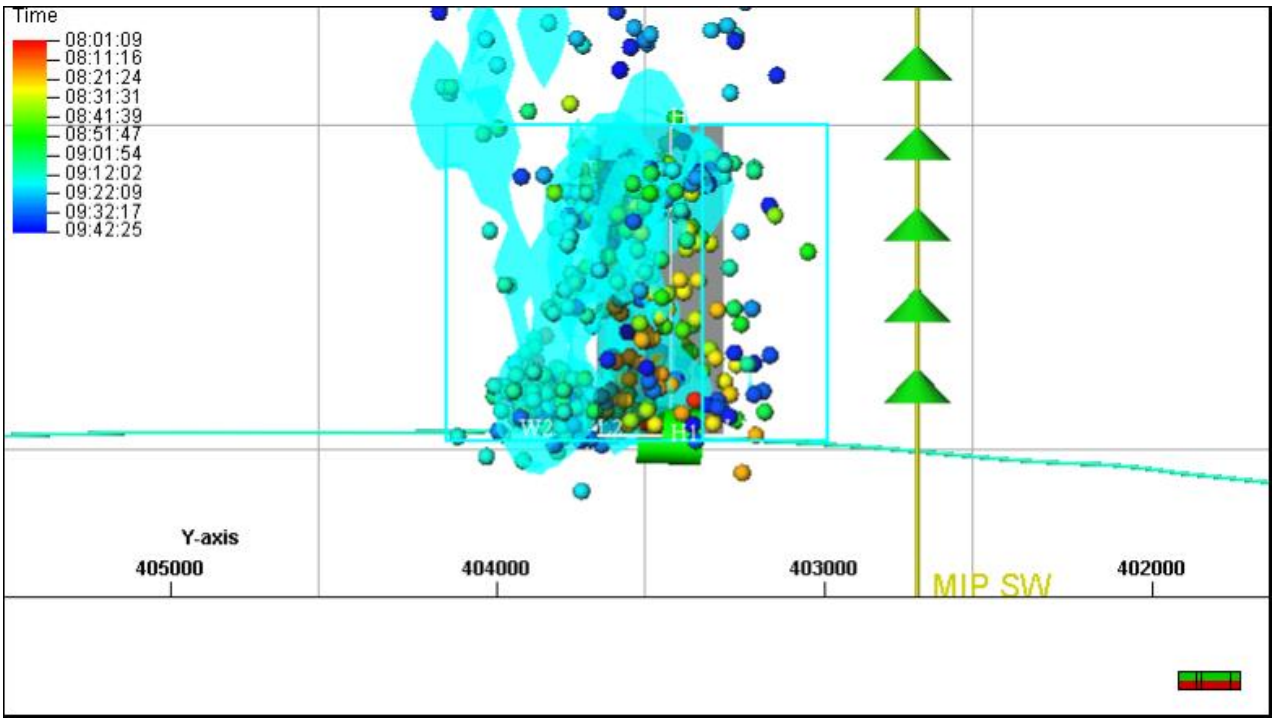



**Figure 5-202 - MIP 5H Stage 19 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 19 are shown below in map and transverse views.

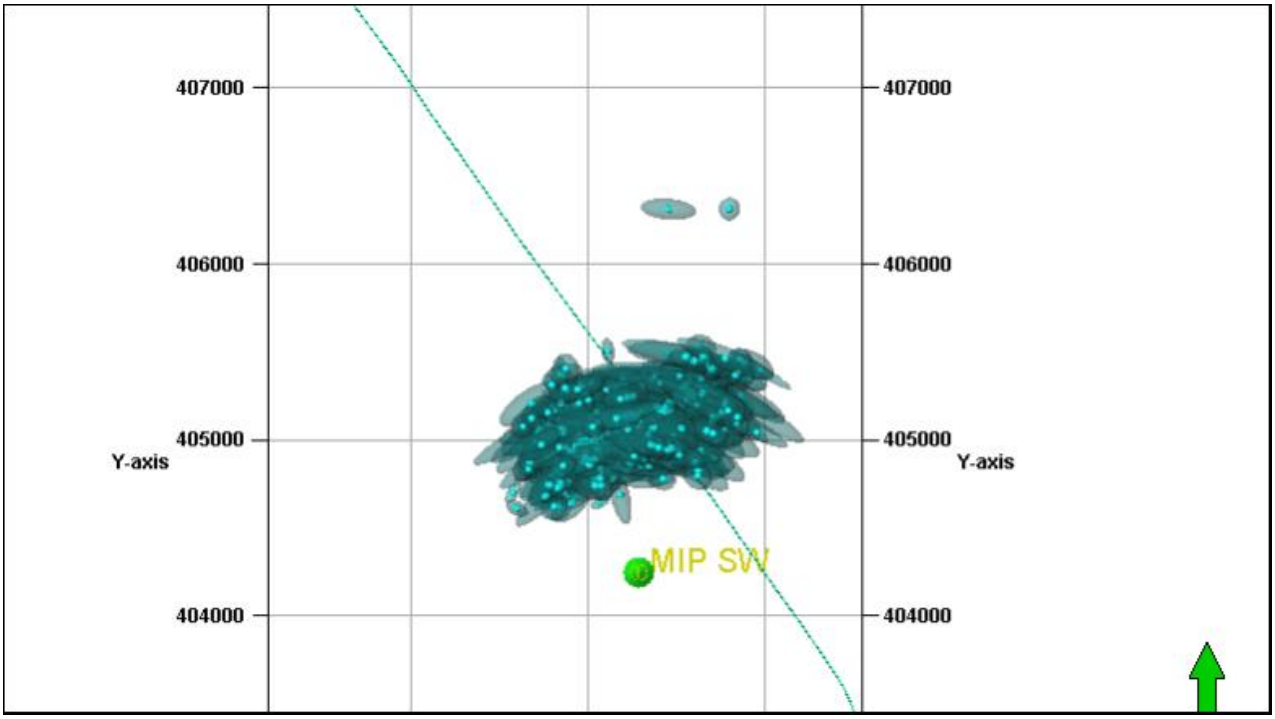



**Figure 5-203 - MIP 5H Stage 19 event location uncertainty ellipsoids – map view**

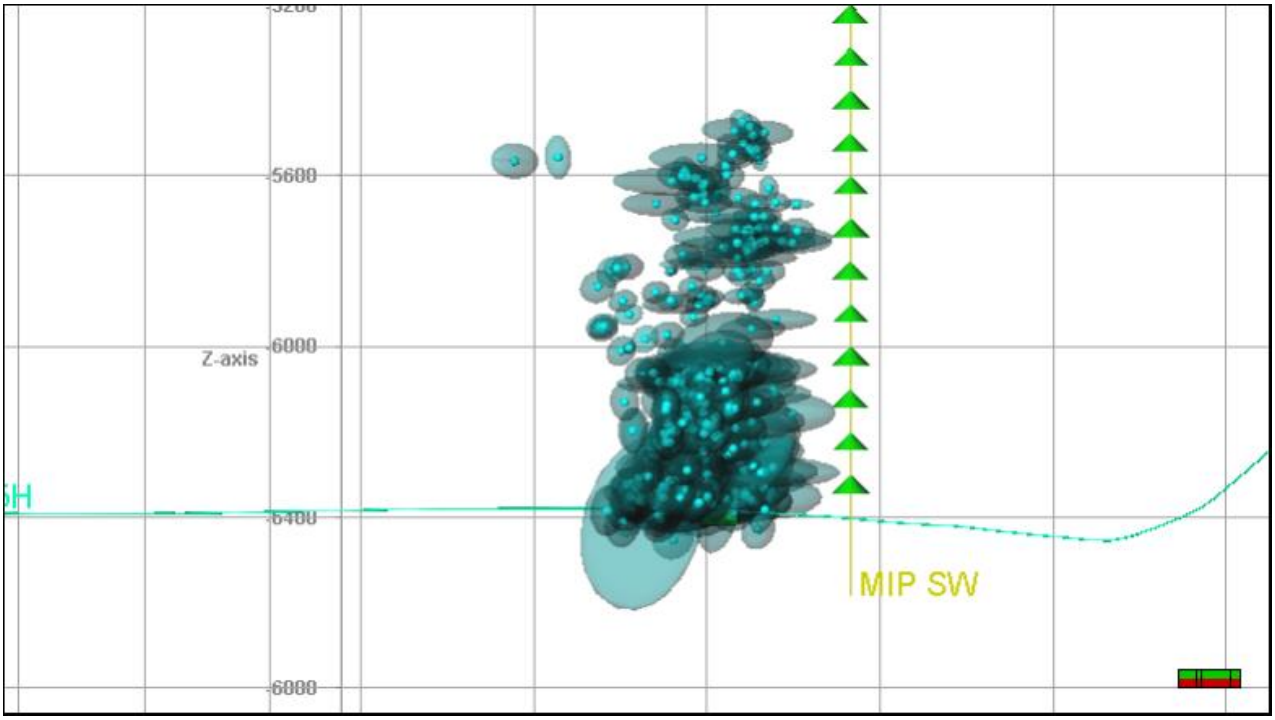



**Figure 5-204 - MIP 5H Stage 19 event location uncertainty ellipsoids – side view**

### 5.41.1 MIP 5H Stage 19 On-Site Notes and Observations

## 5.42 MIP 5H Stage 20

The MIP 5H Stage 20 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

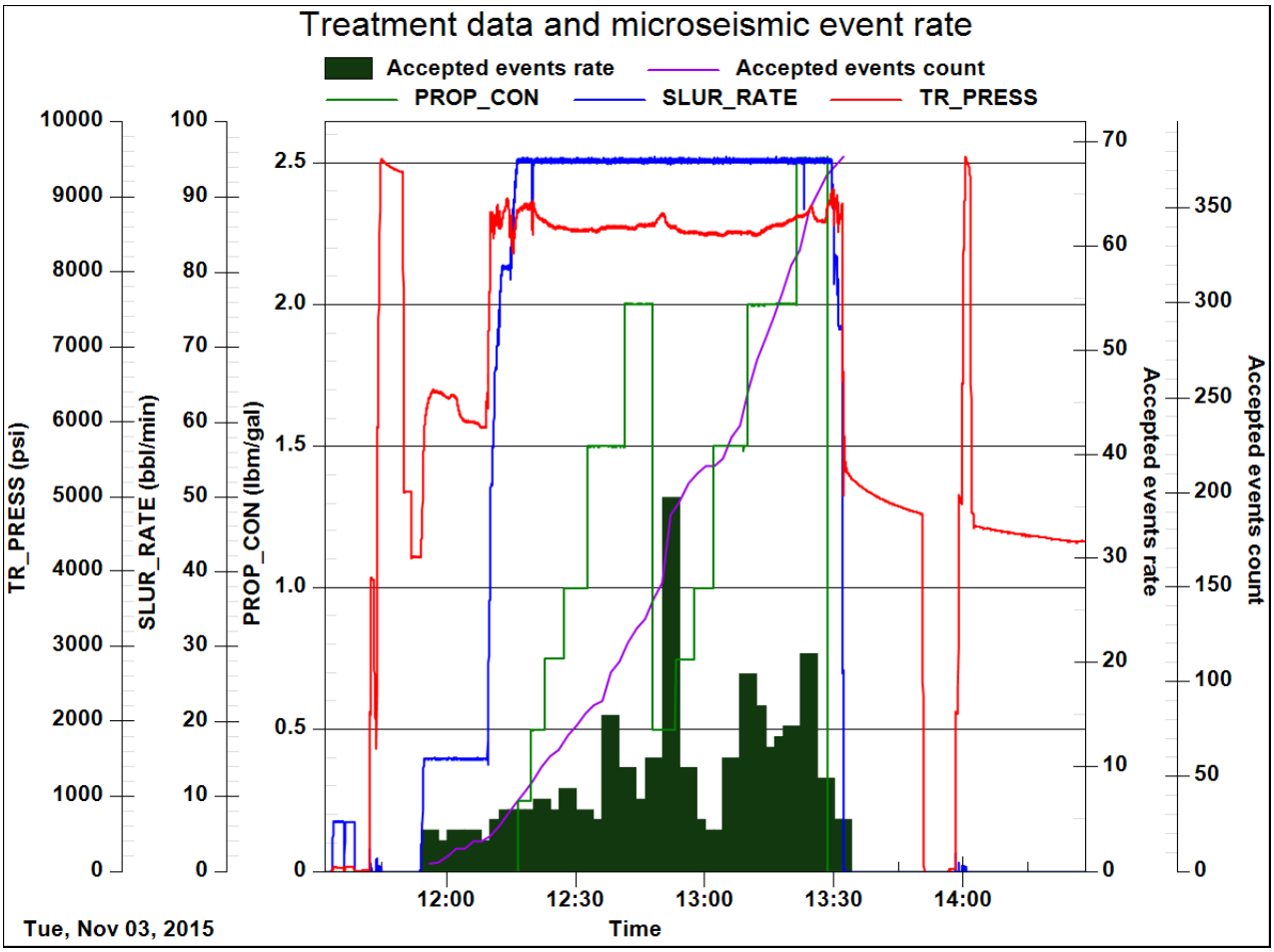



**Figure 5-205 - MIP 5H Stage 20 treatment data and microseismic event rate**

**Table 5.124 - MIP 5H Stage 20 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 310487 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 313487 |
| 100 Mesh (lbm) | 140000 | 146960 |
| 40/70 White (lbm) | 260000 | 231640 |
| Total proppants (lbm) | 400000 | 378600 |

**Table 5.125 - MIP 5H Stage 20 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 94.4 |
| Average pressure (psi) | 8613 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5535 |
| Maximum PPA (lbm/gal) | 2.521 |

**Table 5.126 - MIP 5H Stage 20 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 60 |
| MS length (ft) | 1755 |
| MS height (ft) | 453 |
| MS volume (million ft3) | 15.6 |

The microseismic data from MIP 5H Stage 20 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

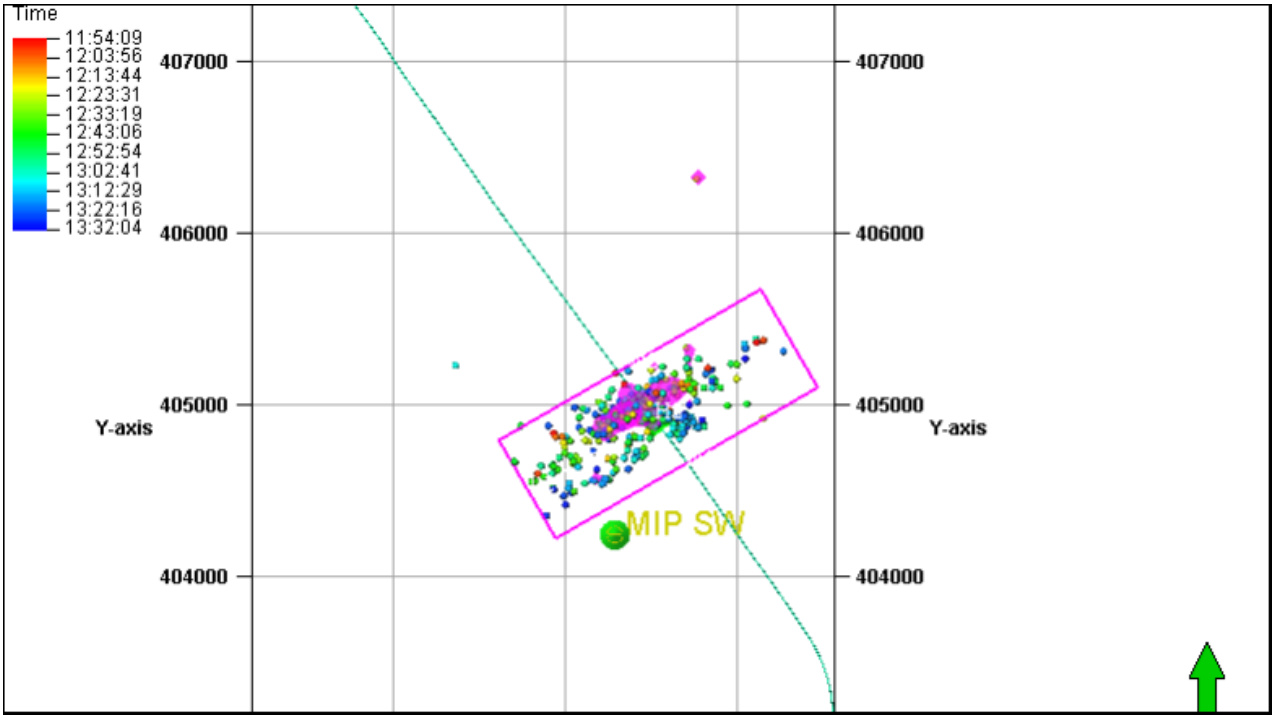



**Figure 5-206 - MIP 5H Stage 20 map view (length and width)**

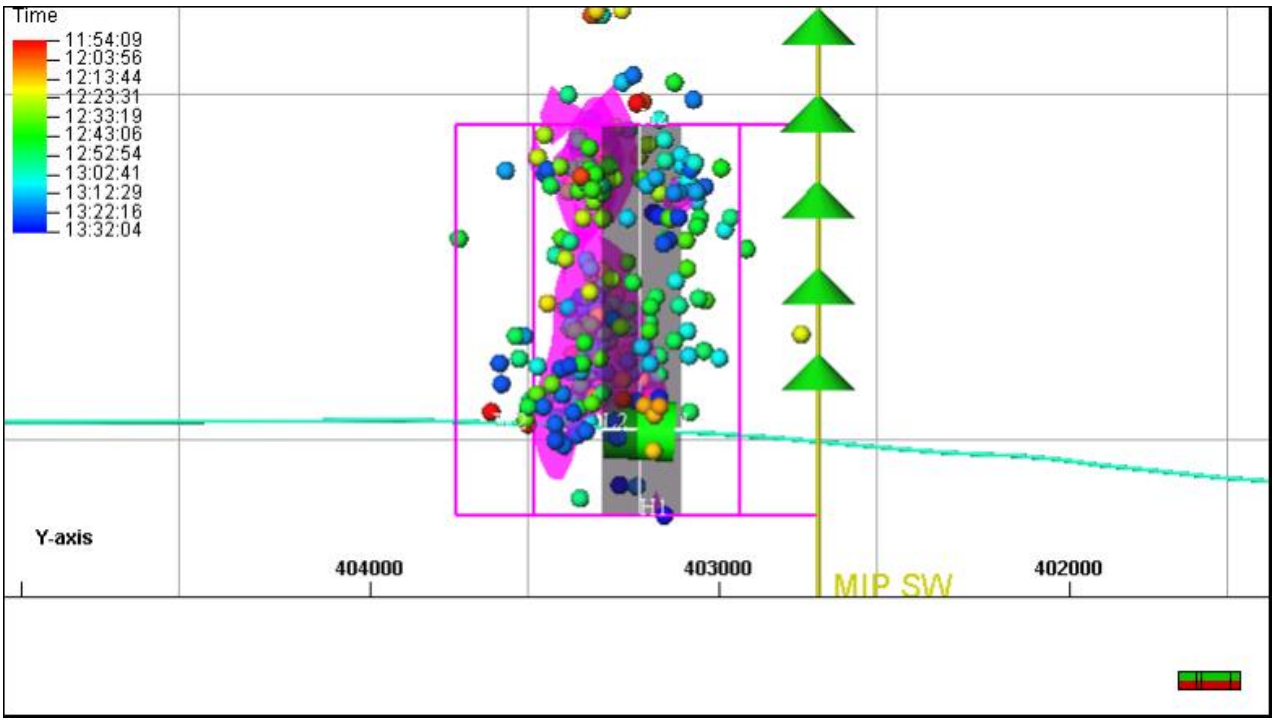



**Figure 5-207 - MIP 5H Stage 20 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 20 are shown below in map and transverse views.

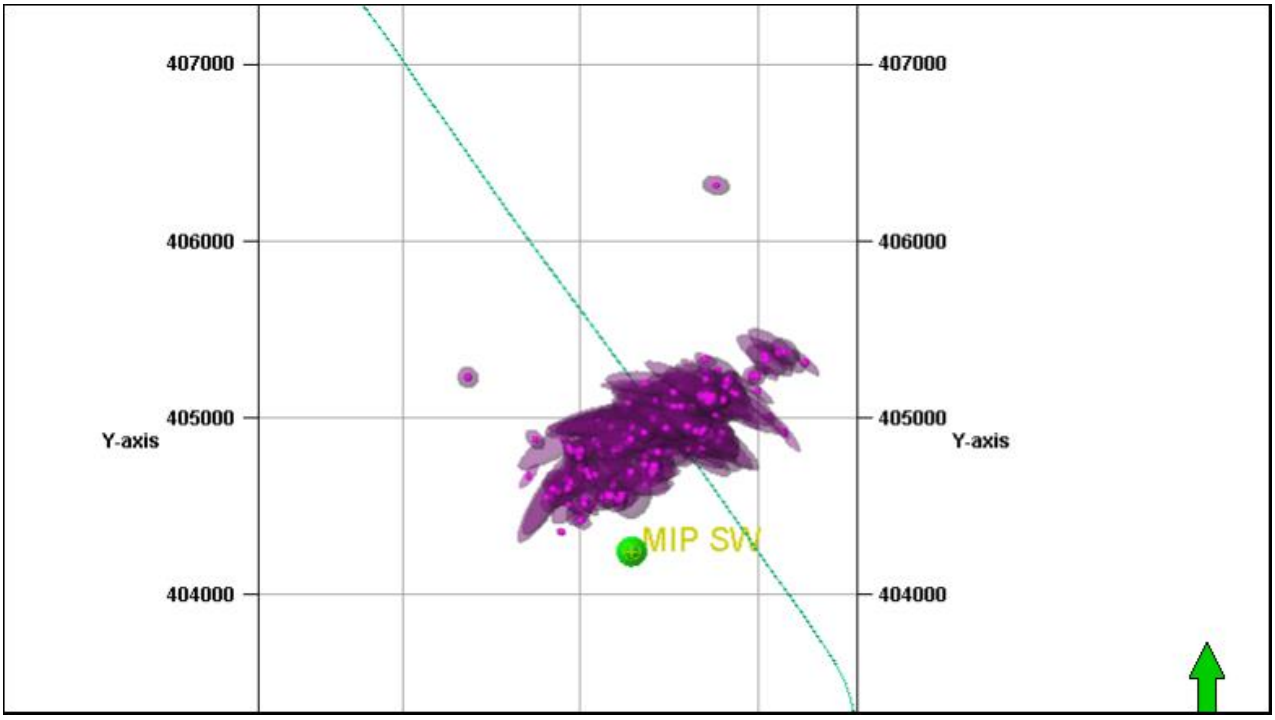



**Figure 5-208 - MIP 5H Stage 20 event location uncertainty ellipsoids – map view**

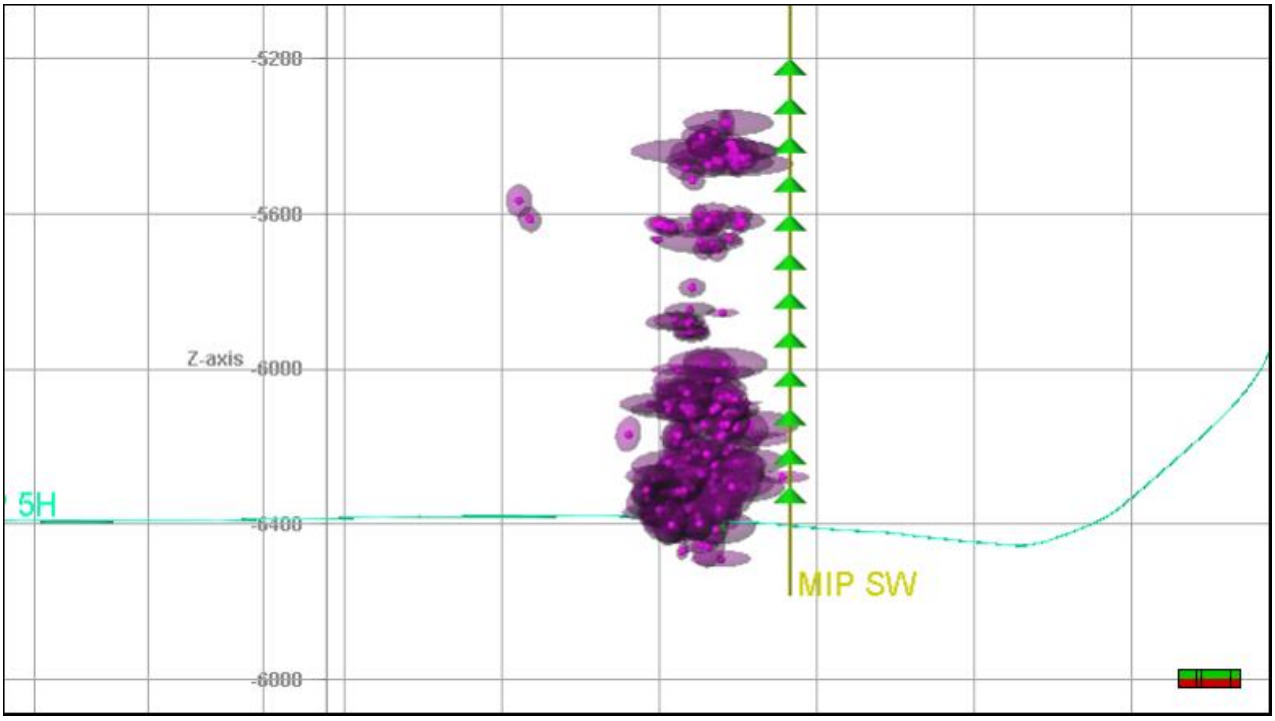



**Figure 5-209 - MIP 5H Stage 20 event location uncertainty ellipsoids – side view**

### 5.42.1 MIP 5H Stage 20 On-Site Notes and Observations

## 5.43 MIP 5H Stage 21

The MIP 5H Stage 21 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

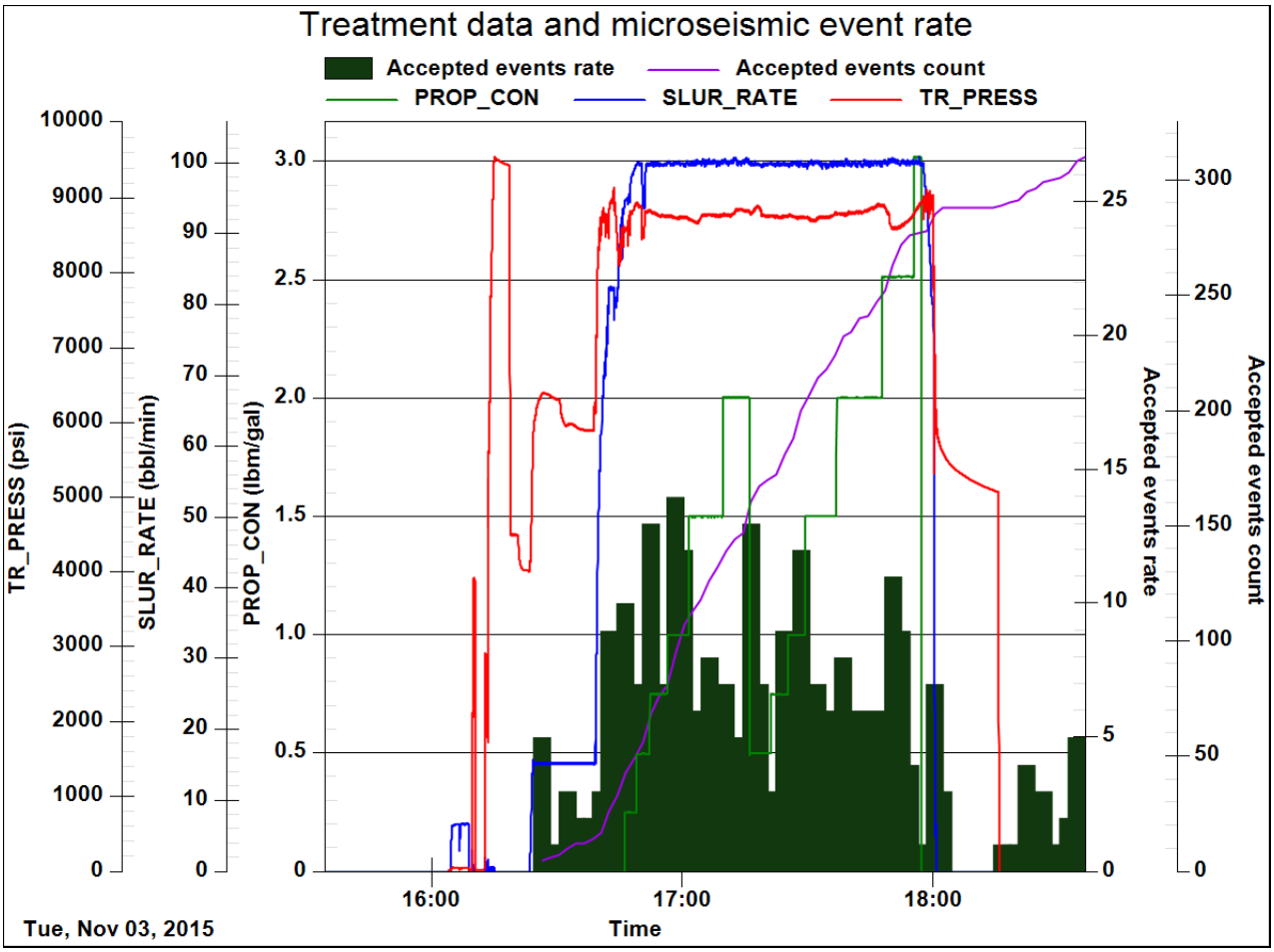



**Figure 5-210 - MIP 5H Stage 21 treatment data and microseismic event rate**

**Table 5.127 - MIP 5H Stage 21 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 319982 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 2853 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 322835 |
| 100 Mesh (lbm) | 140000 | 140520 |
| 40/70 White (lbm) | 260000 | 302100 |
| Total proppants (lbm) | 400000 | 442620 |

**Table 5.128 - MIP 5H Stage 21 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.5 |
| Average pressure (psi) | 8773 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6145 |
| Maximum PPA (lbm/gal) | 3.019 |

**Table 5.129 - MIP 5H Stage 21 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 53 |
| MS length (ft) | 1516 |
| MS height (ft) | 400 |
| MS volume (million ft3) | 24.7 |

The microseismic data from MIP 5H Stage 21 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

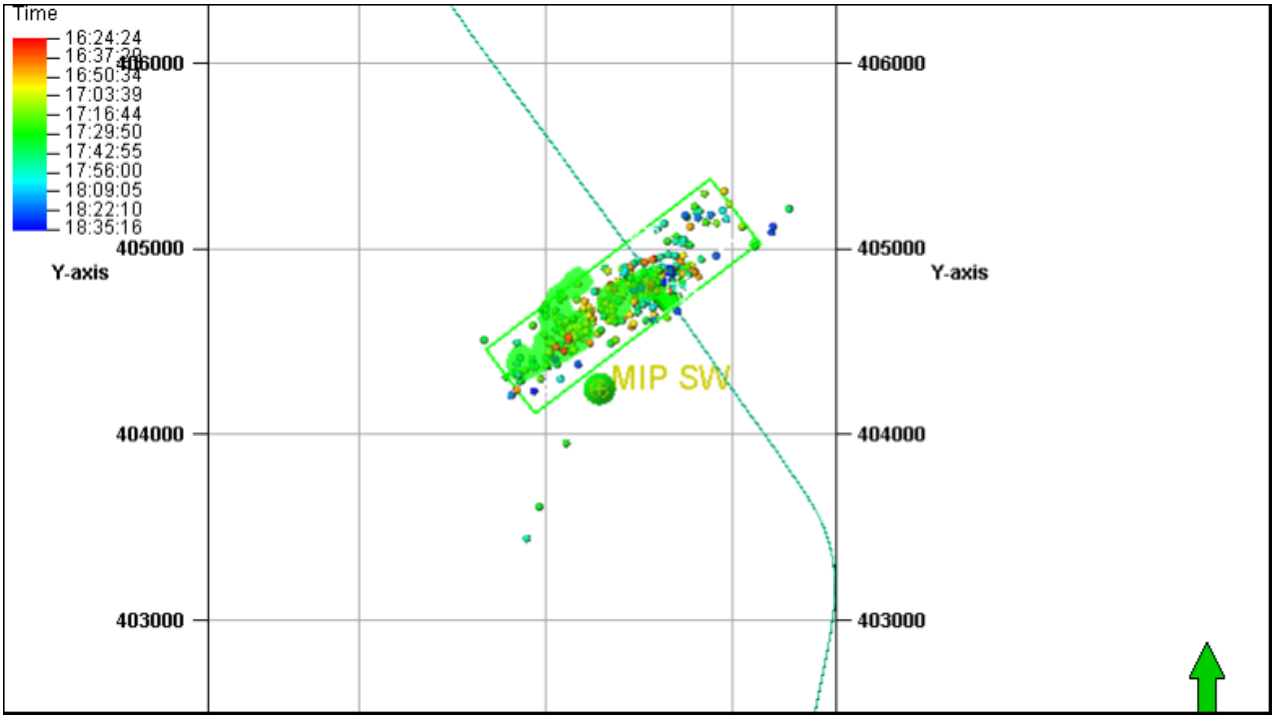



**Figure 5-211 - MIP 5H Stage 21 map view (length and width)**

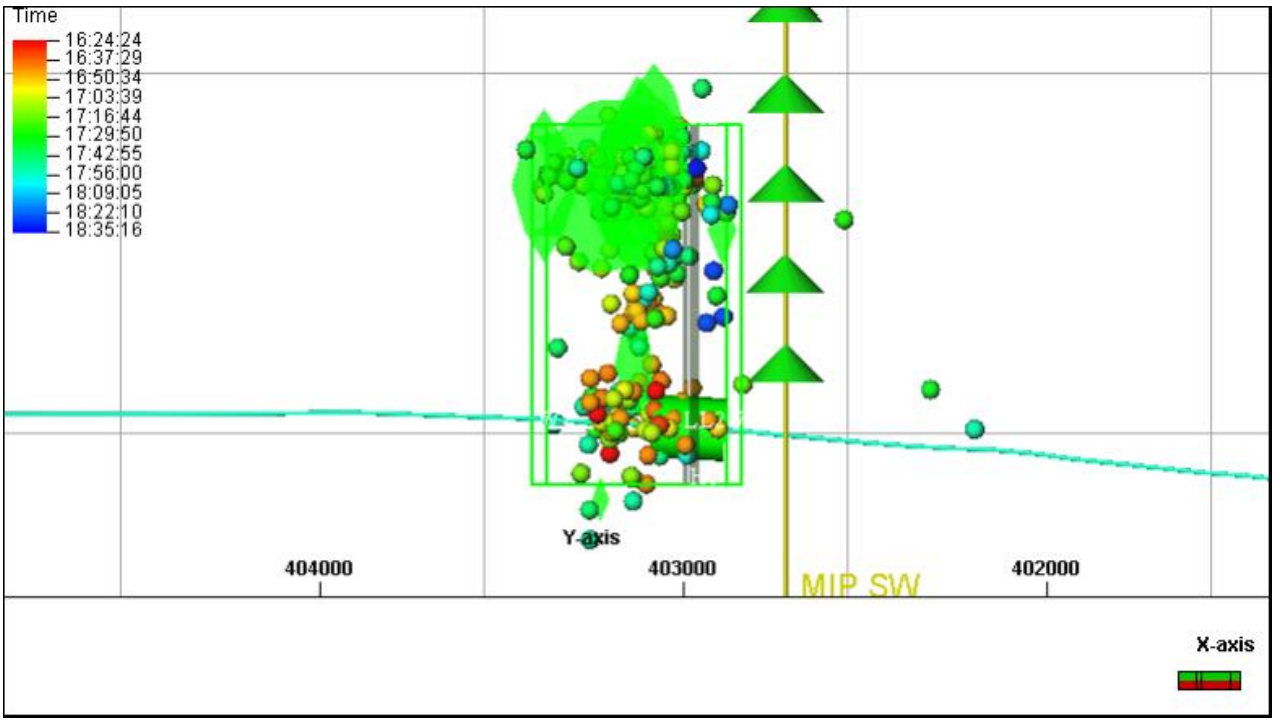



**Figure 5-212 - MIP 5H Stage 21 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 21 are shown below in map and transverse views.

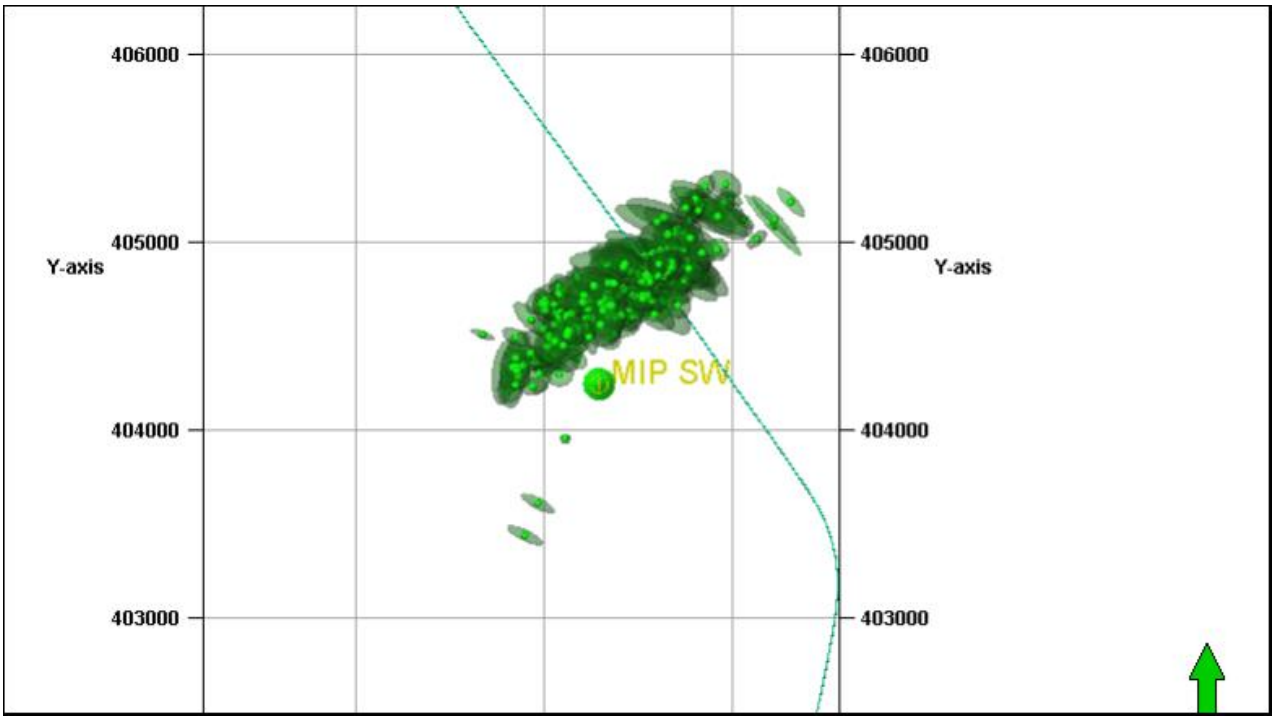



**Figure 5-213 - MIP 5H Stage 21 event location uncertainty ellipsoids – map view**

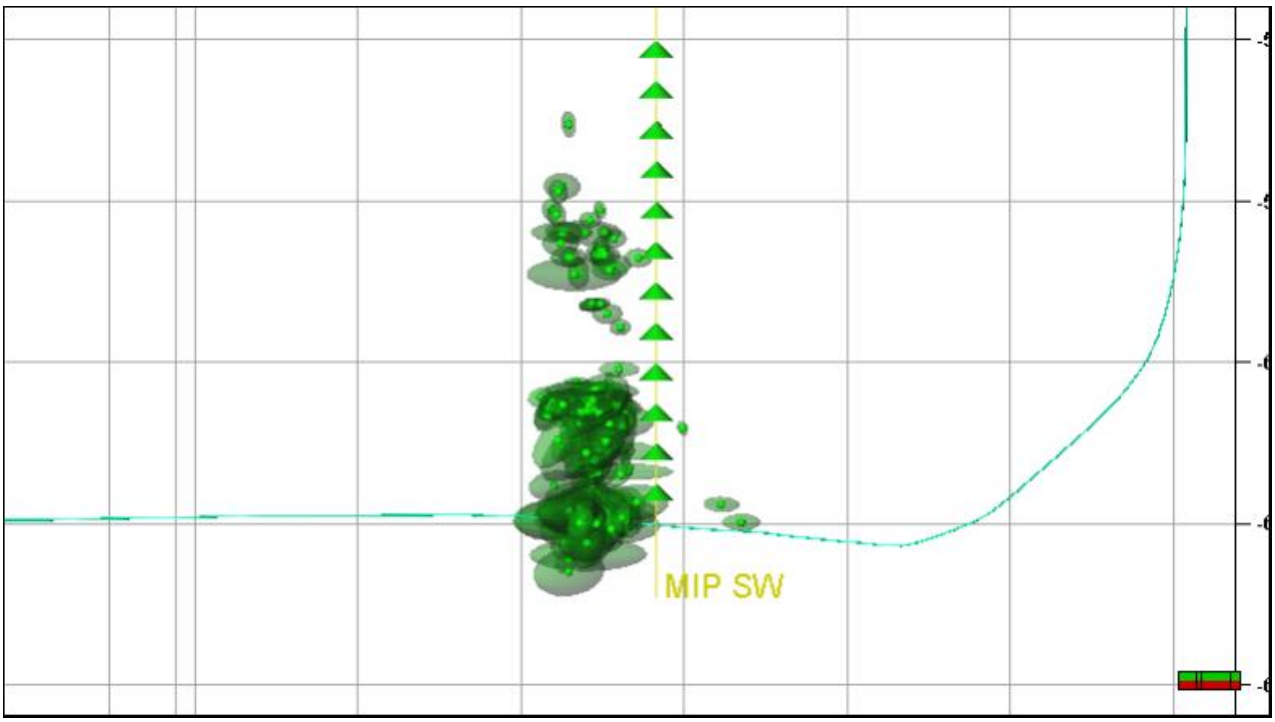



**Figure 5-214 - MIP 5H Stage 21 event location uncertainty ellipsoids – side view**

### 5.43.1 MIP 5H Stage 21 On-Site Notes and Observations

## 5.44 MIP 5H Stage 22

The MIP 5H Stage 22 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

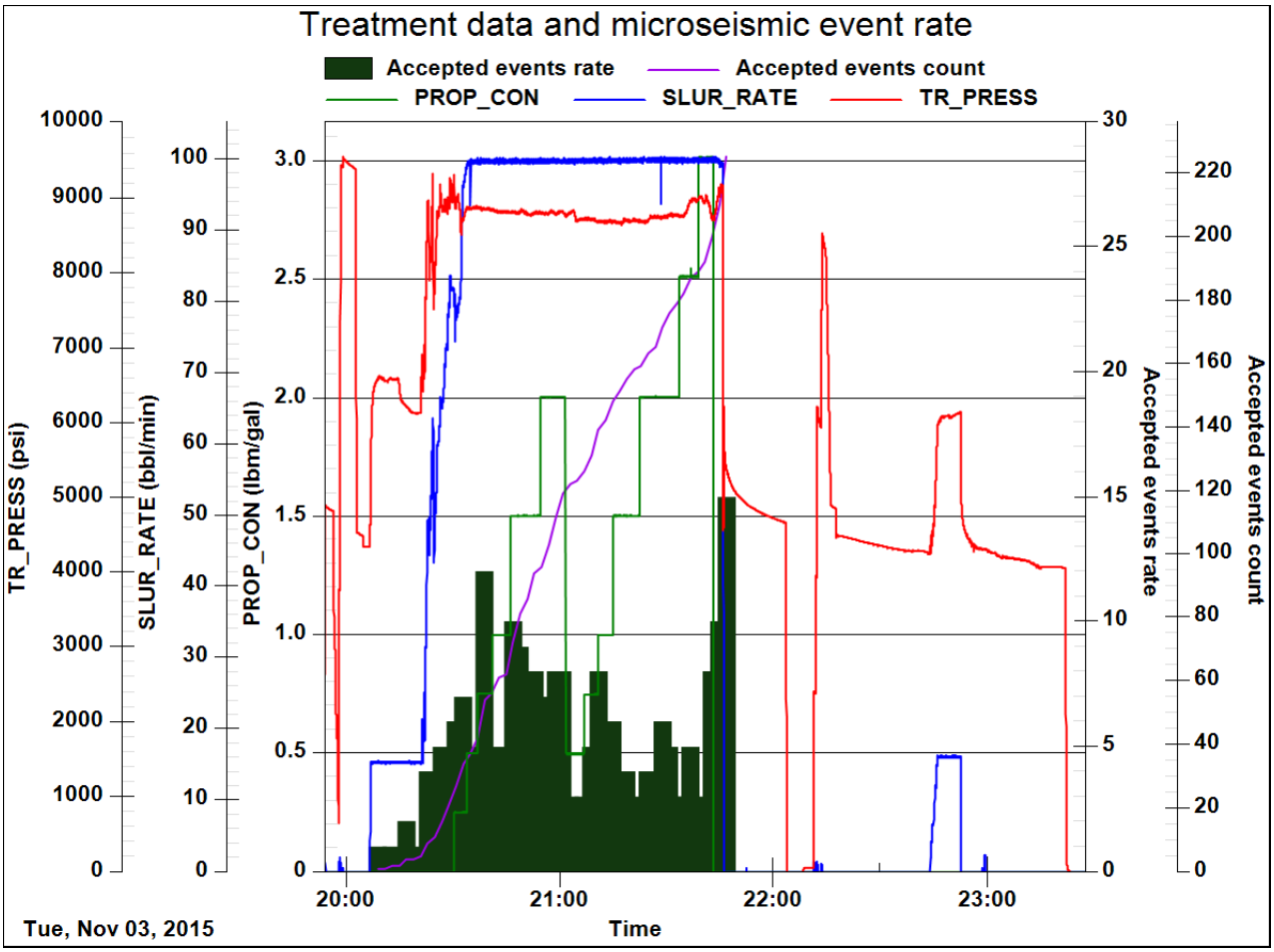



**Figure 5-215 - MIP 5H Stage 22 treatment data and microseismic event rate**

**Table 5.130 - MIP 5H Stage 22 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 324329 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 327329 |
| 100 Mesh (lbm) | 140000 | 141500 |
| 40/70 White (lbm) | 260000 | 260300 |
| Total proppants (lbm) | 400000 | 401800 |

**Table 5.131 - MIP 5H Stage 22 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 94.7 |
| Average pressure (psi) | 8718 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5788 |
| Maximum PPA (lbm/gal) | 3.015 |

**Table 5.132 - MIP 5H Stage 22 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 54 |
| MS length (ft) | 1419 |
| MS height (ft) | 434 |
| MS volume (million ft3) | 19.4 |

The microseismic data from MIP 5H Stage 22 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

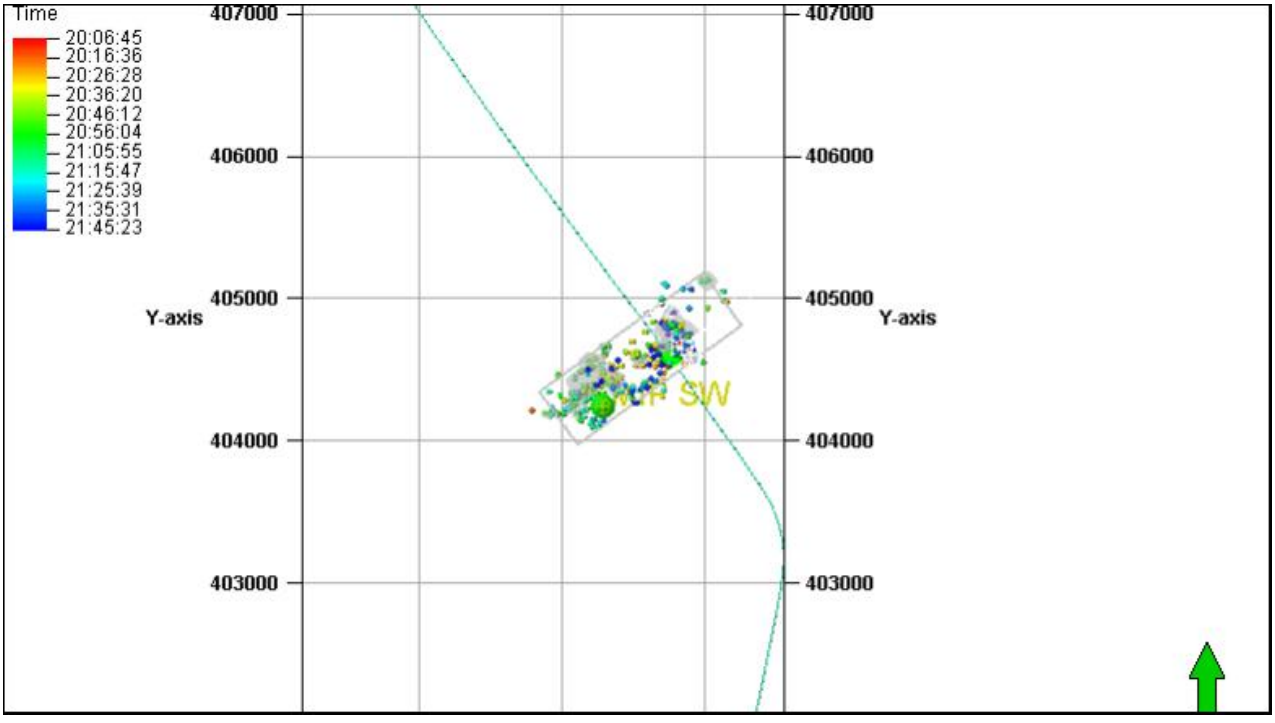



**Figure 5-216 - MIP 5H Stage 22 map view (length and width)**

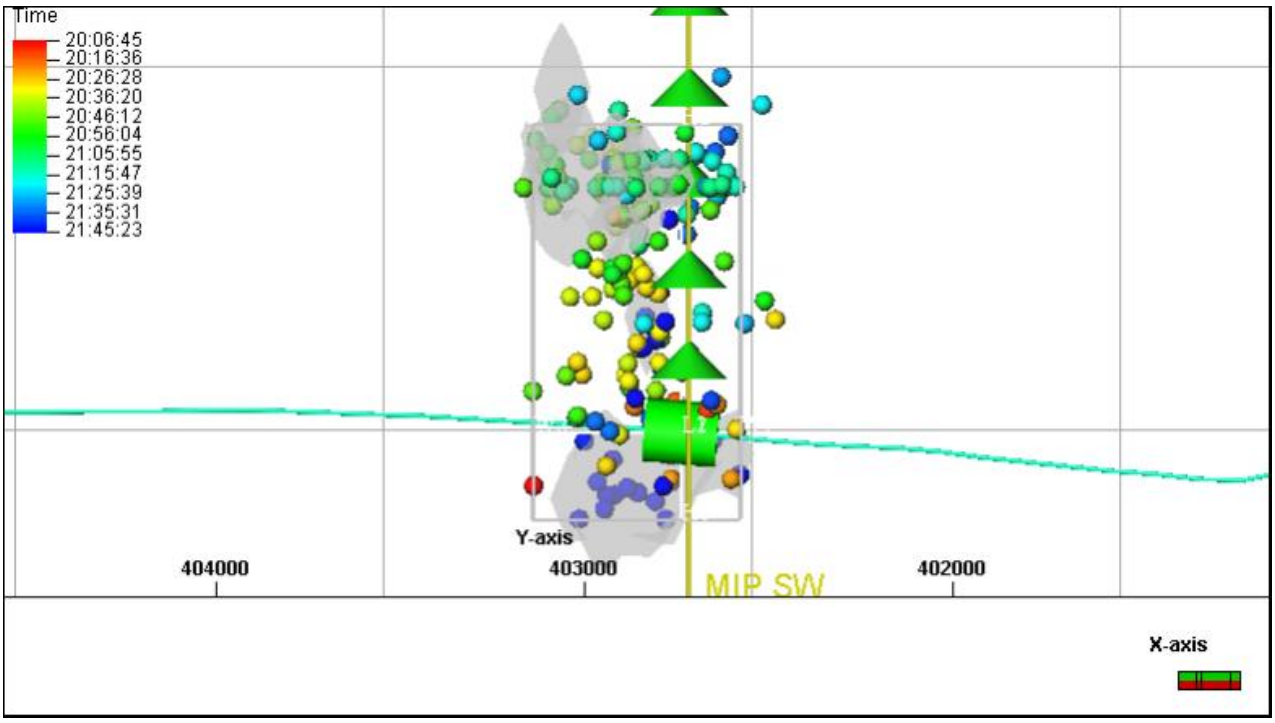



**Figure 5-217 - MIP 5H Stage 22 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 22 are shown below in map and transverse views.

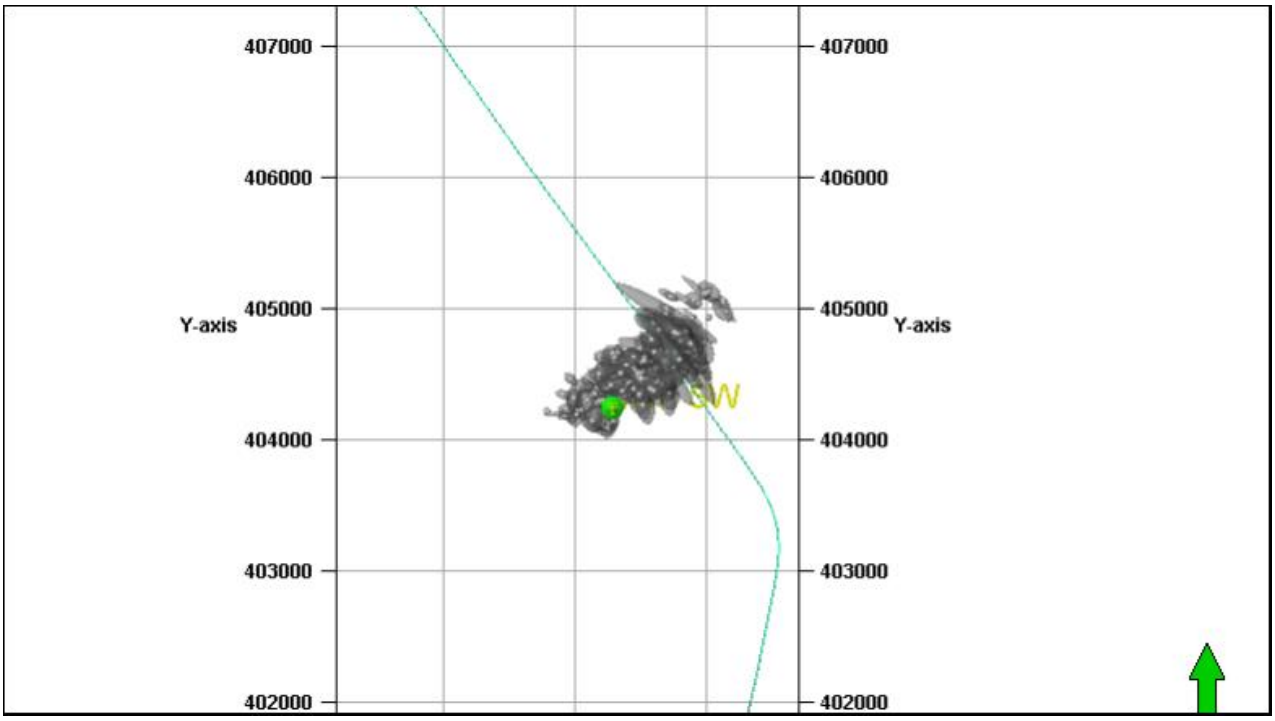



**Figure 5-218 - MIP 5H Stage 22 event location uncertainty ellipsoids – map view**

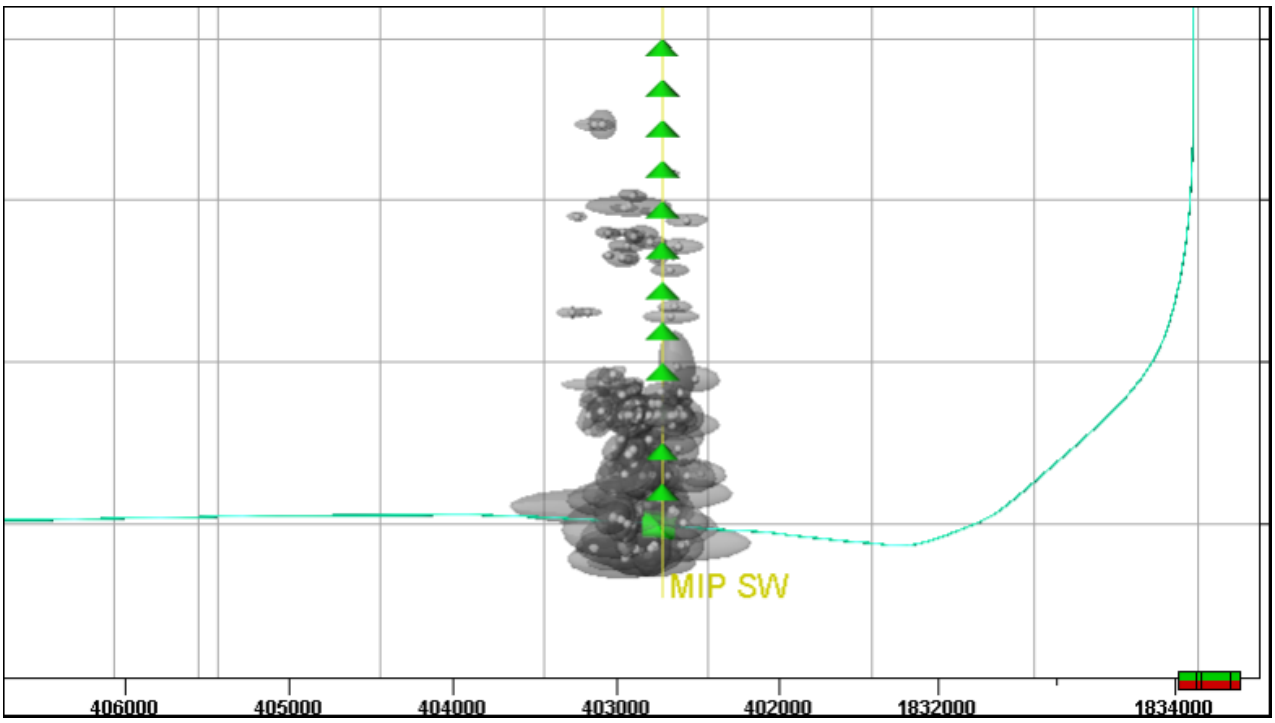



**Figure 5-219 - MIP 5H Stage 22 event location uncertainty ellipsoids – side view**

### 5.44.1 MIP 5H Stage 22 On-Site Notes and Observations

## 5.45 MIP 5H Stage 23

The MIP 5H Stage 23 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

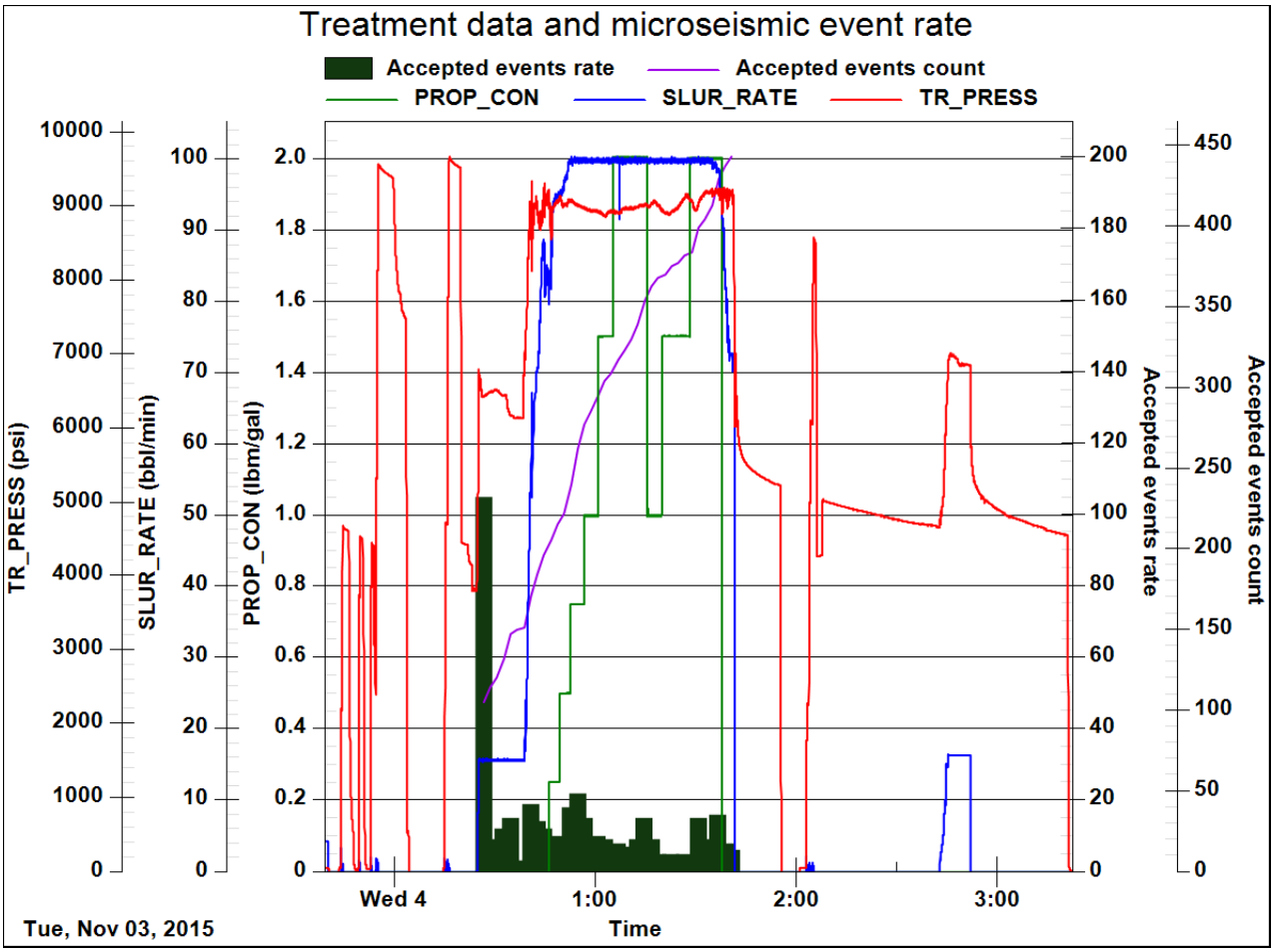



**Figure 5-220 - MIP 5H Stage 23 treatment data and microseismic event rate**

**Table 5.133 - MIP 5H Stage 23 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 239789 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 242789 |
| 100 Mesh (lbm) | 140000 | 144580 |
| 40/70 White (lbm) | 260000 | 146300 |
| Total proppants (lbm) | 400000 | 290880 |

**Table 5.134 - MIP 5H Stage 23 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 92.8 |
| Average pressure (psi) | 8900 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6907 |
| Maximum PPA (lbm/gal) | 2.005 |

**Table 5.135 - MIP 5H Stage 23 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 53 |
| MS length (ft) | 1294 |
| MS height (ft) | 649 |
| MS volume (million ft3) | 38.8 |

The microseismic data from MIP 5H Stage 23 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

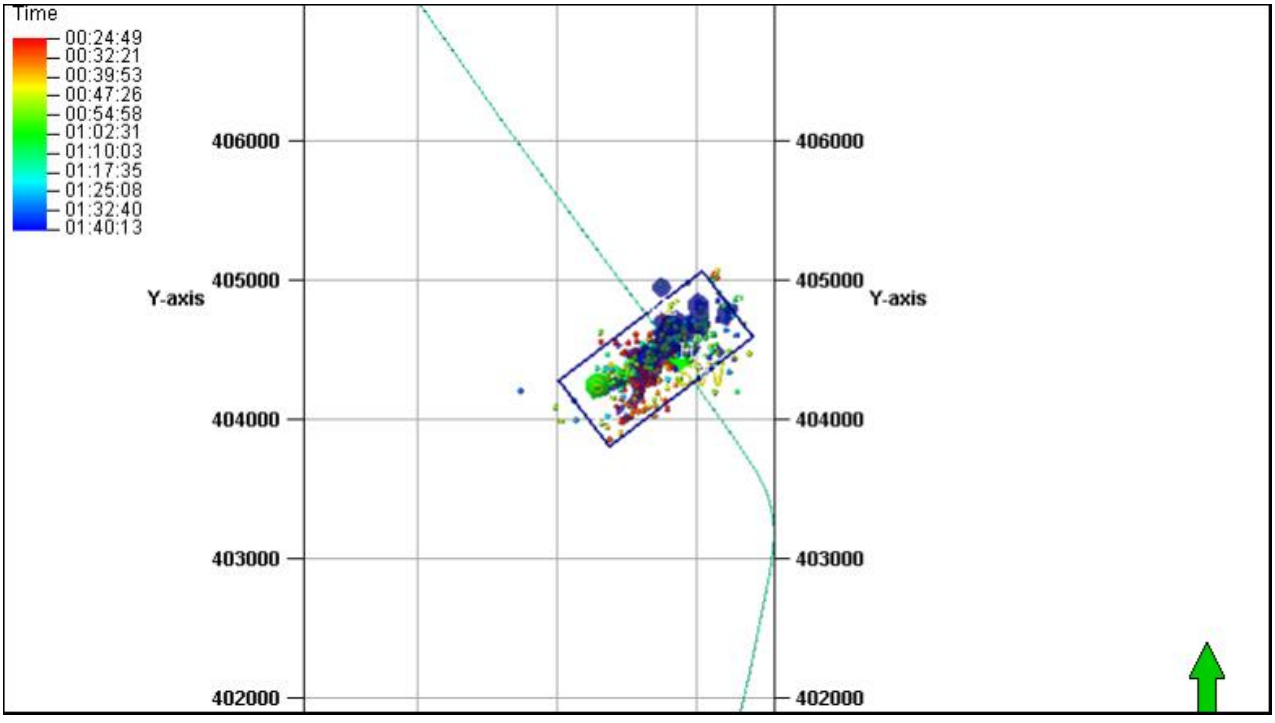



**Figure 5-221 - MIP 5H Stage 23 map view (length and width)**

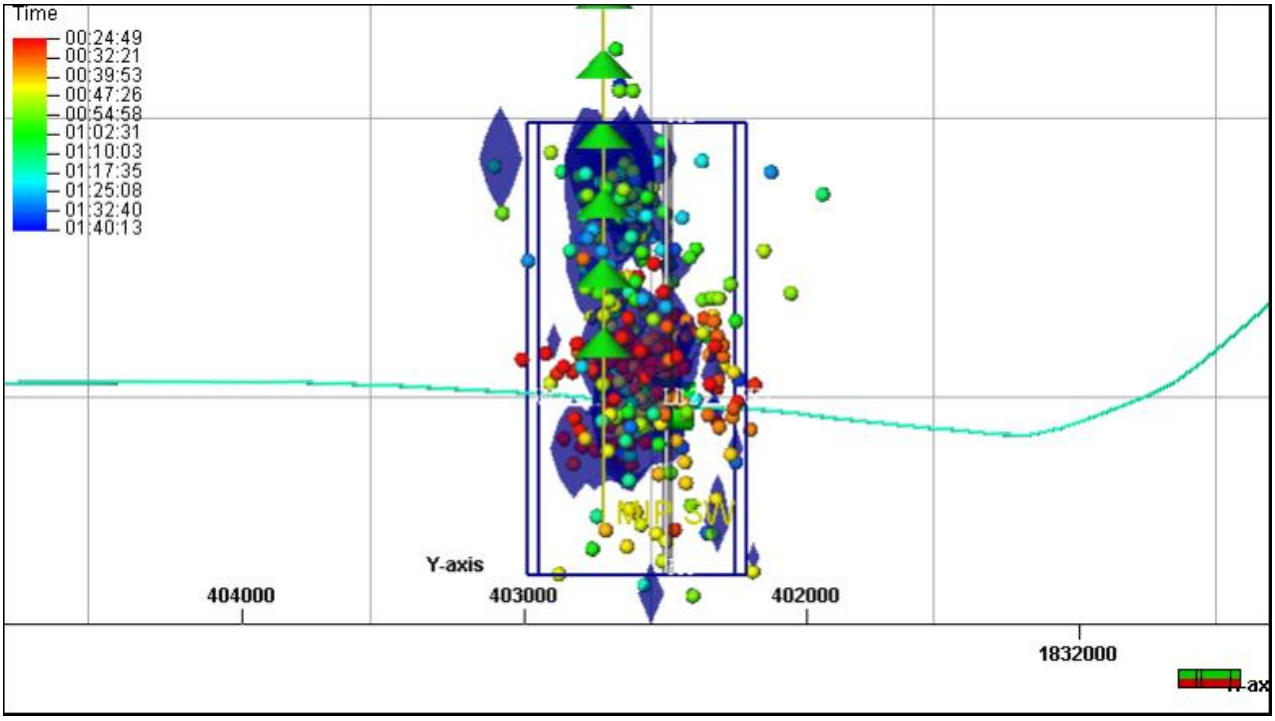



**Figure 5-222 - MIP 5H Stage 23 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 23 are shown below in map and transverse views.

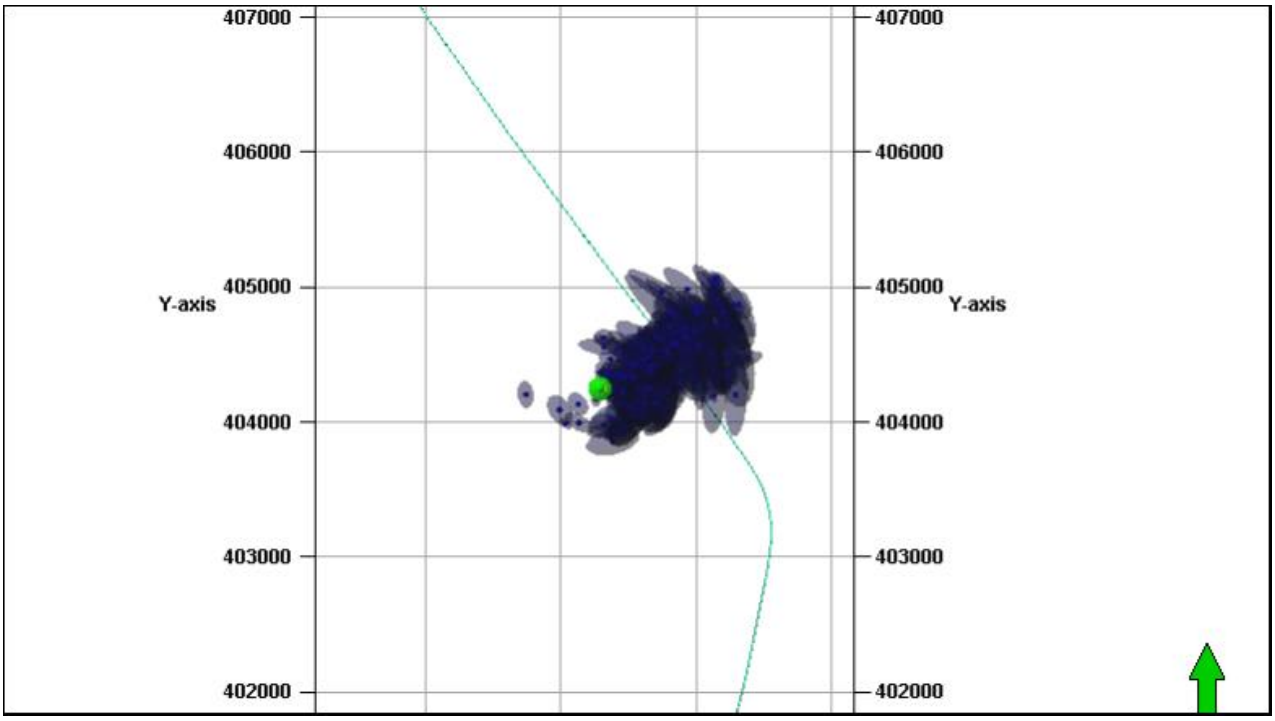



**Figure 5-223 - MIP 5H Stage 23 event location uncertainty ellipsoids – map view**

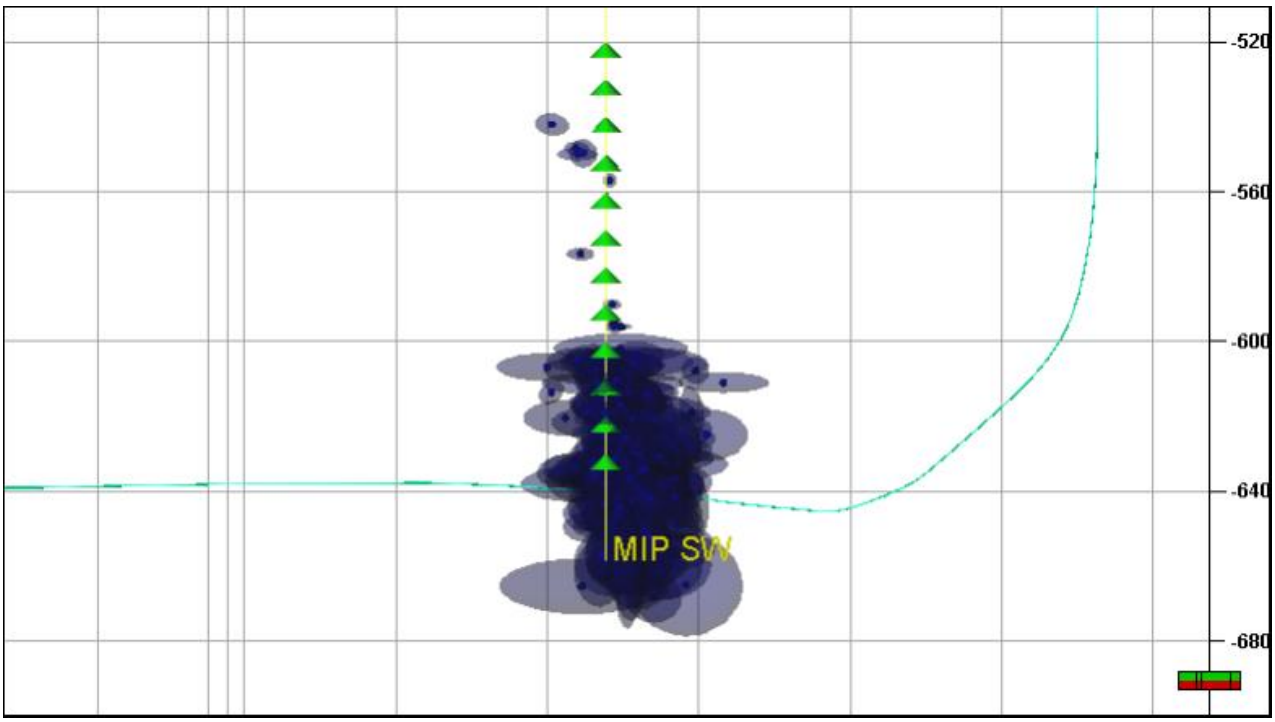



**Figure 5-224 - MIP 5H Stage 23 event location uncertainty ellipsoids – side view**

### 5.45.1 MIP 5H Stage 23 On-Site Notes and Observations

## 5.46 MIP 5H Stage 24

The MIP 5H Stage 24 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

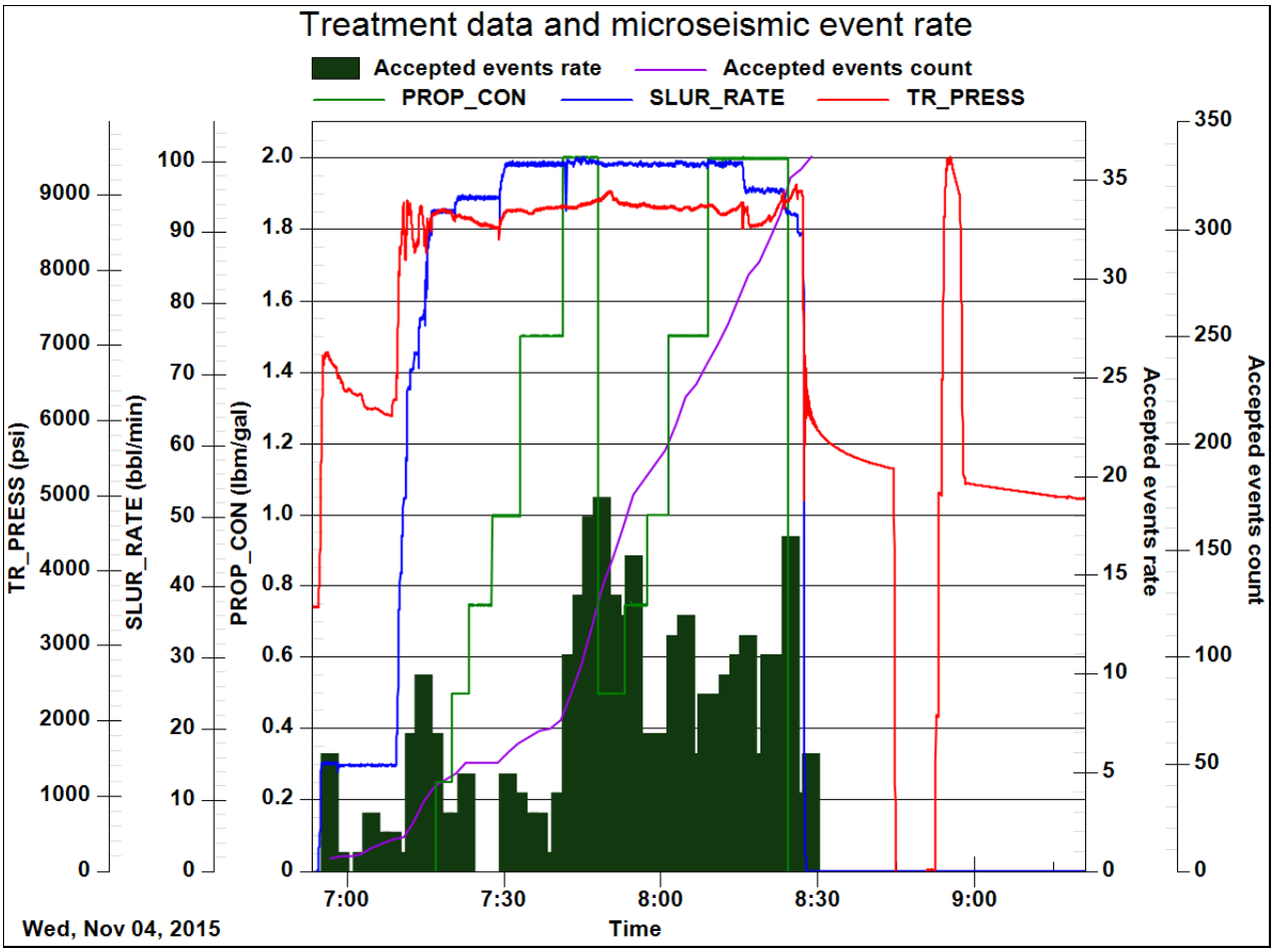



**Figure 5-225 - MIP 5H Stage 24 treatment data and microseismic event rate**

**Table 5.136 - MIP 5H Stage 24 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 302019 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 305019 |
| 100 Mesh (lbm) | 140000 | 143600 |
| 40/70 White (lbm) | 260000 | 191020 |
| Total proppants (lbm) | 400000 | 334620 |

**Table 5.137 - MIP 5H Stage 24 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 97.7 |
| Average pressure (psi) | 8797 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6697 |
| Maximum PPA (lbm/gal) | 2.004 |

**Table 5.138 - MIP 5H Stage 24 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 64 |
| MS length (ft) | 1186 |
| MS height (ft) | 439 |
| MS volume (million ft3) | 11.1 |

The microseismic data from MIP 5H Stage 24 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

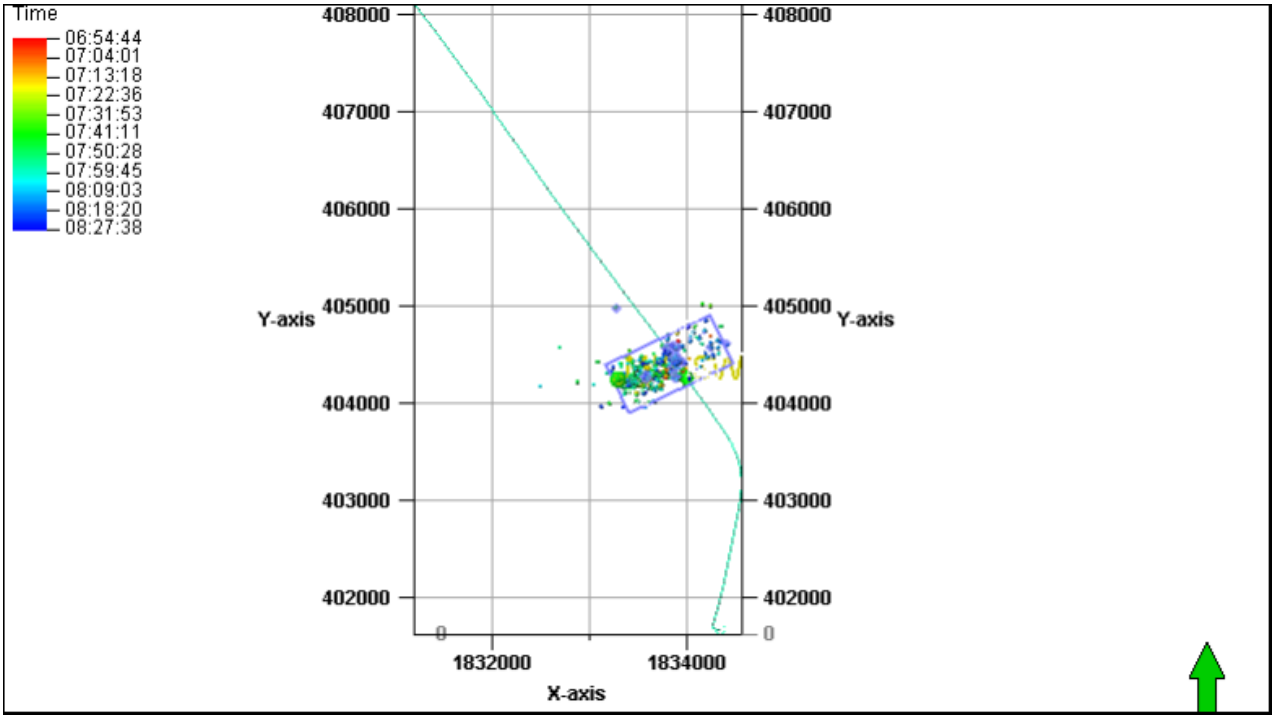



**Figure 5-226 - MIP 5H Stage 24 map view (length and width)**

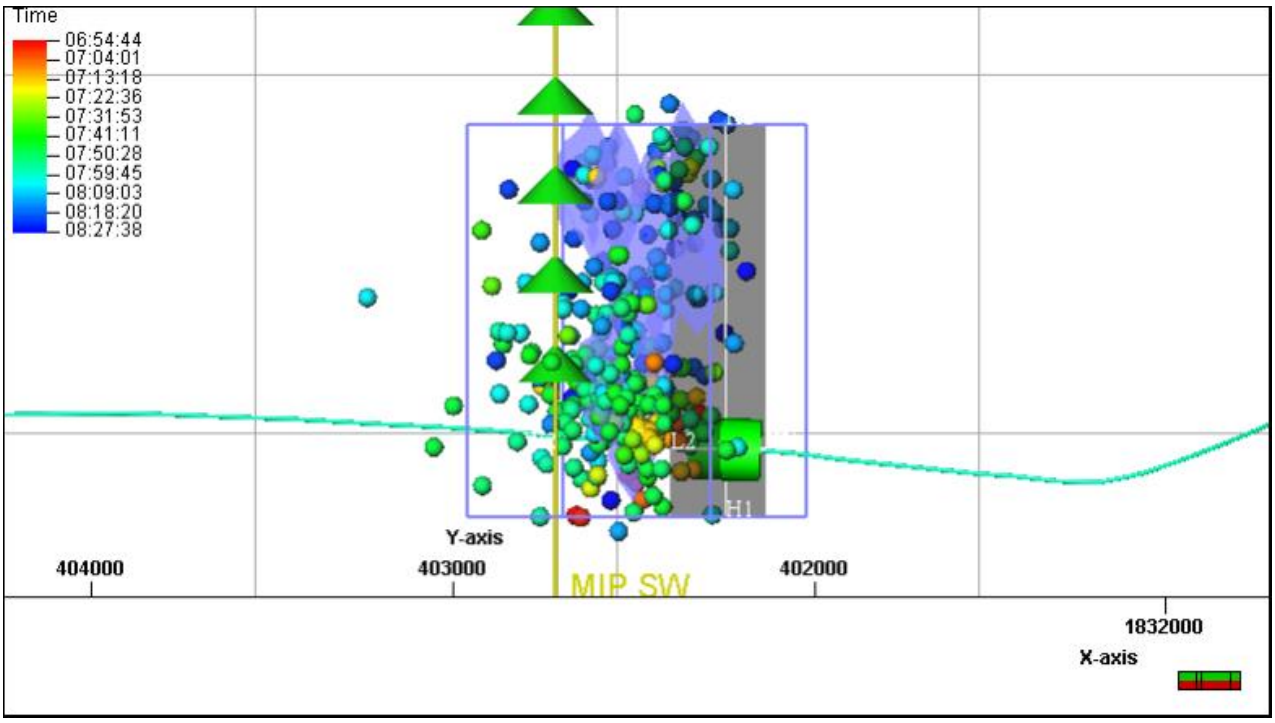



**Figure 5-227 - MIP 5H Stage 24 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 24 are shown below in map and transverse views.

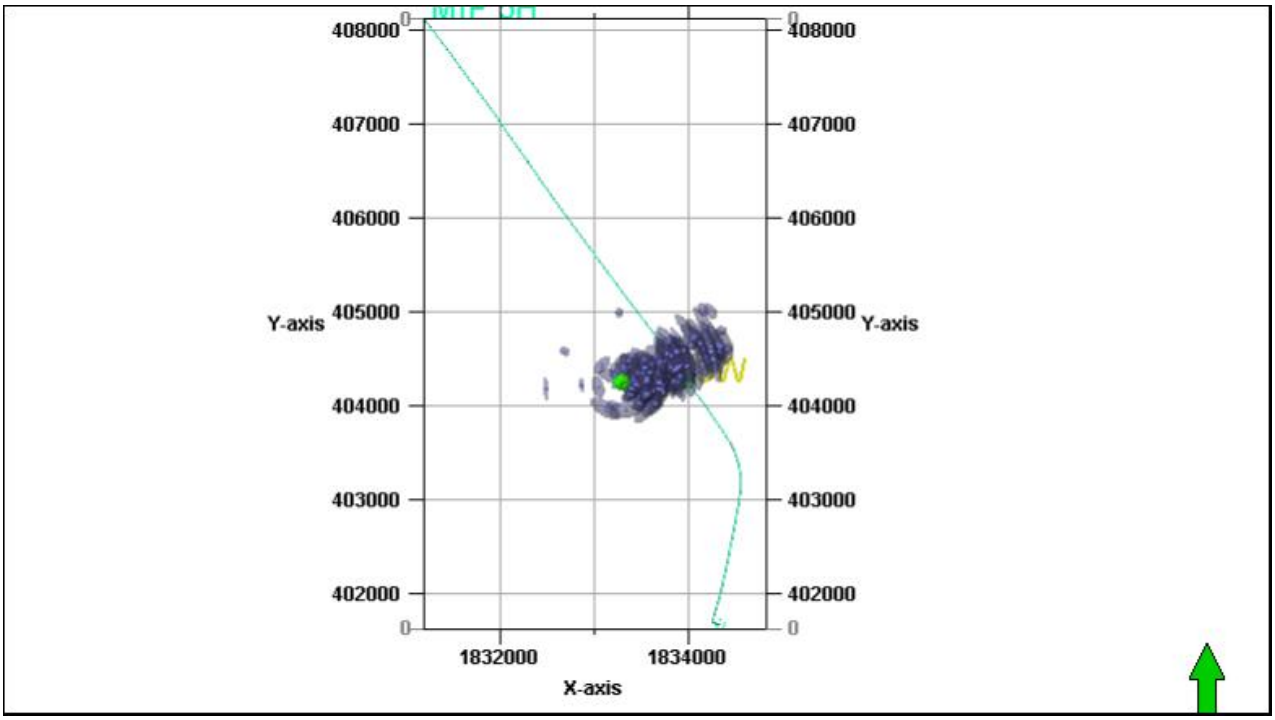



**Figure 5-228 - MIP 5H Stage 24 event location uncertainty ellipsoids – map view**

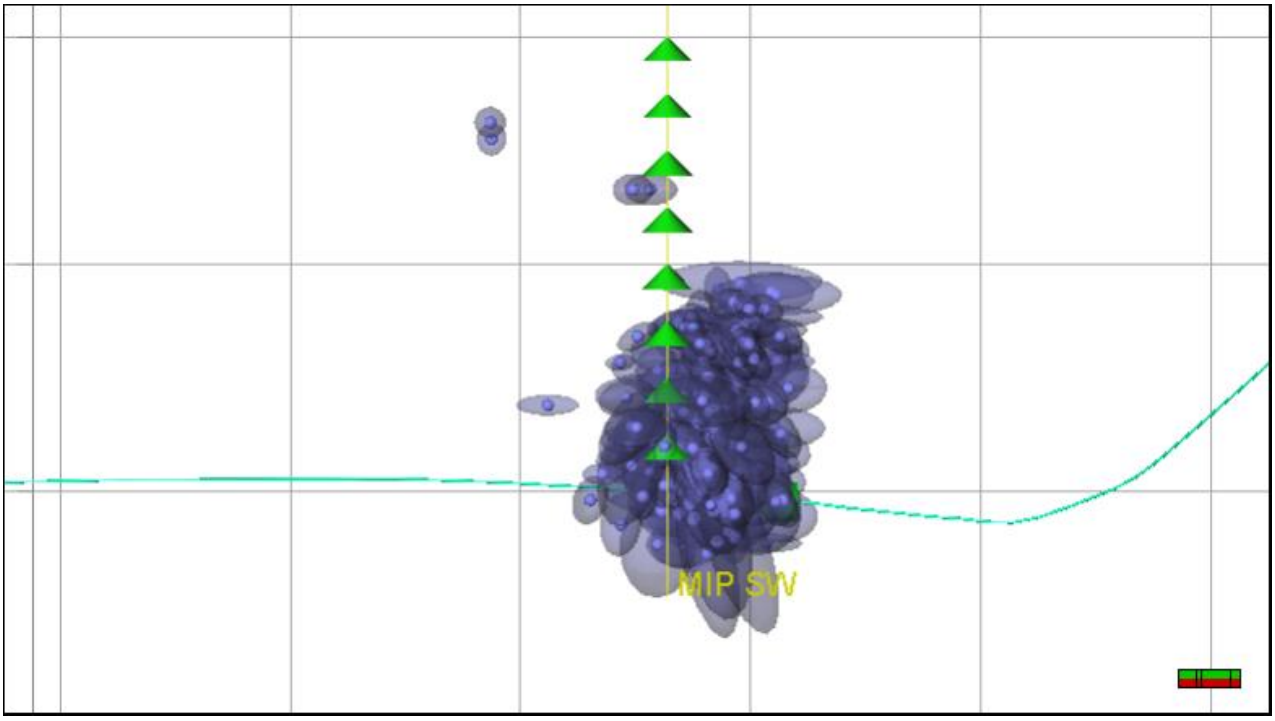



**Figure 5-229 - MIP 5H Stage 24 event location uncertainty ellipsoids – side view**

### 5.46.1 MIP 5H Stage 24 On-Site Notes and Observations

## 5.47 MIP 5H Stage 25

The MIP 5H Stage 25 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

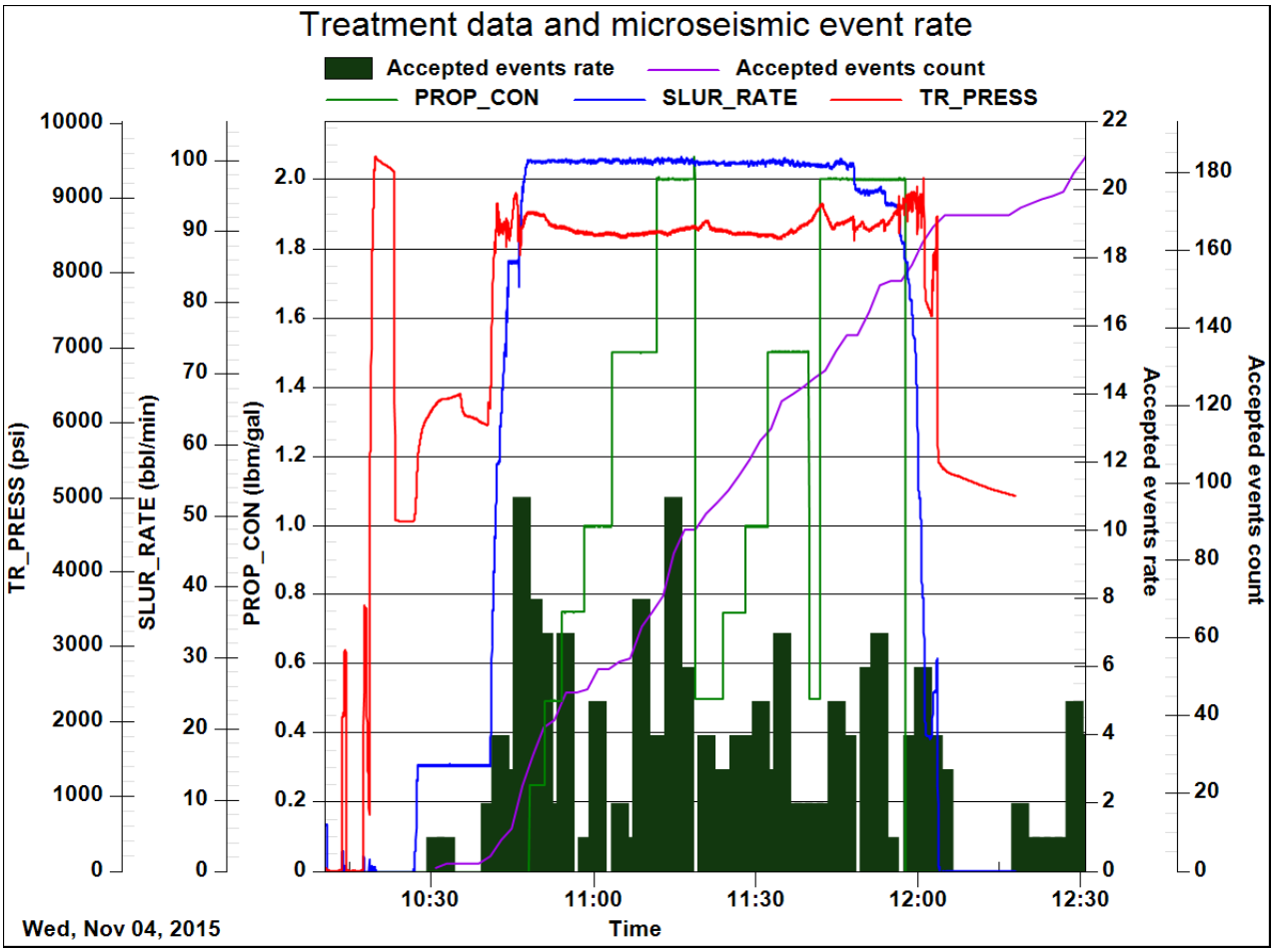



**Figure 5-230 - MIP 5H Stage 25 treatment data and microseismic event rate**

**Table 5.139 - MIP 5H Stage 25 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 313495 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 316495 |
| 100 Mesh (lbm) | 140000 | 145080 |
| 40/70 White (lbm) | 260000 | 213180 |
| Total proppants (lbm) | 400000 | 358260 |

**Table 5.140 - MIP 5H Stage 25 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 97.6 |
| Average pressure (psi) | 8609 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 5596 |
| Maximum PPA (lbm/gal) | 2.065 |

**Table 5.141 - MIP 5H Stage 25 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 57 |
| MS length (ft) | 1121 |
| MS height (ft) | 402 |
| MS volume (million ft3) | 20.7 |

The microseismic data from MIP 5H Stage 25 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

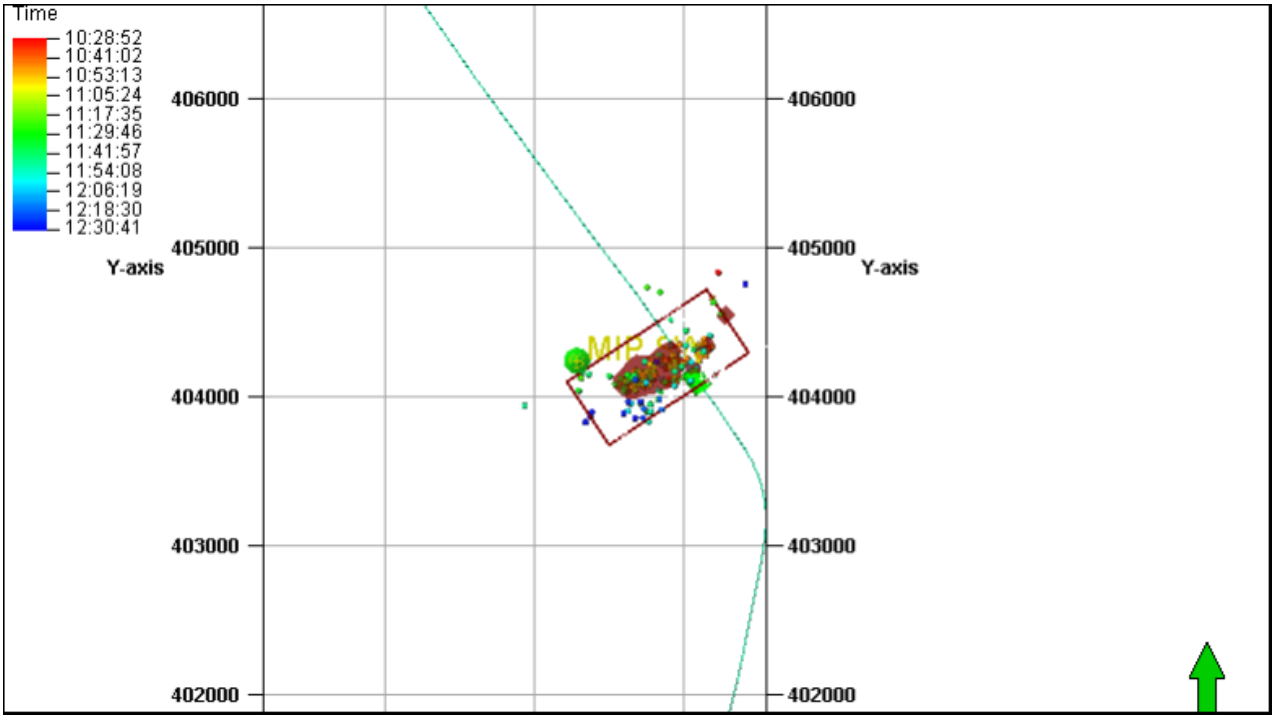



**Figure 5-231 - MIP 5H Stage 25 map view (length and width)**

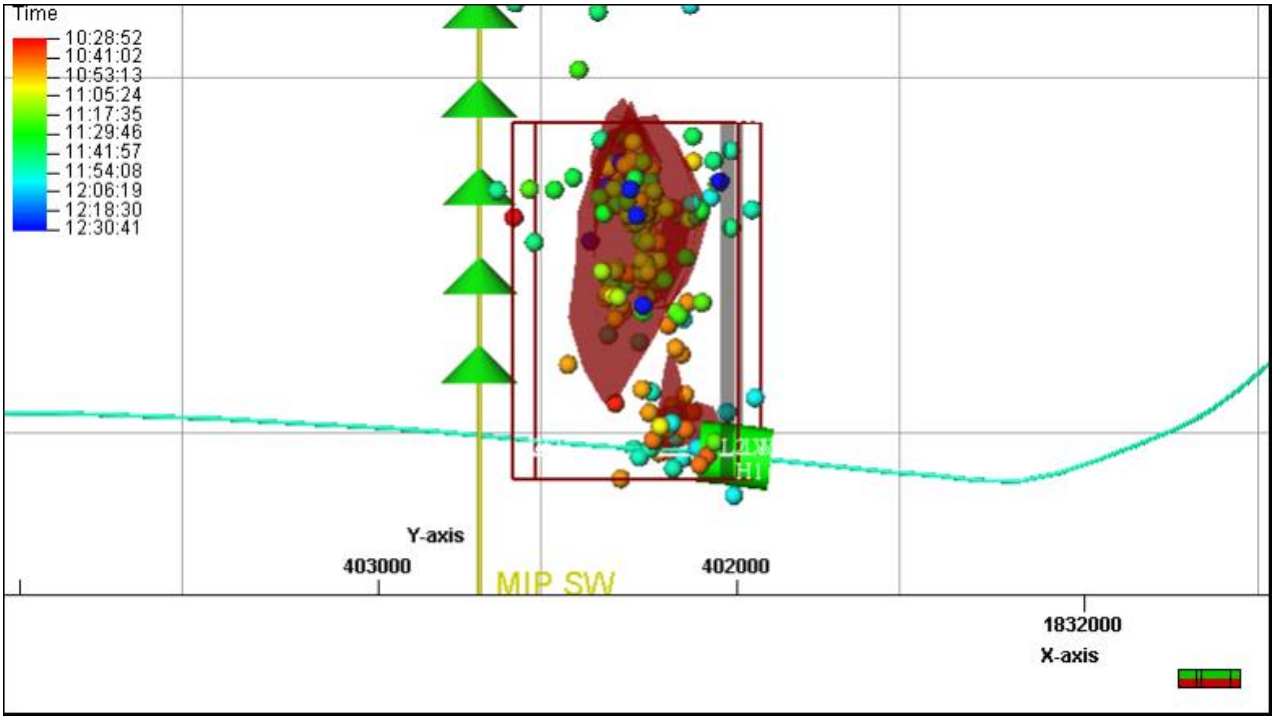



**Figure 5-232 - MIP 5H Stage 25 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 25 are shown below in map and transverse views.

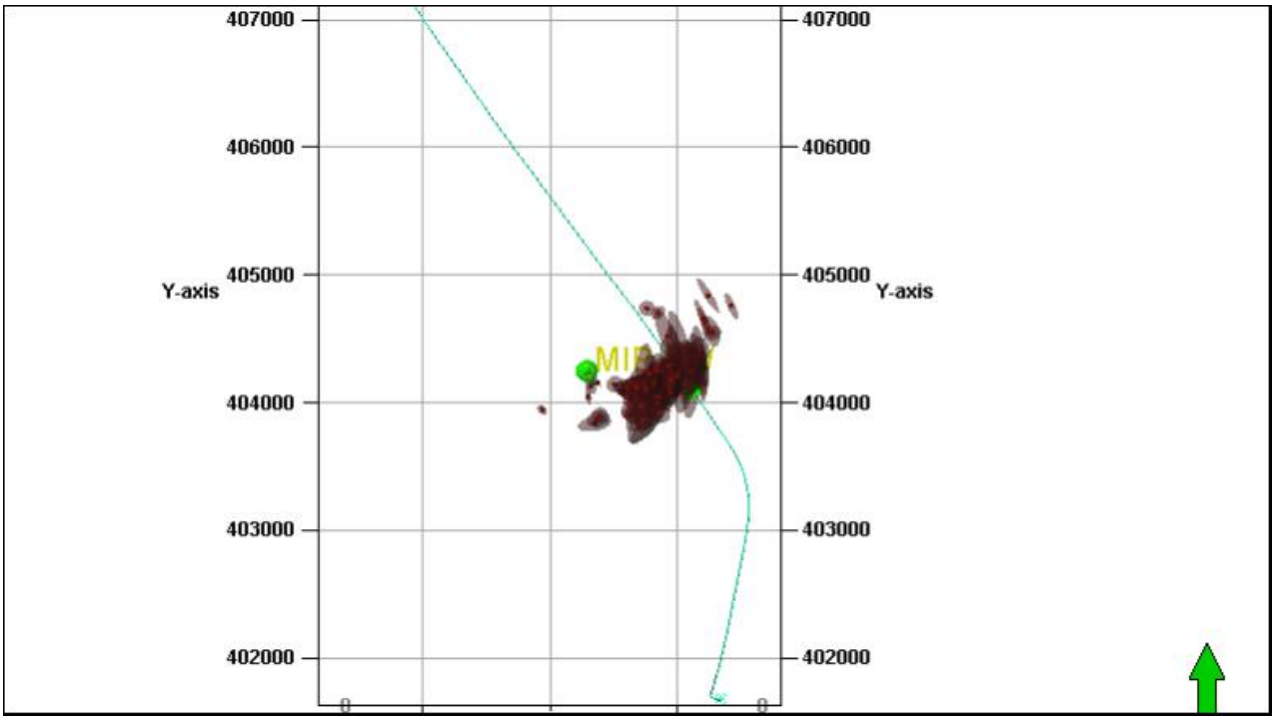



**Figure 5-233 - MIP 5H Stage 25 event location uncertainty ellipsoids – map view**

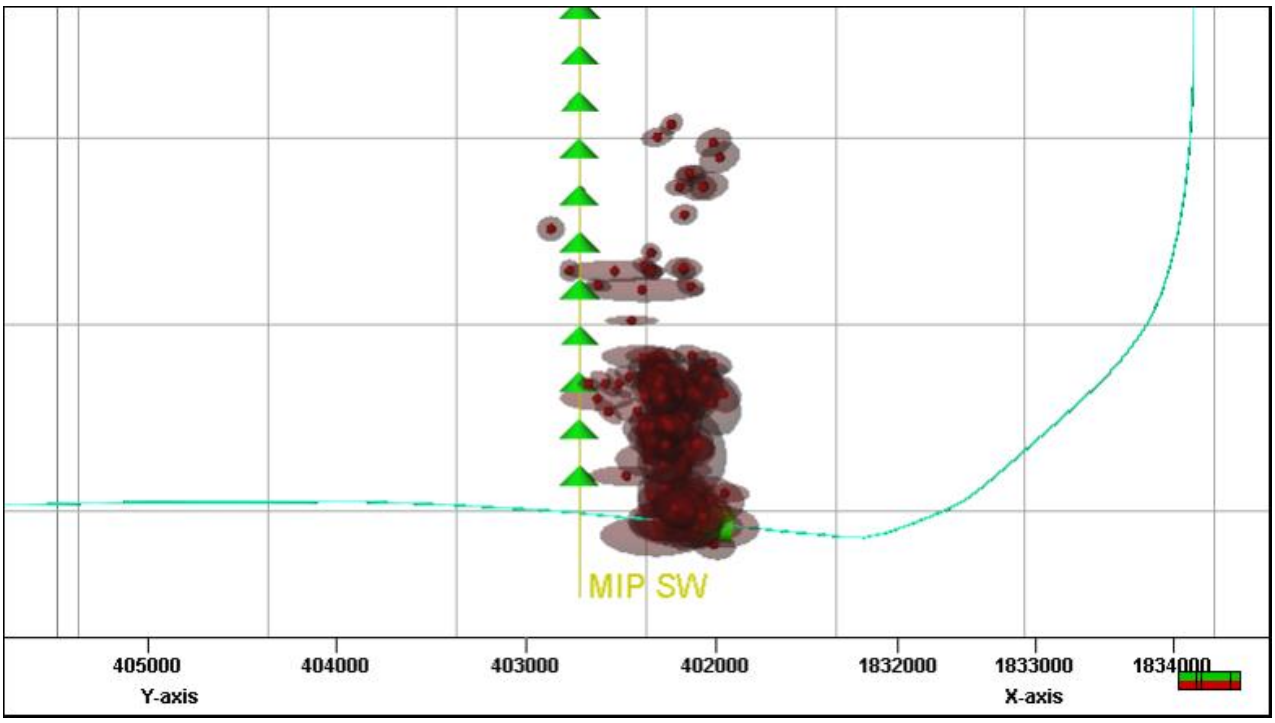



**Figure 5-234 - MIP 5H Stage 25 event location uncertainty ellipsoids – side view**

### 5.47.1 MIP 5H Stage 25 On-Site Notes and Observations

## 5.48 MIP 5H Stage 26

The MIP 5H Stage 26 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

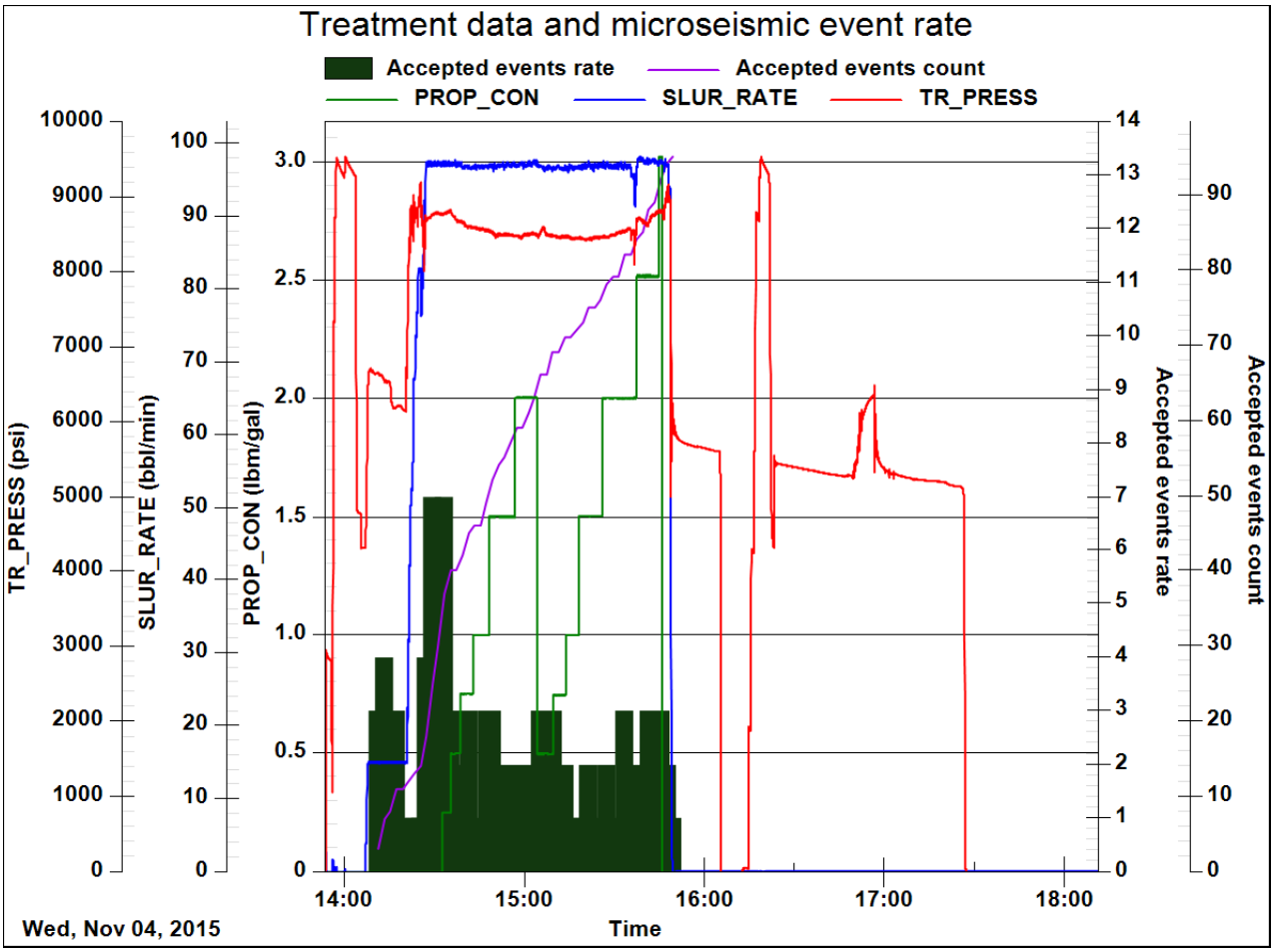



**Figure 5-235 - MIP 5H Stage 26 treatment data and microseismic event rate**

**Table 5.142 - MIP 5H Stage 26 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 337048 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 340048 |
| 100 Mesh (lbm) | 140000 | 145520 |
| 40/70 White (lbm) | 260000 | 256580 |
| Total proppants (lbm) | 400000 | 402100 |

**Table 5.143 - MIP 5H Stage 26 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 96.9 |
| Average pressure (psi) | 8577 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6323 |
| Maximum PPA (lbm/gal) | 3.02 |

**Table 5.144 - MIP 5H Stage 26 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 81 |
| MS length (ft) | 1349 |
| MS height (ft) | 371 |
| MS volume (million ft3) | 11.8 |

The microseismic data from MIP 5H Stage 26 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

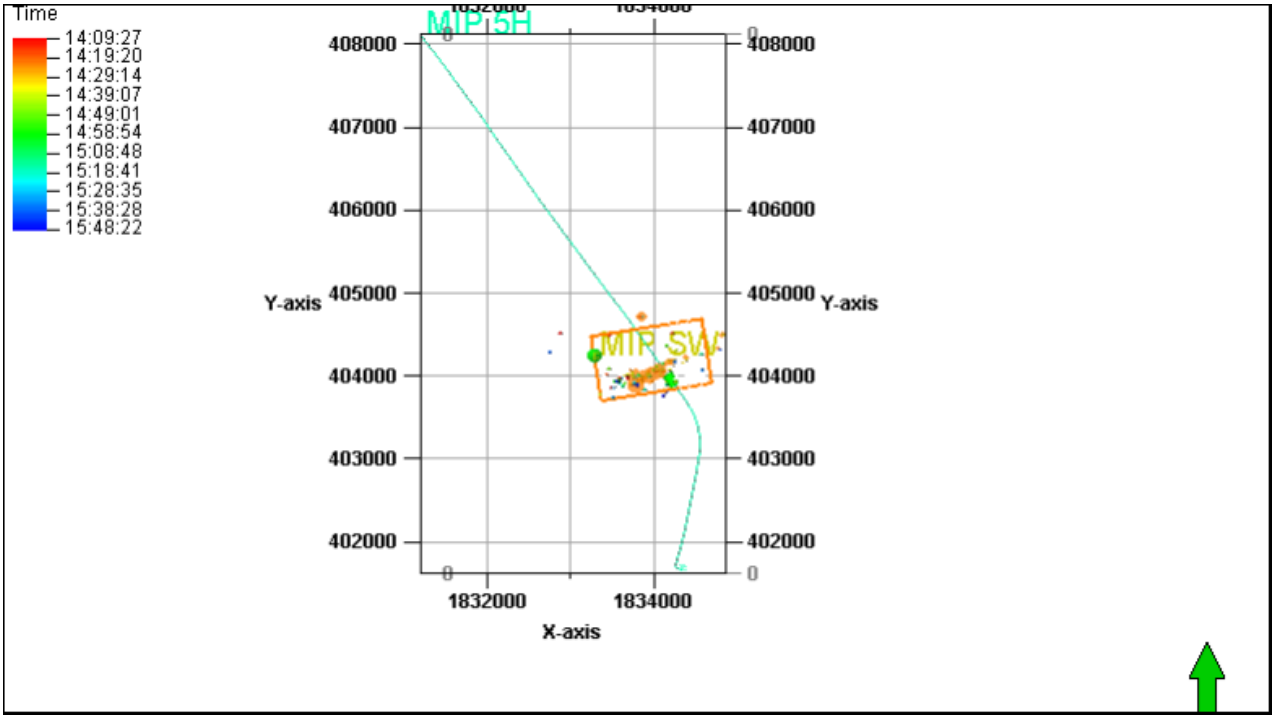



**Figure 5-236 - MIP 5H Stage 26 map view (length and width)**

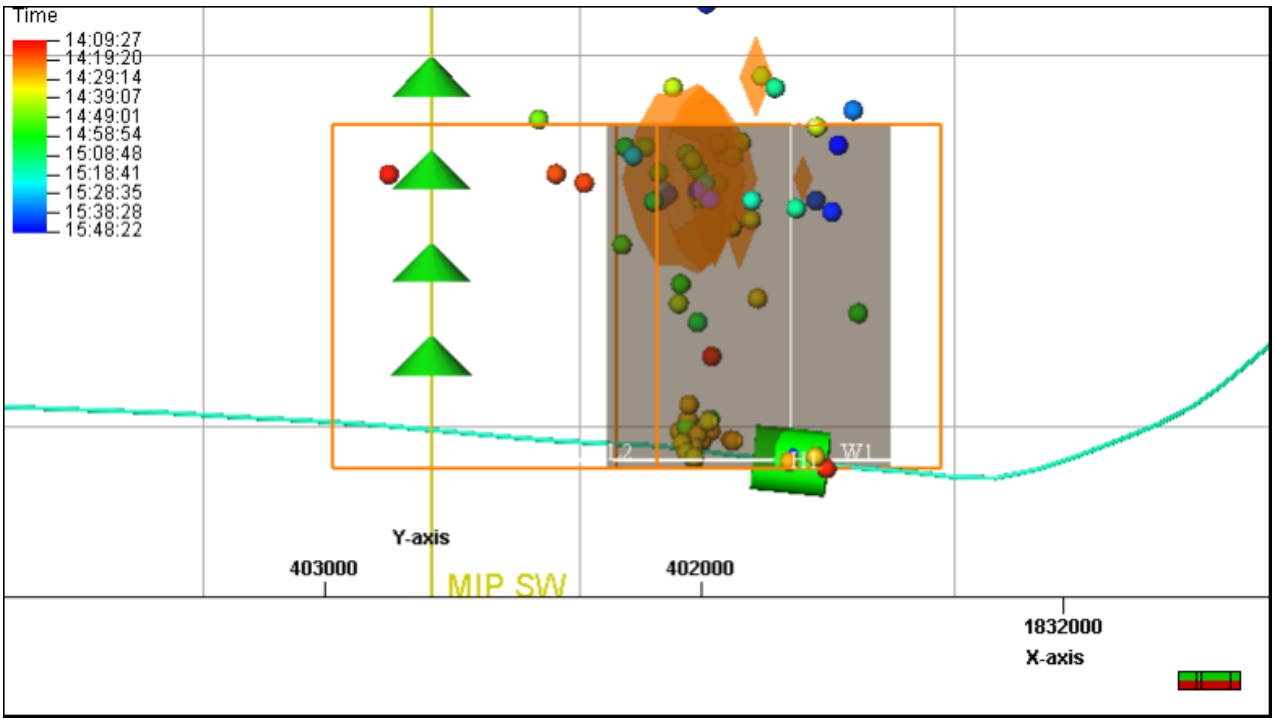



**Figure 5-237 - MIP 5H Stage 26 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 26 are shown below in map and transverse views.

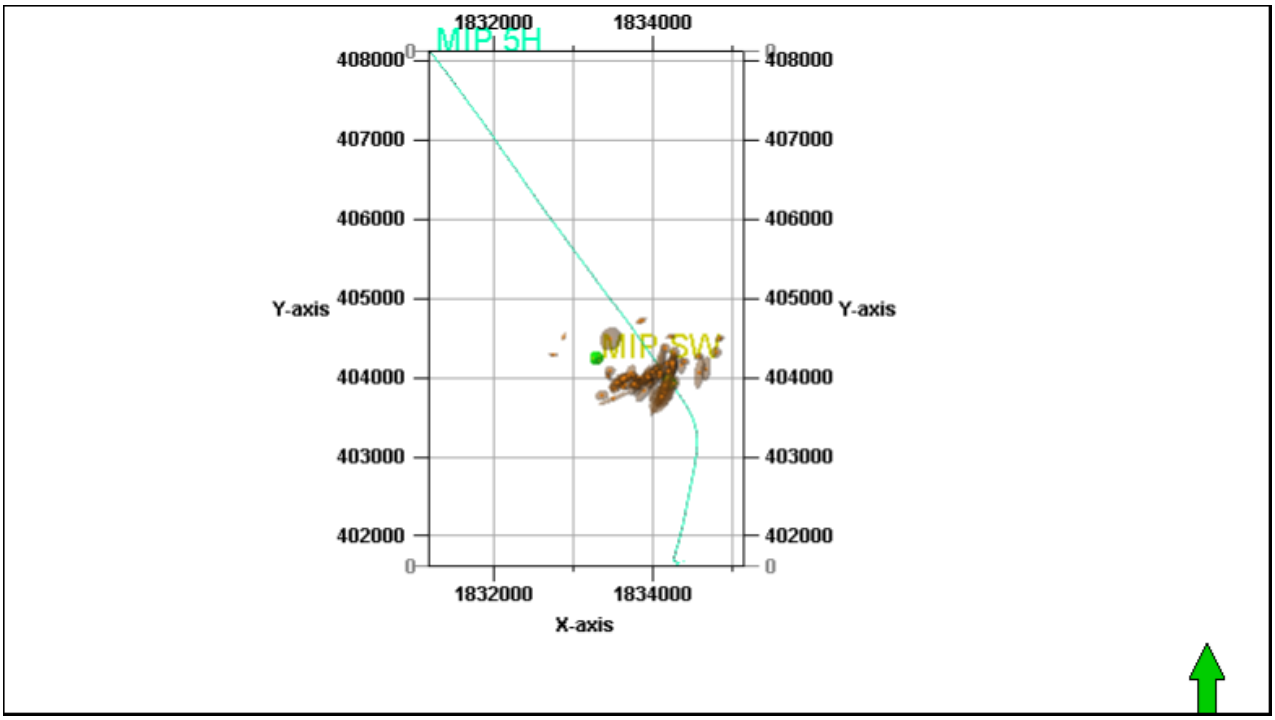



**Figure 5-238 - MIP 5H Stage 26 event location uncertainty ellipsoids – map view**

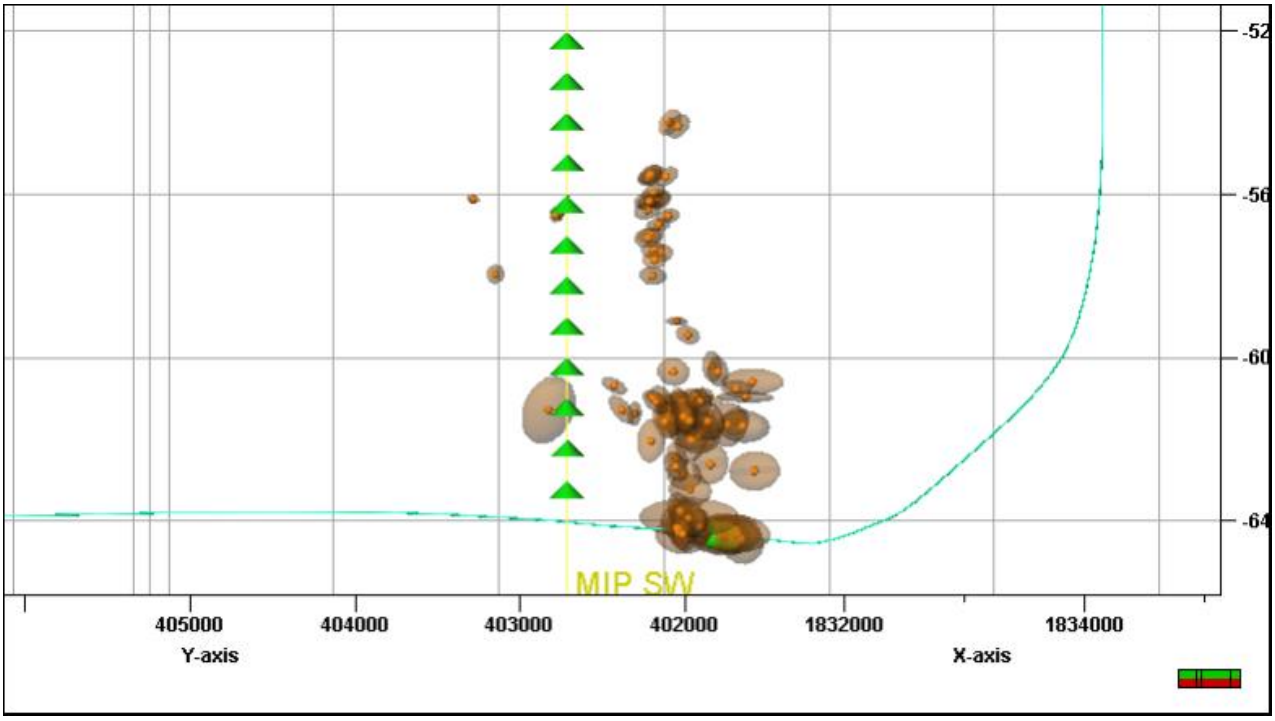



**Figure 5-239 - MIP 5H Stage 26 event location uncertainty ellipsoids – side view**

### 5.48.1 MIP 5H Stage 26 On-Site Notes and Observations

## 5.49 MIP 5H Stage 27

The MIP 5H Stage 27 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

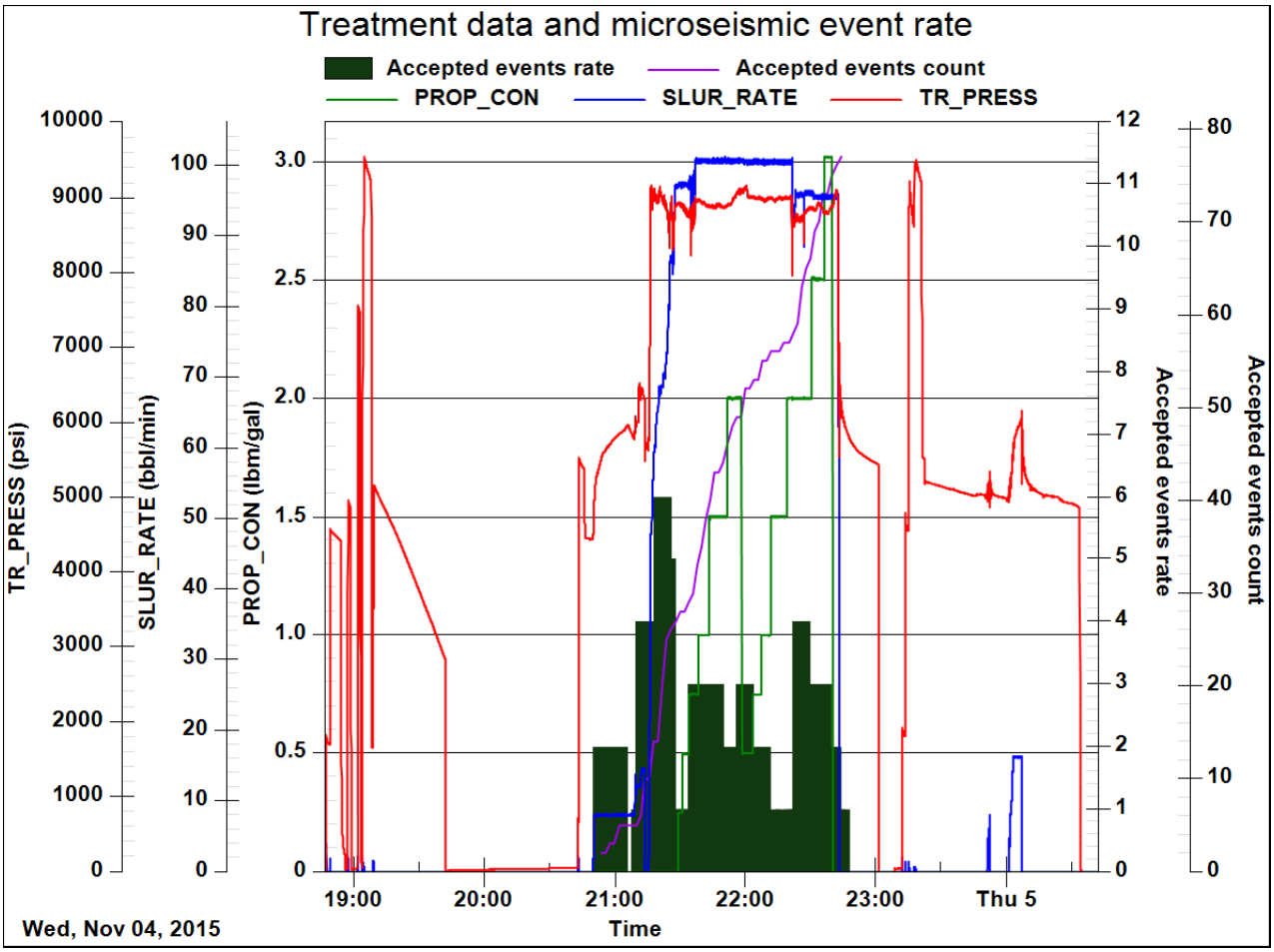



**Figure 5-240 - MIP 5H Stage 27 treatment data and microseismic event rate**

**Table 5.145 - MIP 5H Stage 27 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 333563 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 336563 |
| 100 Mesh (lbm) | 140000 | 140340 |
| 40/70 White (lbm) | 260000 | 258480 |
| Total proppants (lbm) | 400000 | 398820 |

**Table 5.146 - MIP 5H Stage 27 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 93.9 |
| Average pressure (psi) | 8829 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6250 |
| Maximum PPA (lbm/gal) | 3.021 |

**Table 5.147 - MIP 5H Stage 27 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 70 |
| MS length (ft) | 1447 |
| MS height (ft) | 384 |
| MS volume (million ft3) | 2.5 |

The microseismic data from MIP 5H Stage 27 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

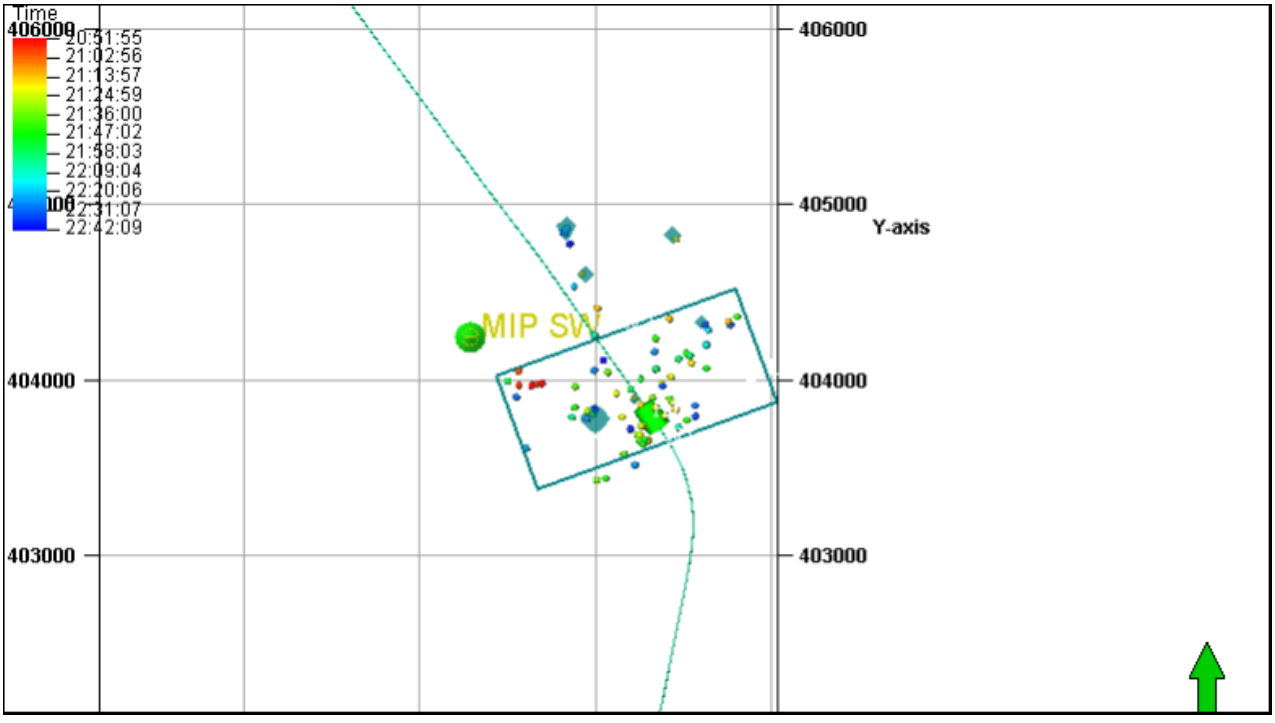



**Figure 5-241 - MIP 5H Stage 27 map view (length and width)**

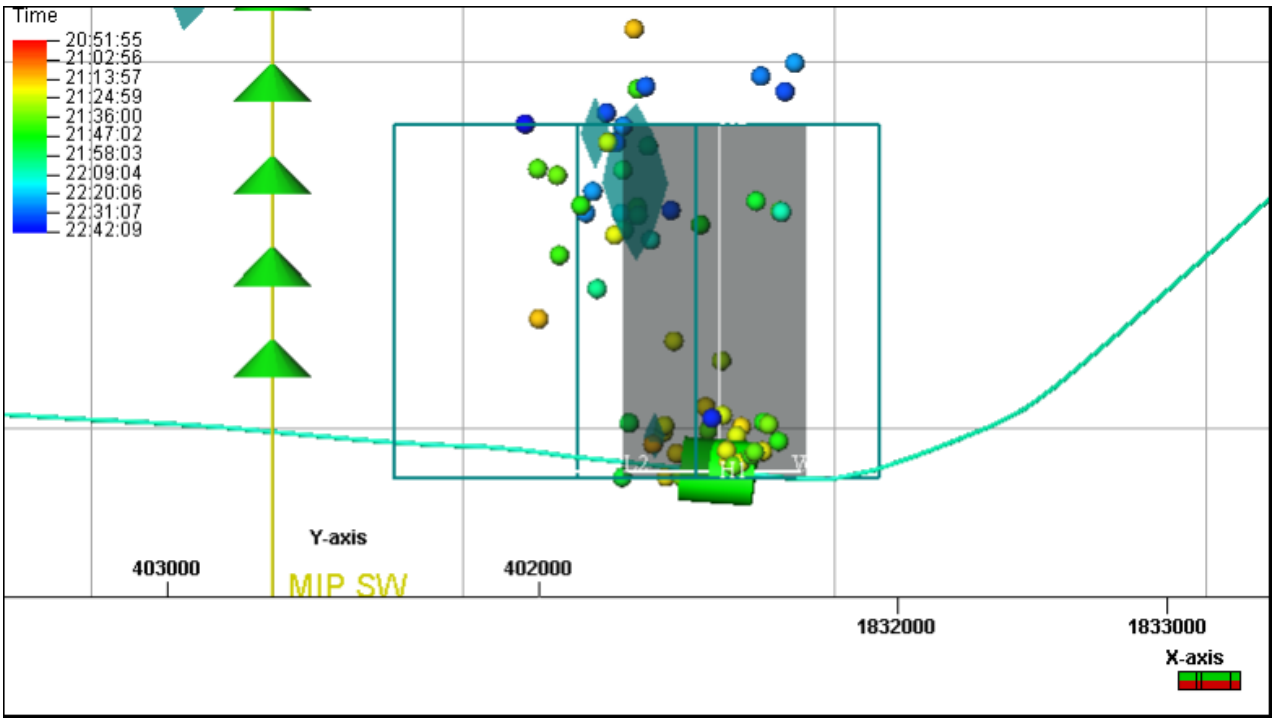



**Figure 5-242 - MIP 5H Stage 27 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 27 are shown below in map and transverse views.

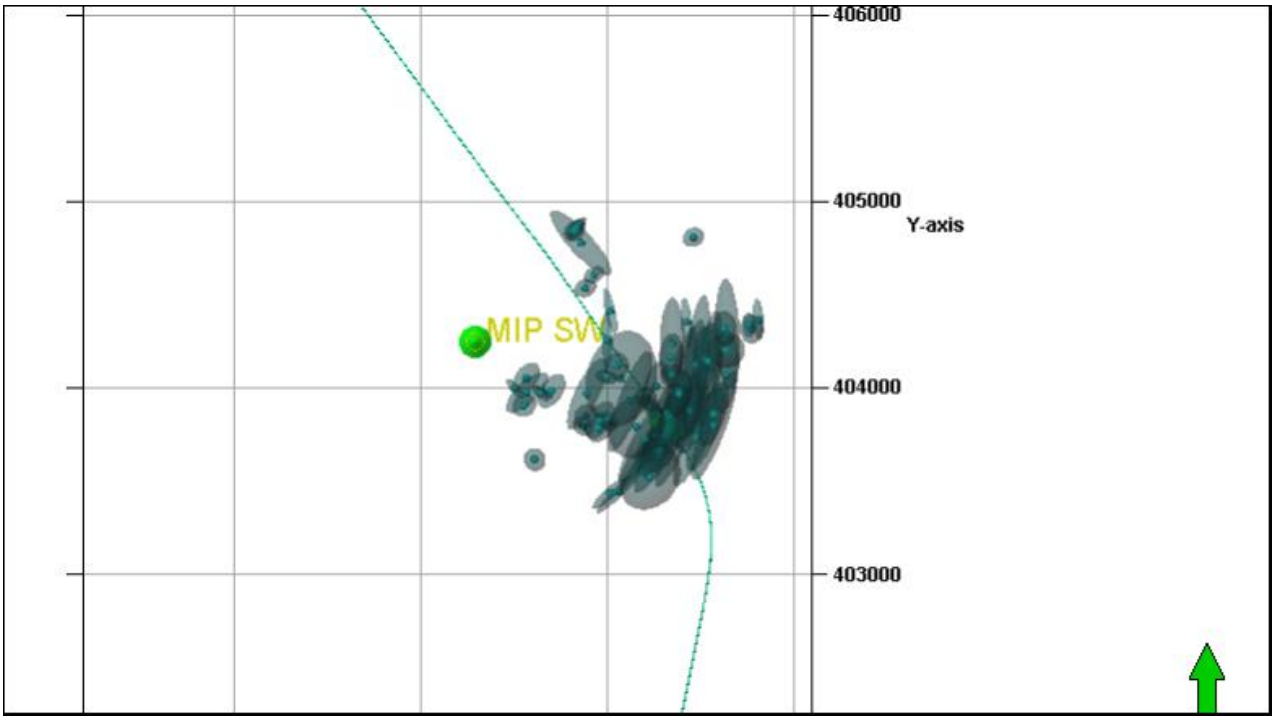



**Figure 5-243 - MIP 5H Stage 27 event location uncertainty ellipsoids – map view**

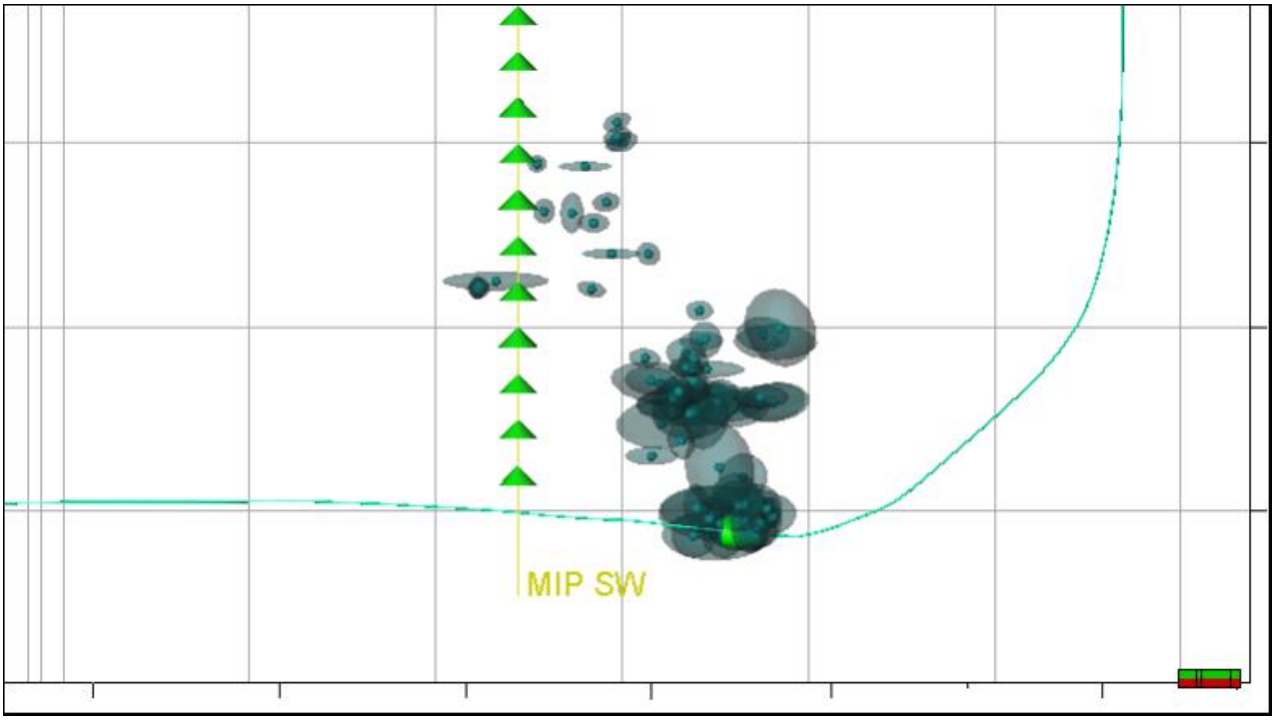



**Figure 5-244 - MIP 5H Stage 27 event location uncertainty ellipsoids – side view**

### 5.49.1 MIP 5H Stage 27 On-Site Notes and Observations

## 5.50 MIP 5H Stage 28

The MIP 5H Stage 28 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

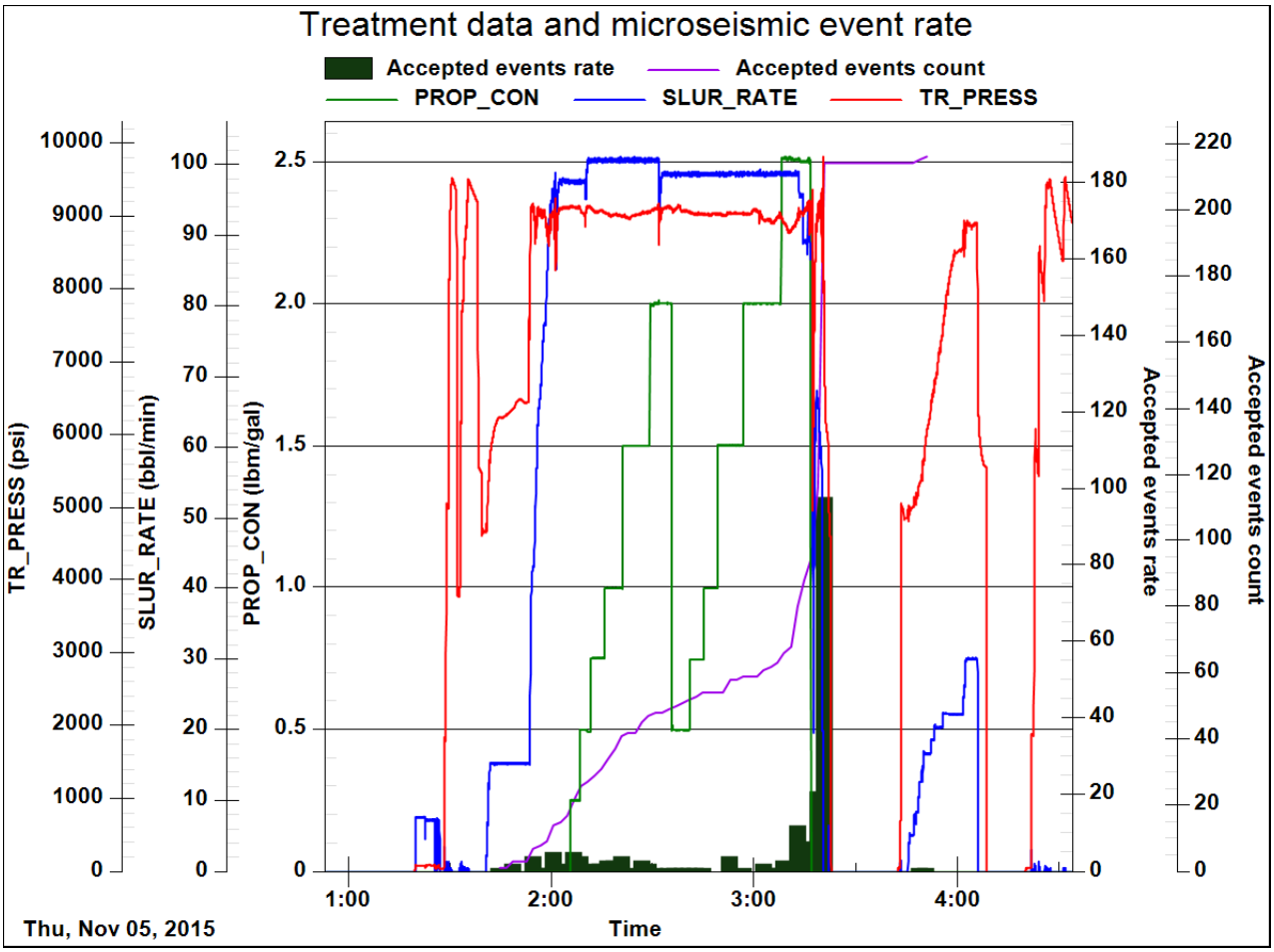



**Figure 5-245 - MIP 5H Stage 28 treatment data and microseismic event rate**

**Table 5.148 - MIP 5H Stage 28 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 348350 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 351350 |
| 100 Mesh (lbm) | 140000 | 140980 |
| 40/70 White (lbm) | 260000 | 253800 |
| Total proppants (lbm) | 400000 | 394780 |

**Table 5.149 - MIP 5H Stage 28 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 91.2 |
| Average pressure (psi) | 8899 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6358 |
| Maximum PPA (lbm/gal) | 2.518 |

**Table 5.150 - MIP 5H Stage 28 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 30 |
| MS length (ft) | 1192 |
| MS height (ft) | 473 |
| MS volume (million ft3) | 24.8 |

The microseismic data from MIP 5H Stage 28 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

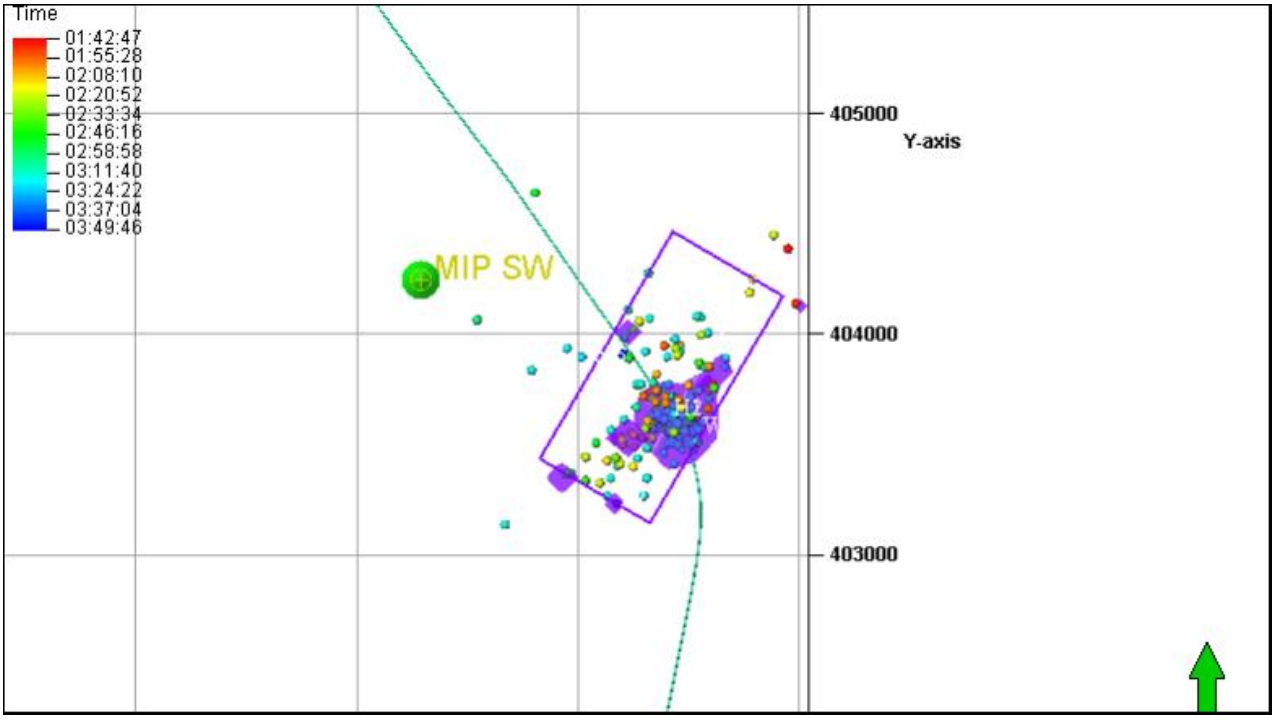



**Figure 5-246 - MIP 5H Stage 28 map view (length and width)**

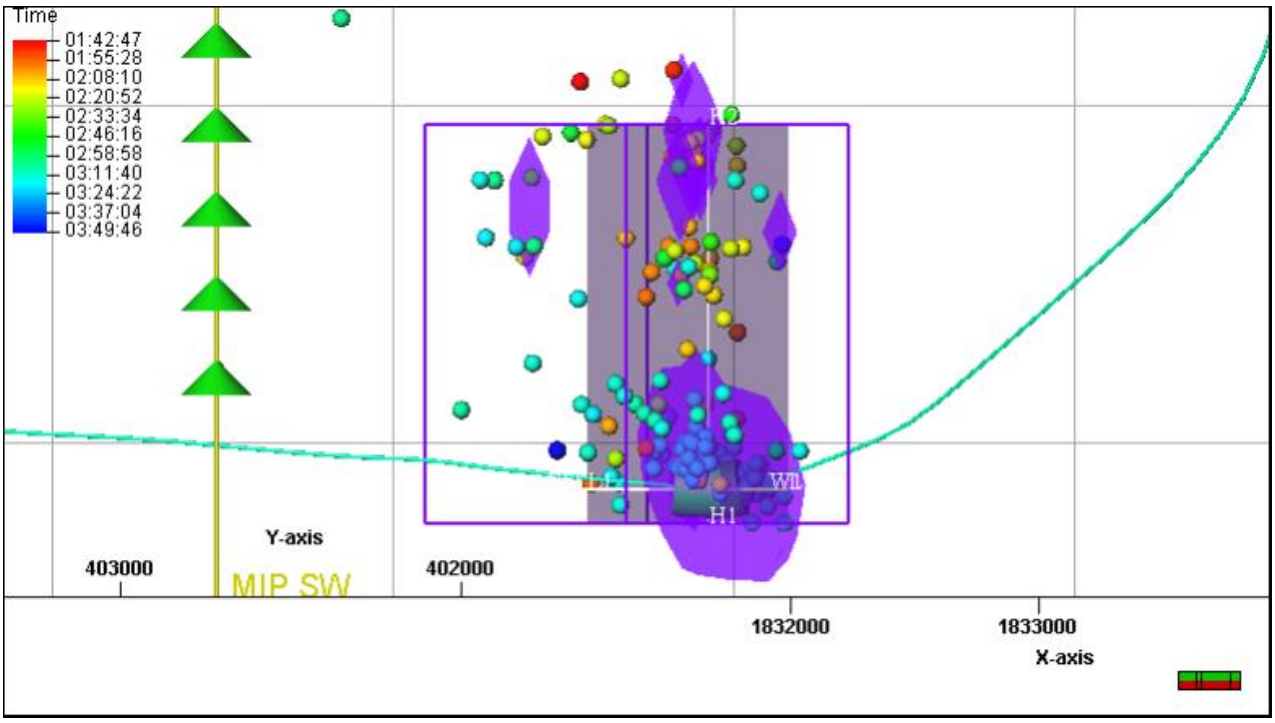



**Figure 5-247 - MIP 5H Stage 28 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 28 are shown below in map and transverse views.

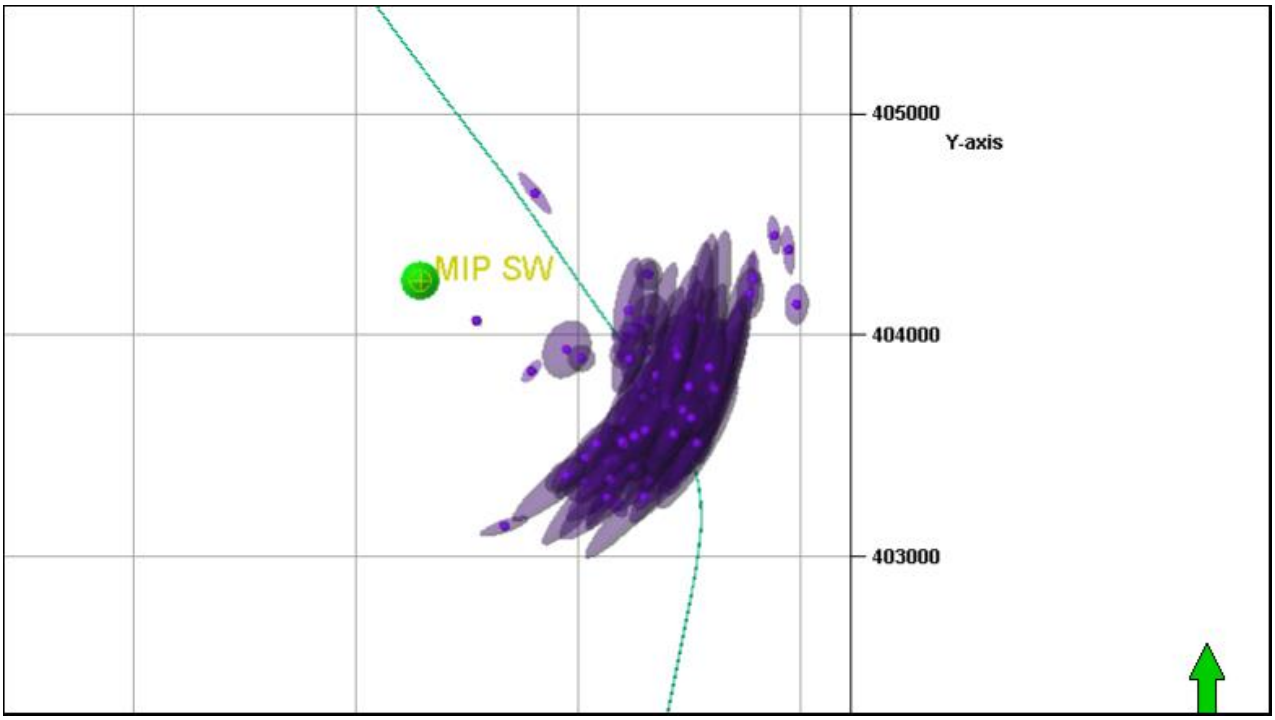



**Figure 5-248 - MIP 5H Stage 28 event location uncertainty ellipsoids – map view**

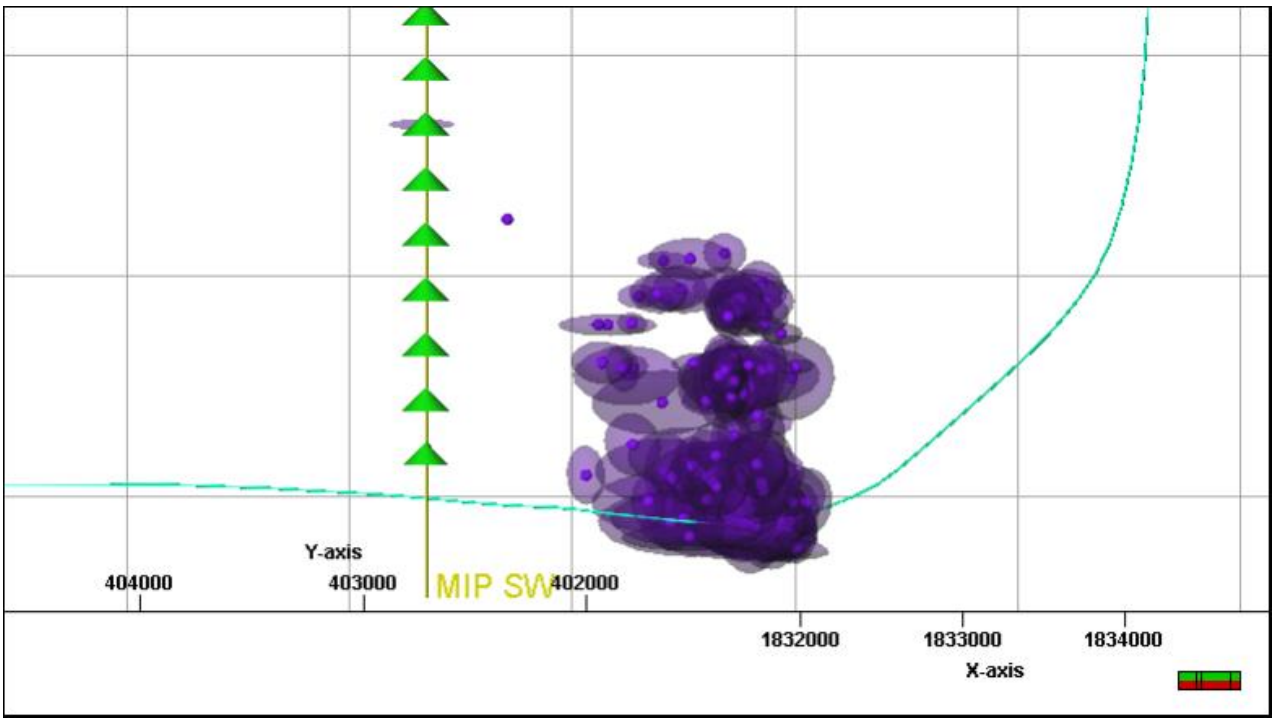



**Figure 5-249 - MIP 5H Stage 28 event location uncertainty ellipsoids – side view**

### 5.50.1 MIP 5H Stage 28 On-Site Notes and Observations

## 5.51 MIP 5H Stage 29

The MIP 5H Stage 29 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

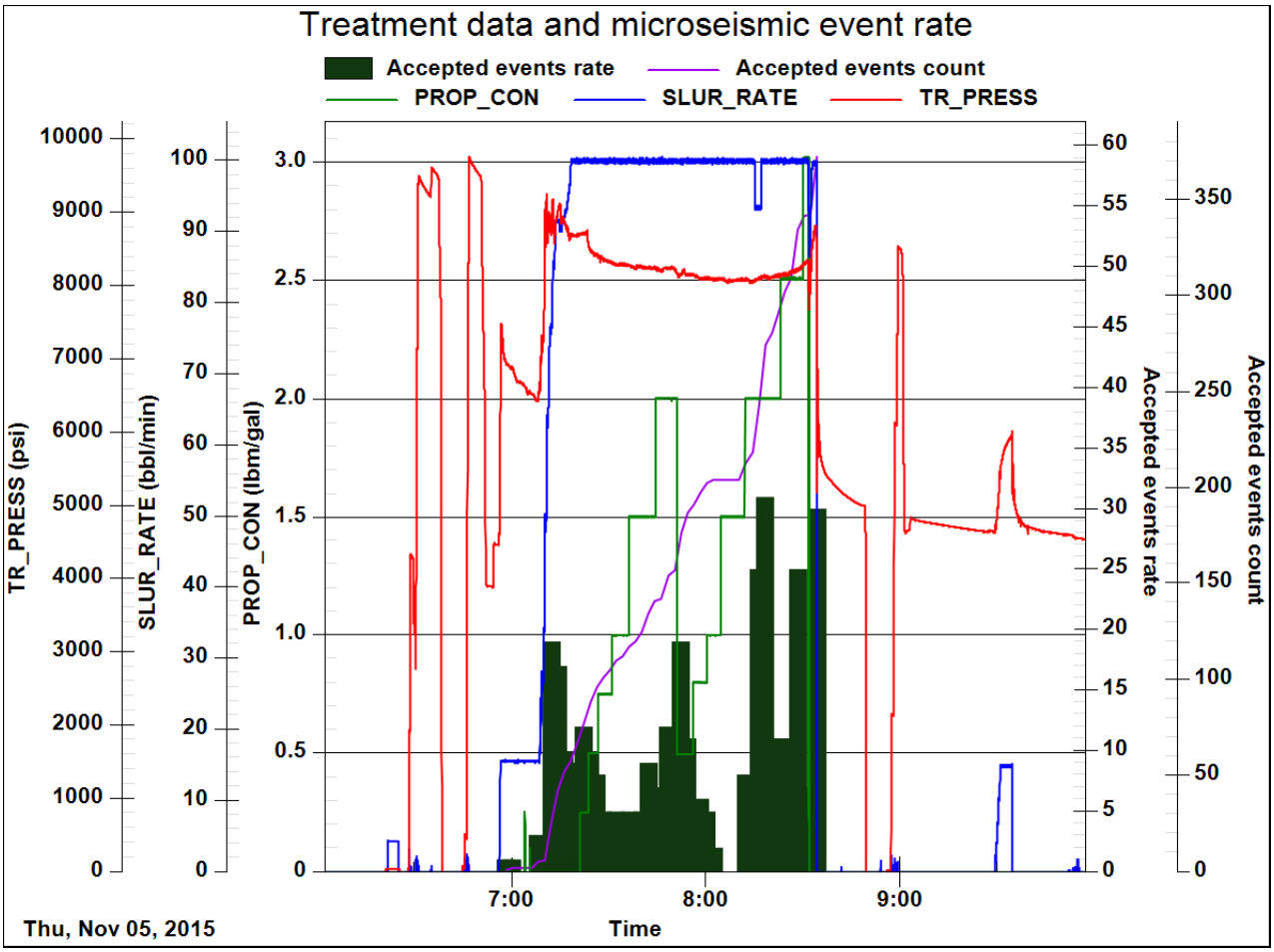



**Figure 5-250 - MIP 5H Stage 29 treatment data and microseismic event rate**

**Table 5.151 - MIP 5H Stage 29 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 334151 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 337151 |
| 100 Mesh (lbm) | 140000 | 139720 |
| 40/70 White (lbm) | 260000 | 260000 |
| Total proppants (lbm) | 400000 | 399720 |

**Table 5.152 - MIP 5H Stage 29 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.6 |
| Average pressure (psi) | 8229 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6513 |
| Maximum PPA (lbm/gal) | 3.022 |

**Table 5.153 - MIP 5H Stage 29 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 48 |
| MS length (ft) | 773 |
| MS height (ft) | 487 |
| MS volume (million ft3) | 40.6 |

The microseismic data from MIP 5H Stage 29 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

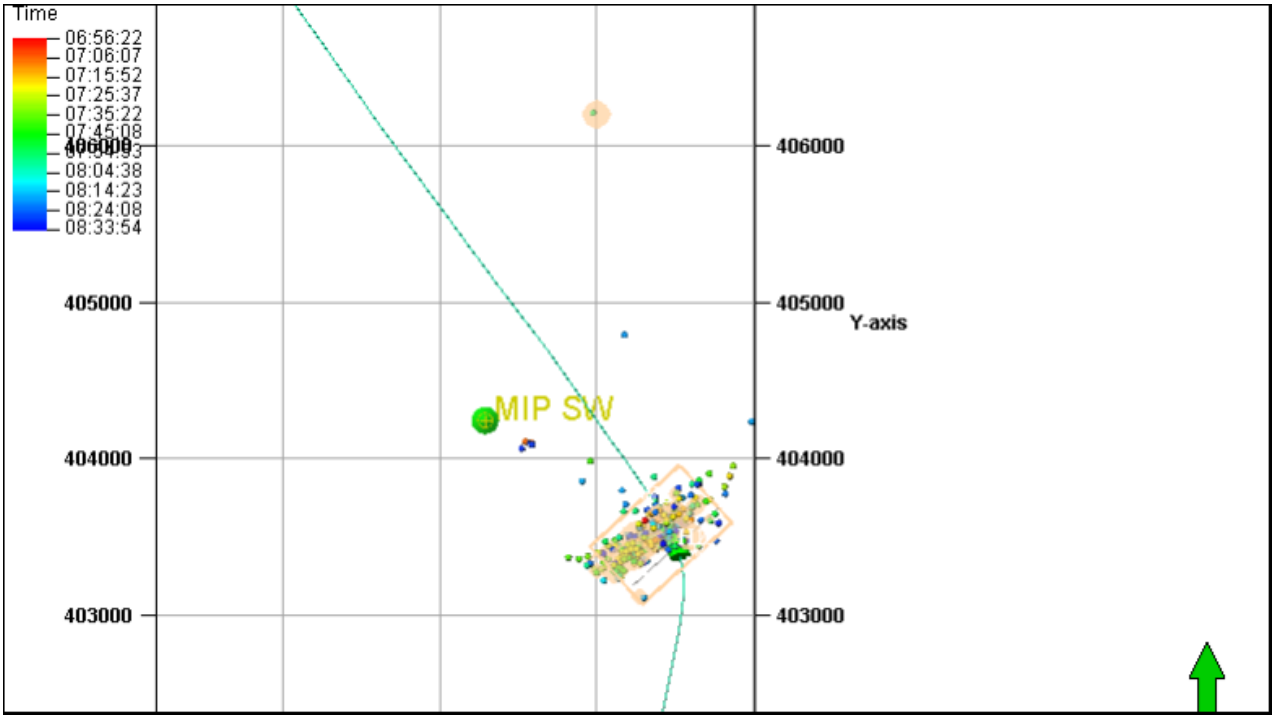



**Figure 5-251 - MIP 5H Stage 29 map view (length and width)**

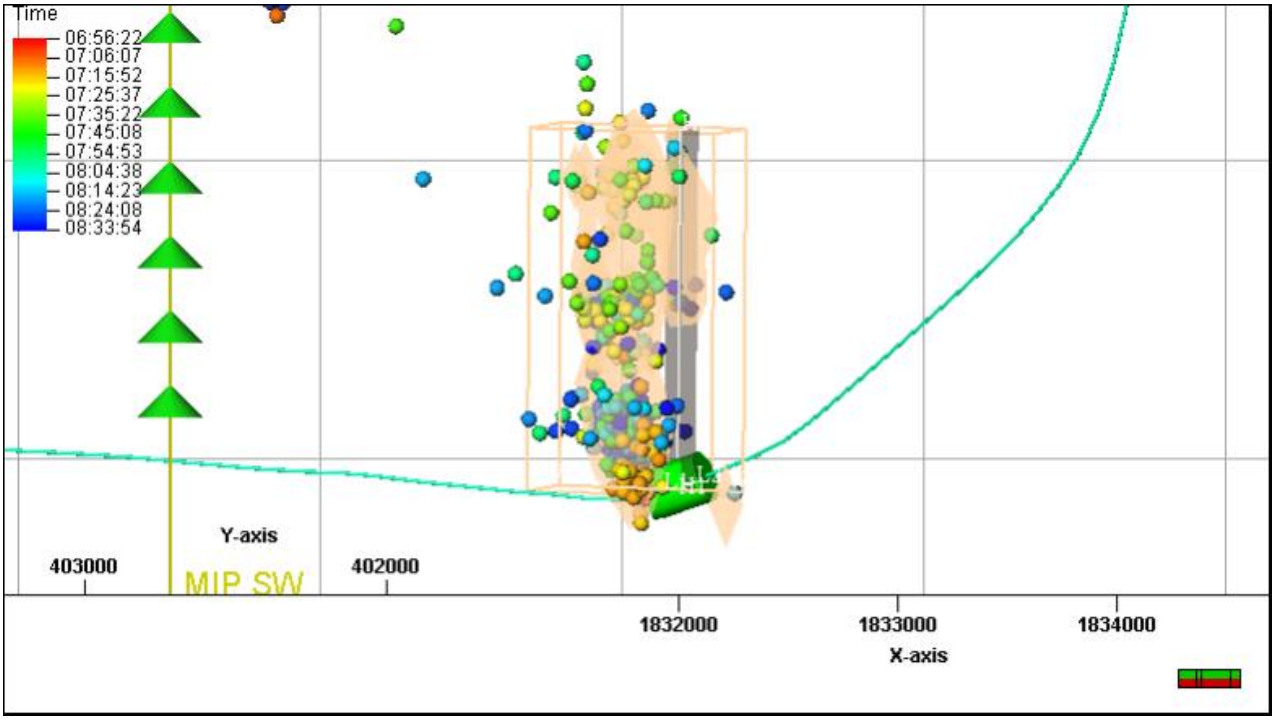



**Figure 5-252 - MIP 5H Stage 29 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 29 are shown below in map and transverse views.

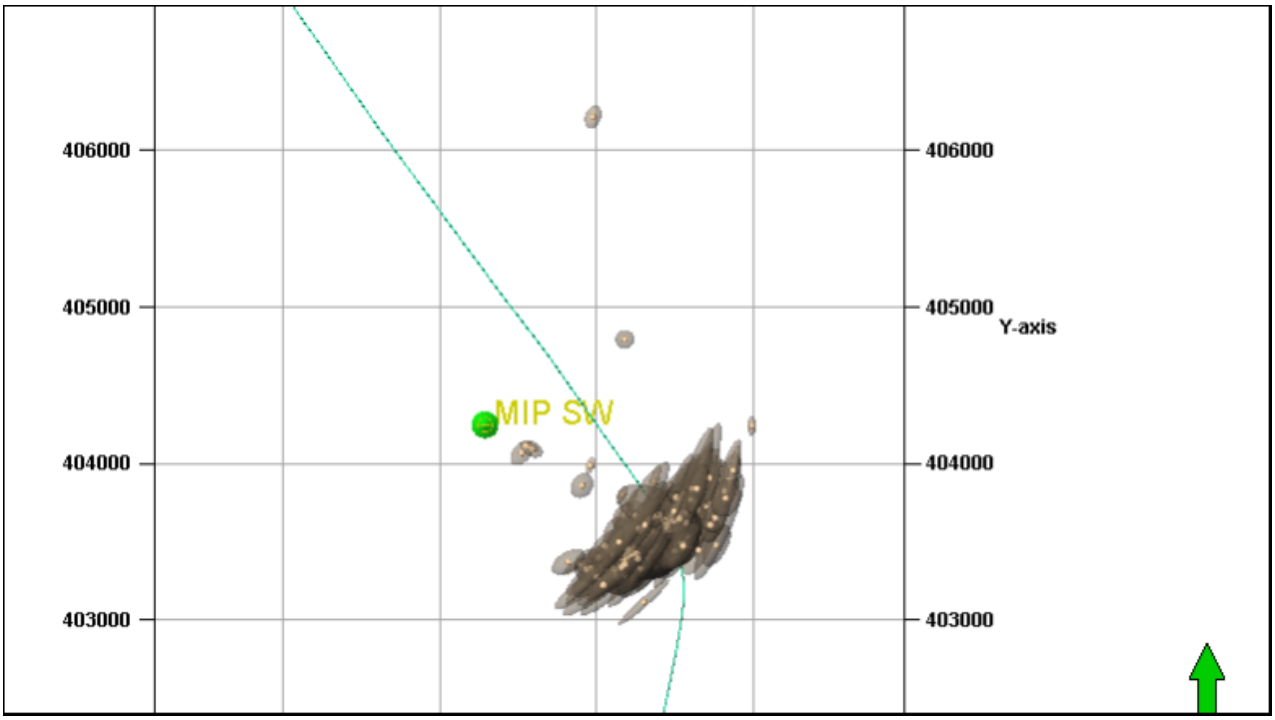



**Figure 5-253 - MIP 5H Stage 29 event location uncertainty ellipsoids – map view**

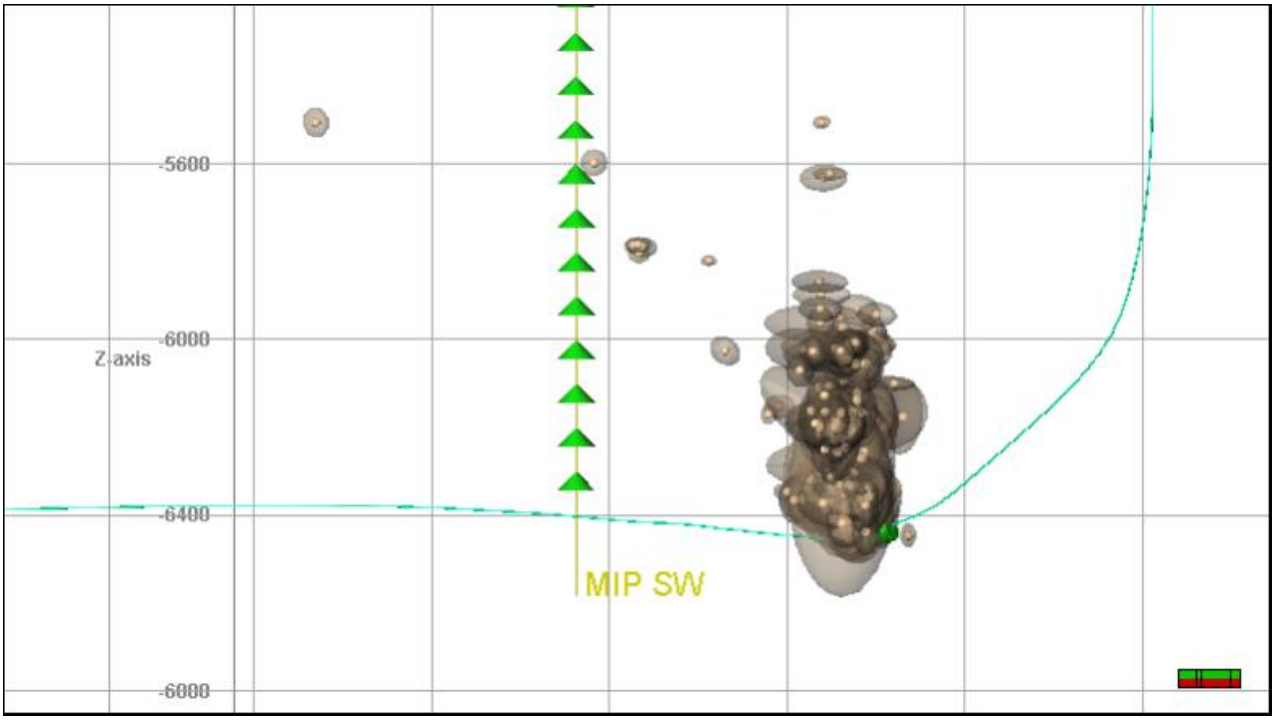



**Figure 5-254 - MIP 5H Stage 29 event location uncertainty ellipsoids – side view**

### 5.51.1 MIP 5H Stage 29 On-Site Notes and Observations

## 5.52 MIP 5H Stage 30

The MIP 5H Stage 30 treatment data and microseismic event rate are shown below. The microseismic events are color coded according to time as shown in the legend for each figure.

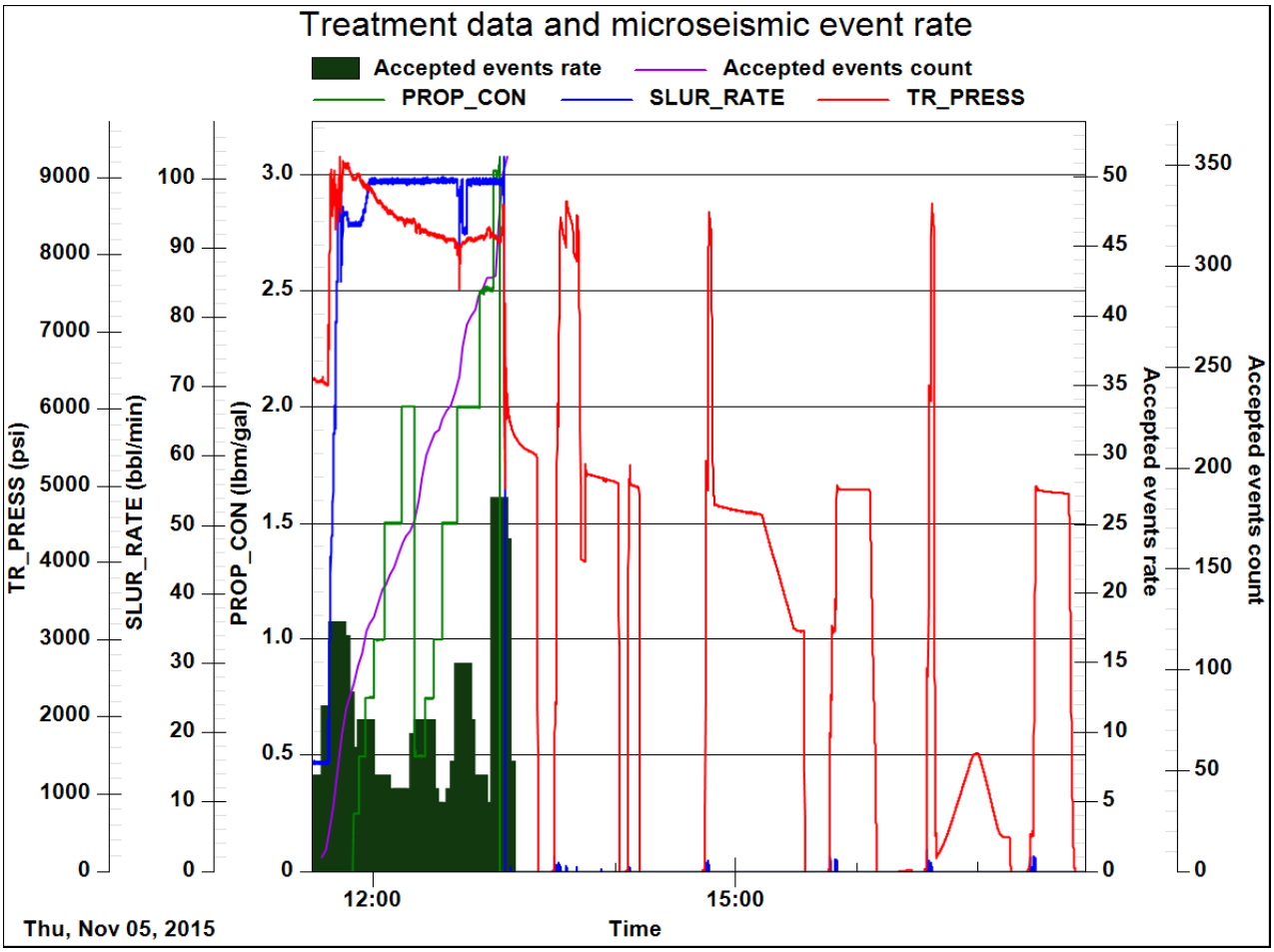



**Figure 5-255 - MIP 5H Stage 30 treatment data and microseismic event rate**

**Table 5.154 - MIP 5H Stage 30 fracture treatment volumes**

| Description | Designed | Placed |
|---|---|---|
| Slickwater (gal) | 244840 | 338951 |
| Sapphire (gal) | 0 | 0 |
| HCl (gal) | 3000 | 3000 |
| WF (gal) | Not used | 0 |
| Total fluids (gal) | 247840 | 341951 |
| 100 Mesh (lbm) | 140000 | 140620 |
| 40/70 White (lbm) | 260000 | 259940 |
| Total proppants (lbm) | 400000 | 400560 |

**Table 5.155 - MIP 5H Stage 30 treatment data summary**

| Description | Value |
|---|---|
| Average rate (bbl/min) | 99.2 |
| Average pressure (psi) | 8368 |
| Pre-treatment ISIP (psi) | N/A |
| Post-treatment ISIP (psi) | 6482 |
| Maximum PPA (lbm/gal) | 3.077 |

**Table 5.156 - MIP 5H Stage 30 microseismic event geometry**

| Description | Microseismic geometry |
|---|---|
| Fracture azimuth (deg) | 70 |
| MS length (ft) | 1334 |
| MS height (ft) | 567 |
| MS volume (million ft3) | 62.4 |

The microseismic data from MIP 5H Stage 30 is shown below in map and transverse views. The microseismic events are color coded according to time as shown on the plot legend. The microseismic dimensions are also shown.

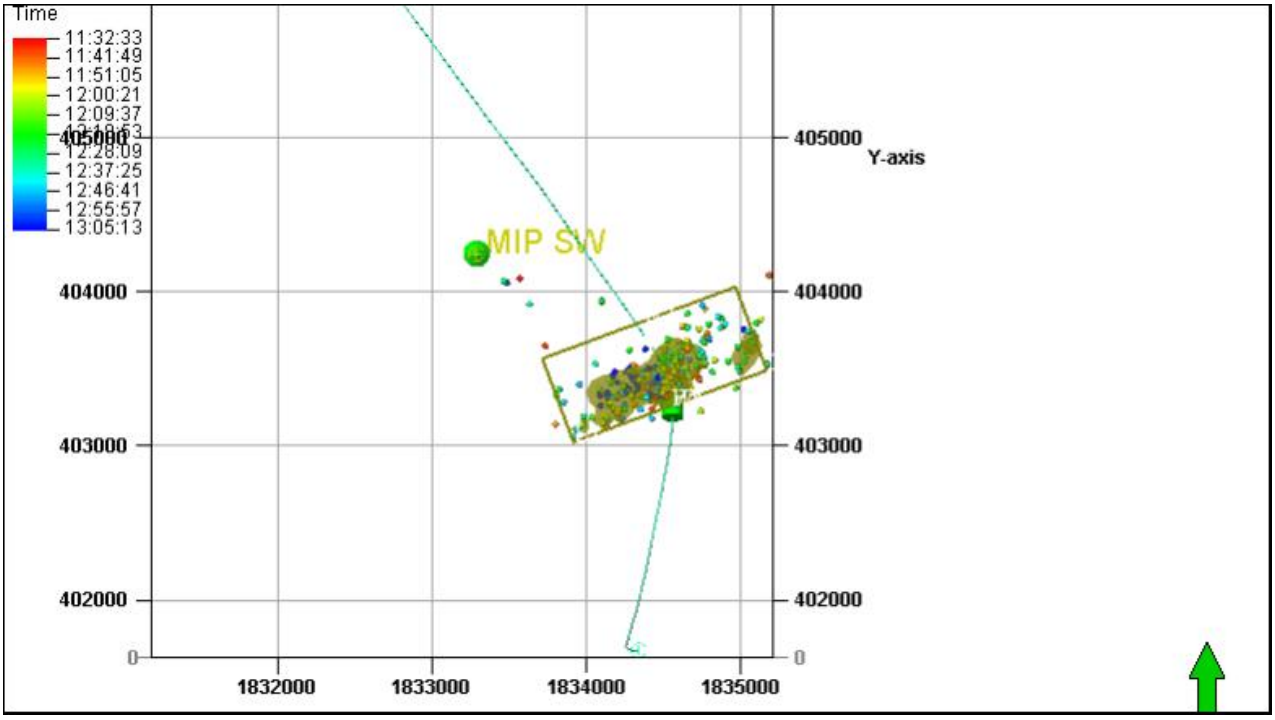



**Figure 5-256 - MIP 5H Stage 30 map view (length and width)**

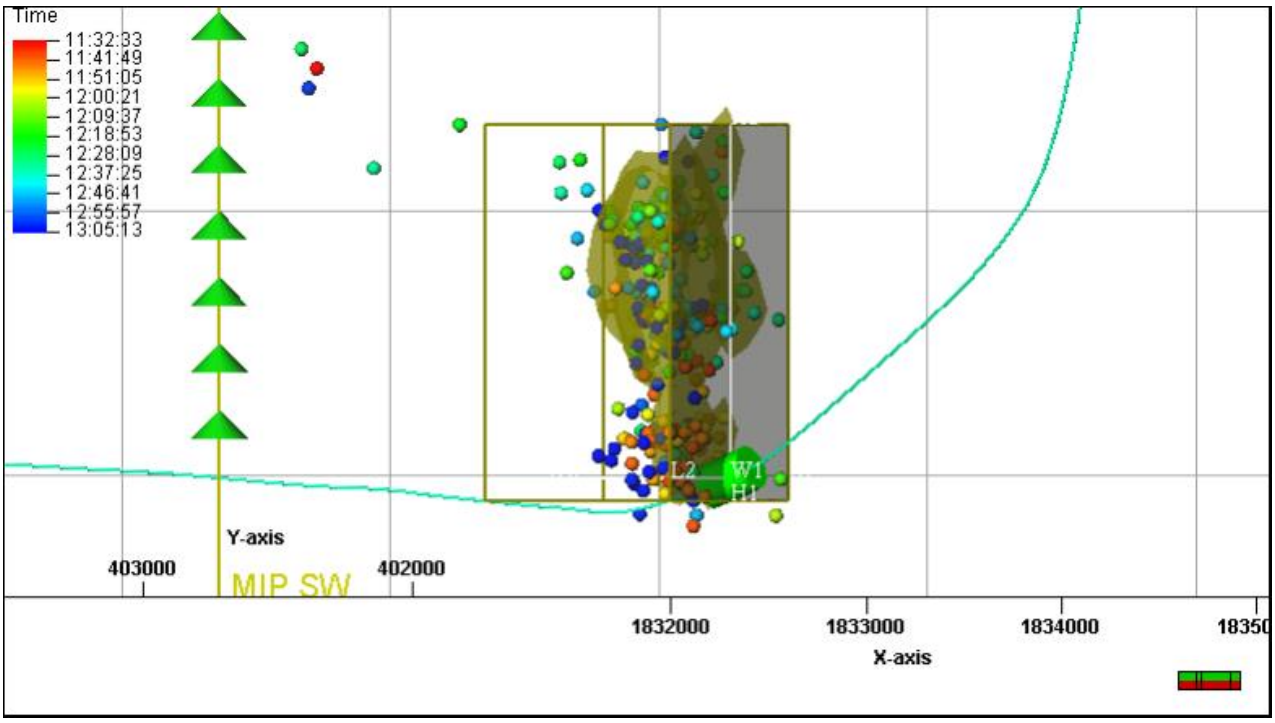



**Figure 5-257 - MIP 5H Stage 30 transverse view (height and width)**

The microseismic event location uncertainty ellipsoids for MIP 5H Stage 30 are shown below in map and transverse views.

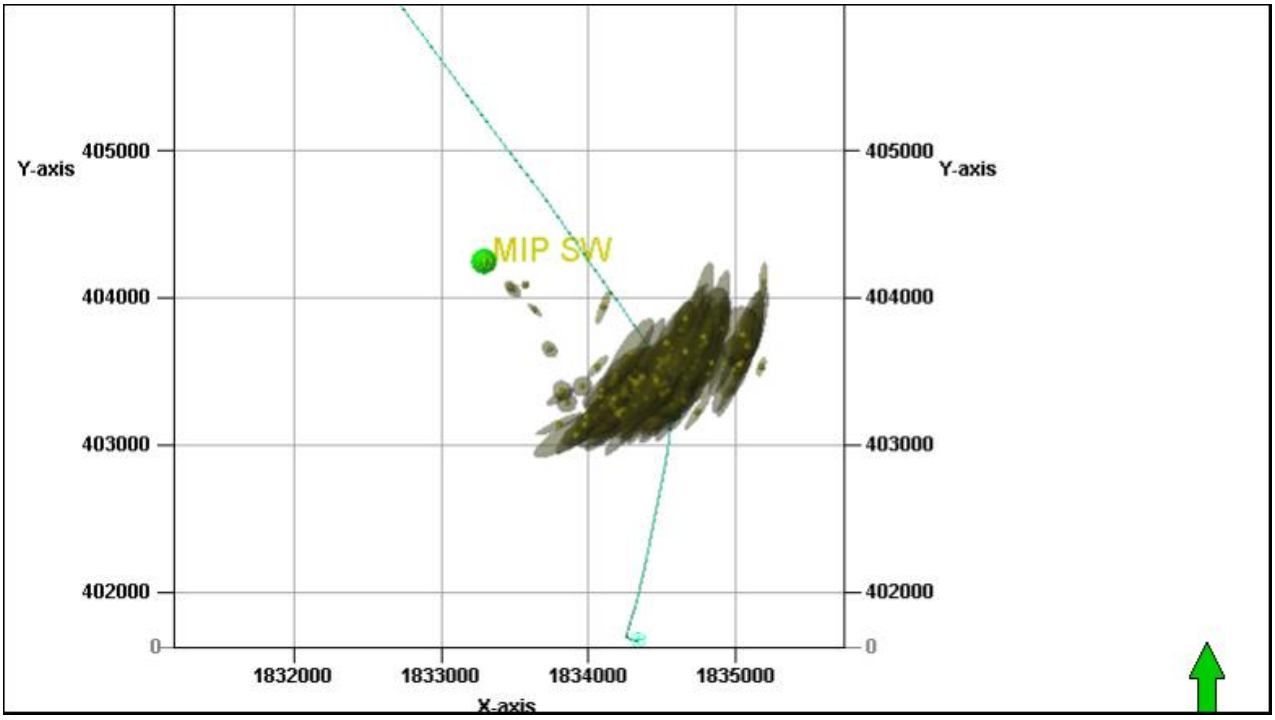



**Figure 5-258 - MIP 5H Stage 30 event location uncertainty ellipsoids – map view**

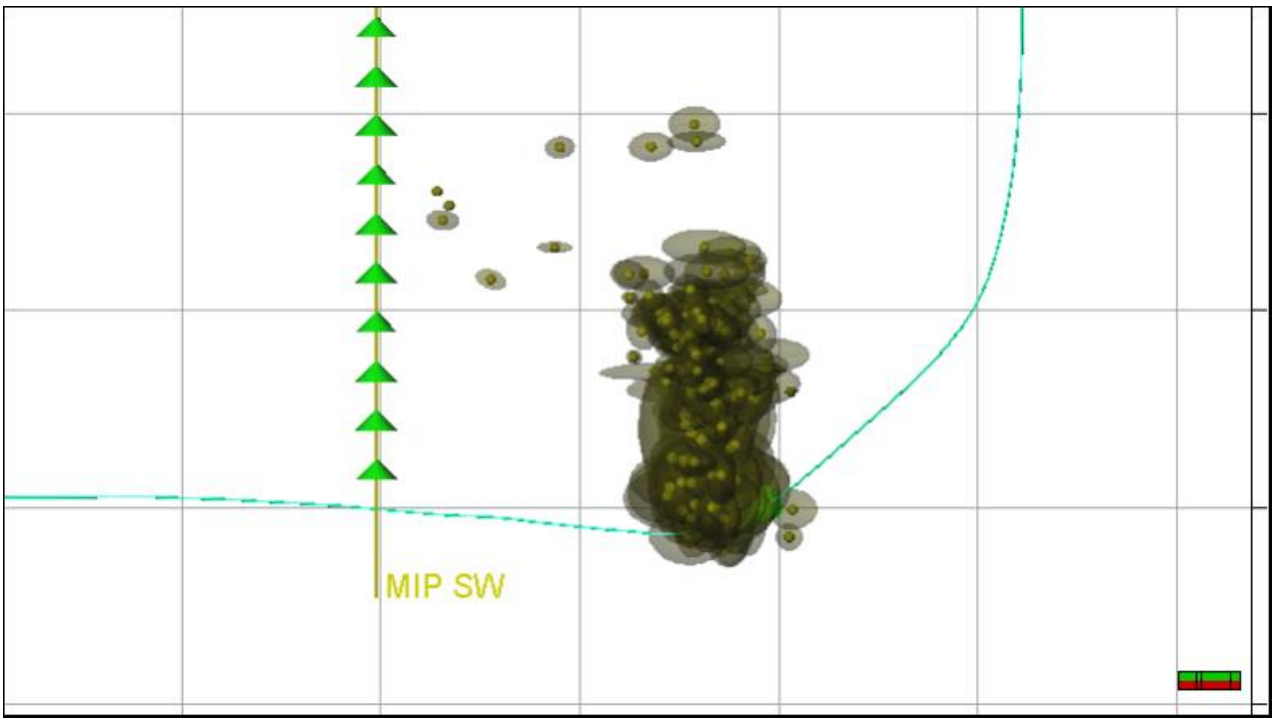



**Figure 5-259 - MIP 5H Stage 30 event location uncertainty ellipsoids – side view**

### 5.52.1 MIP 5H Stage 30 On-Site Notes and Observations

# 6. Appendix B: QAQC Geophysics Processing Review

The total data set was scanned with an event detector algorithm which first detects signals above a given signal-to-noise threshold on each shuttle. For each detected signal, the known velocity model can be used to calculate a range of expected signal arrival times for the other shuttles. Signals arriving in these expected time ranges are said to be associated, meaning they come from the same microseismic event. If signals are detected on a given minimum number of shuttles, an event is declared and stored in an event file for further processing.

Coalescent Microseismic Mapping, or CMM, is an innovative Schlumberger method for micro-earthquake hypocenter determination. Event locations are calculated without manual P and S picking. CMM determined P and S times are visually reviewed and edited for quality control only. Results are usually as good as or better than would be possible with tedious and slow manual picking.

**Monitoring Pattern**

The completion design of the NNE MIP 5H well was a 30-stage plug and perf completion design with five clusters per stage. Stages 1 through 30 were monitored using a 12-shuttle VSI geophone array deployed in the MIP SW well. Data was recorded using a 0.5 ms sampling rate. Tool orientations, calibration shot examples, and quality indicator information are presented later in this report to facilitate evaluation of processes and data quality for this project.

The NNE MIP 3H was a 28-stage plug and perf completion design, with four to five clusters per stage. Stages 7 through 28 were monitored with the same configuration as for the MIP 5H treatment.

**Table 157 - Well head locations**

| Well name | KB (ft) | Easting (ft)* | Northing (ft)* |
|---|---|---|---|
| Treatment Well: MIP 3H | 1082 | 1834344.9 | 401656.6 |
| Treatment Well: MIP 5H | 1072 | 1834336.9 | 401674.9 |
| Monitor Well: MIP SW | 1088 | 1833288.7 | 404245.6 |
| Sonic Well : MIP 3H Pilot | 1080.5 | 1834344.9 | 401656.6 |
| Sonic Well : Statler 3 Pilot | 1080 | 1777699.24 | 440673.53 |

**Table 158 - Summary of stages monitored**

| Treatment well and stage name | Monitored by |
|---|---|
| MIP 5H -- Stages 1-30 | 12-receiver arrays(0.5ms sampling) in MIP SW (6305.99-7405.99' MD) |
| MIP 3H -- Stages 7-28 | 12-receiver arrays(0.5ms sampling) in MIP SW (6305.99-7405.99' MD) |

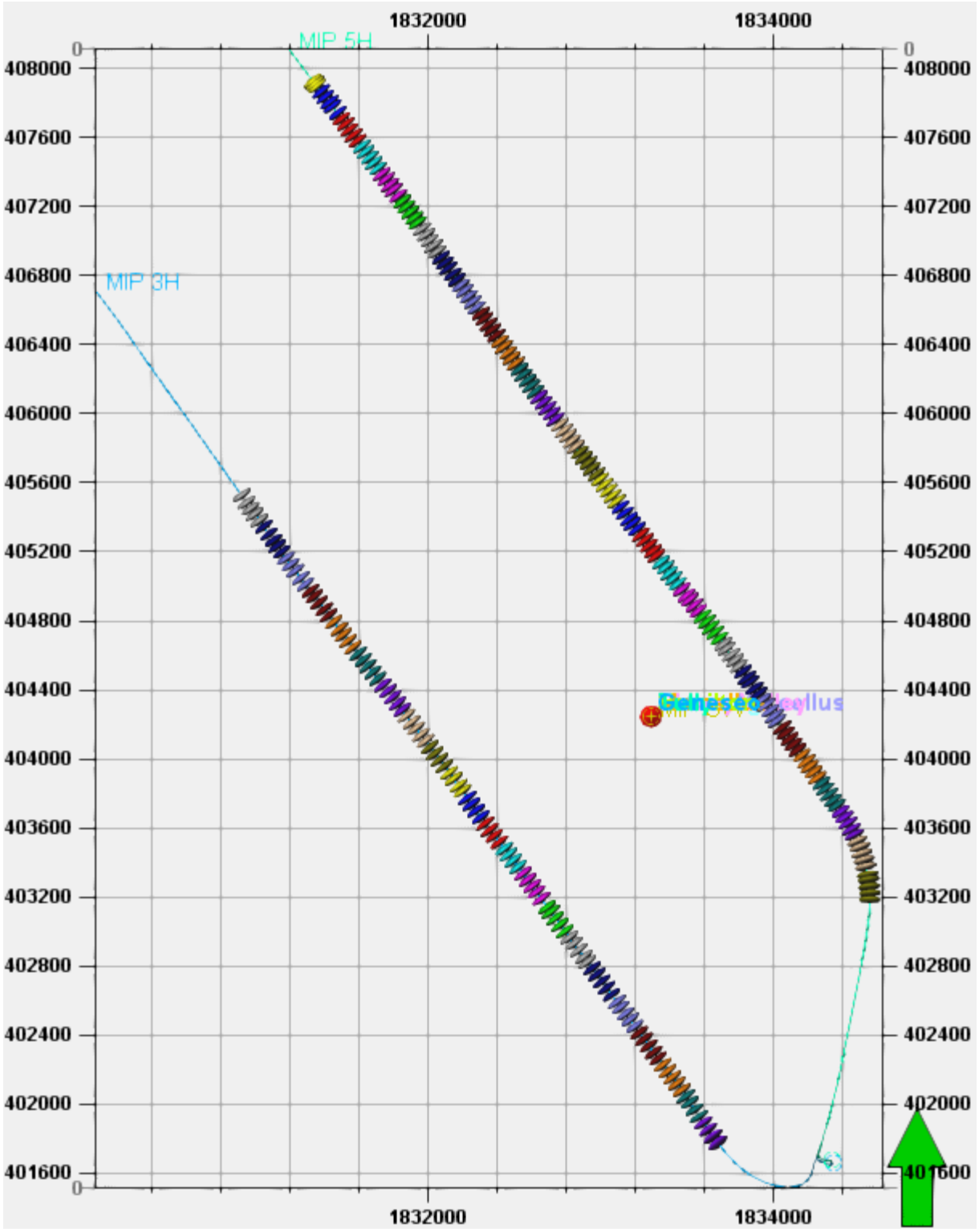



**Figure 6-1 – Map view of the monitoring layout for treatment of the MIP 5H and 3H wells. Stages 1-30 on the 5H and 7-28 on the 3H were monitored using a vertical tool deployment in the MIP SW well.**

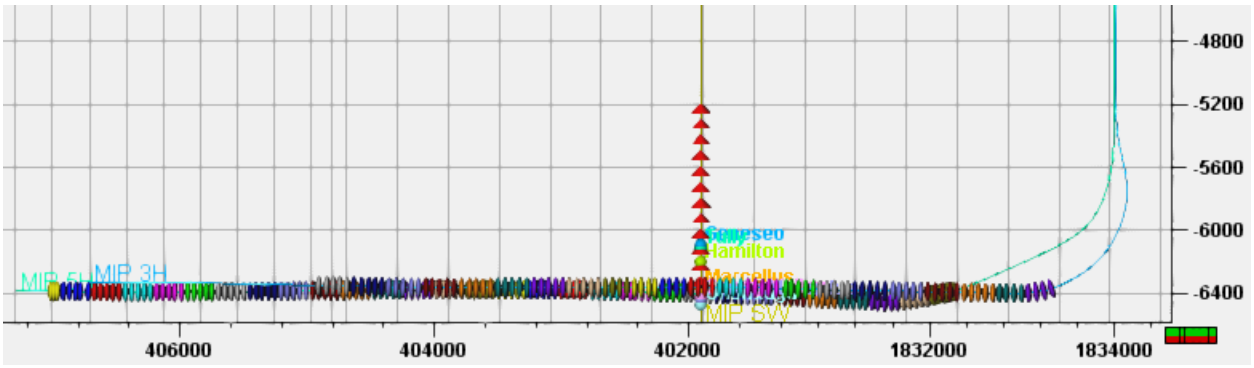



**Figure 6-2 – Cross-section view toward N54°E of the monitoring layout for treatment of the MIP 5H and 3H wells. Stages 1-30 on the 5H and 7-28 on the 3H were monitored using a vertical tool deployment in the MIP SW well.**

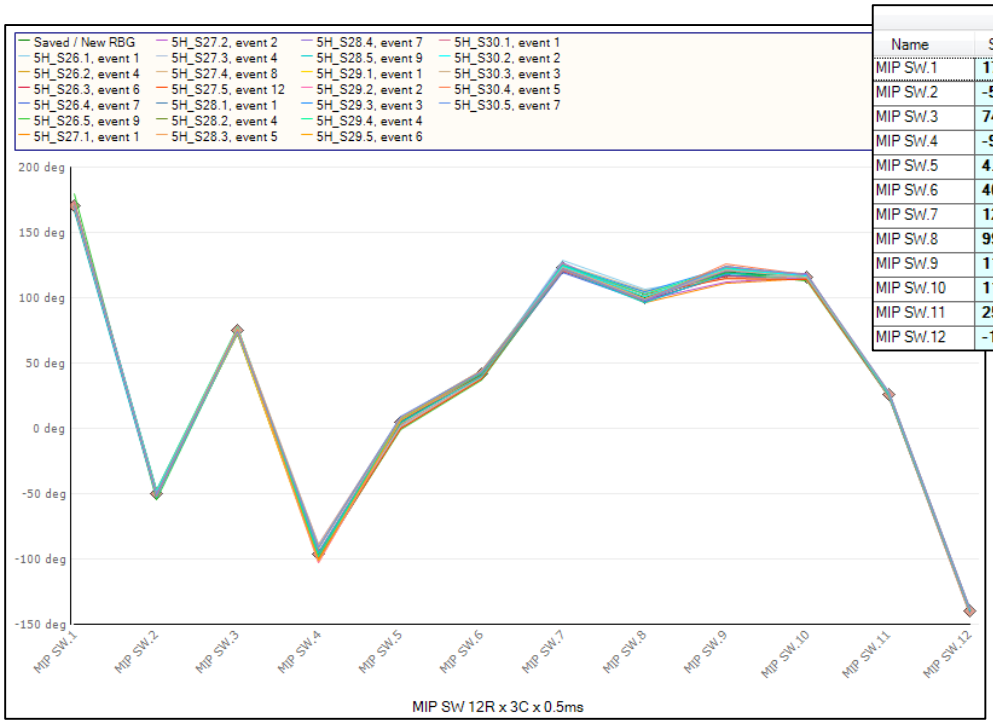
**Sensor Orientation Overview**

The 3C sensor arrays is deployed in the monitor well via wireline cable. Each 3C sensor forms a random 3 axis local coordinate system. Calibration of the 3C sensor arrays orientation is accomplished by recording shots from known location(s), allowing for rotation of each sensor into a global coordinate system. Suitable orientation shots can be:

- Perforation shots in the treatment well
- String shots (back-off shots) from the treatment well
- String shots in a nearby well.
- Vibrator shots from one or more know surface locations

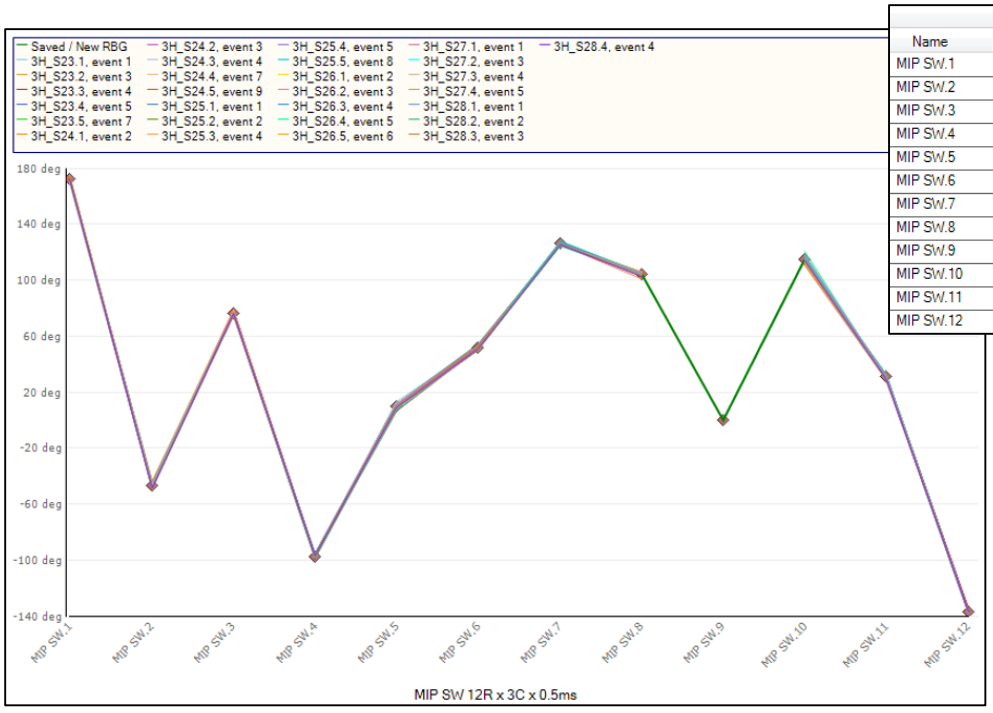
Accurate calibration of the 3C sensor orientation depends on accurate knowledge of the location of the shot point in 3D space (X, Y, Z) as well as accurate location of the 3C sensor stations. Wellhead locations verified by GPS and gyro well deviation survey recorded from TD to surface are required measurements. Inaccuracies in these measurements lead to inaccuracy in sensor orientation.

Tool orientation was determined using perforation shots in the NNE MIP 5H and 3H treatment wells. The following figures display the final tool orientation and shuttle azimuths for the toolset as calculated from the perforation shots recorded by the arrays in the NNE MIP SW monitor well.




| | Receiver | |
|---|---|---|
| Name | Saved RBG deg | Saved RBG std dev |
| MIP SW.1 | **170.29** | 2.43 |
| MIP SW.2 | **-50.13** | 1.67 |
| MIP SW.3 | **74.18** | 1.56 |
| MIP SW.4 | **-97.22** | 4.16 |
| MIP SW.5 | **4.60** | 3.13 |
| MIP SW.6 | **40.77** | 2.28 |
| MIP SW.7 | **122.94** | 2.10 |
| MIP SW.8 | **99.78** | 2.78 |
| MIP SW.9 | **119.22** | 4.05 |
| MIP SW.10 | **115.54** | 1.34 |
| MIP SW.11 | **25.06** | 1.13 |
| MIP SW.12 | **-140.24** | 1.29 |

**Figure 6-3 – MIP SW sensor orientation for monitoring MIP 5H.**




| | Receiver | |
|---|---|---|
| Name | Saved RBG deg | Saved RBG std dev |
| MIP SW.1 | **172.60** | 0.96 |
| MIP SW.2 | **-46.69** | 1.39 |
| MIP SW.3 | **76.54** | 1.06 |
| MIP SW.4 | **-97.41** | 0.91 |
| MIP SW.5 | **9.57** | 1.47 |
| MIP SW.6 | **51.29** | 1.19 |
| MIP SW.7 | **125.87** | 0.71 |
| MIP SW.8 | **104.23** | 1.01 |
| MIP SW.9 | **0.00** | 0.00 |
| MIP SW.10 | **114.92** | 2.03 |
| MIP SW.11 | **30.76** | 0.87 |
| MIP SW.12 | **-137.01** | 0.74 |

**Figure 6-4 – MIP SW sensor orientation for monitoring MIP 3H. Shuttle 9 displays a relative bearing angle of 0º because it was disabled for processing part of the 3H treatment.**

## Velocity Model Construction

Vertical Vp and Vs are typically obtained from sonic logs ideally run in open hole in a vertical wellbore. Logs are blocked by application of an edge detection algorithm and refined with minimum layer thickness derived from Backus averaging criteria. Optional smoothing may be applied to account for lateral uncertainty in the earth model.

The velocity model was built from sonic logs from the NNE MIP 3H pilot well, with the overburden section spliced in from the NNE Statler 3 pilot. Smoothing and blocking were applied to the raw compressional and shear slowness logs to build the initial model. The local geology is considered flat over the region of interest, therefore the velocity model was not corrected for any structural dip.

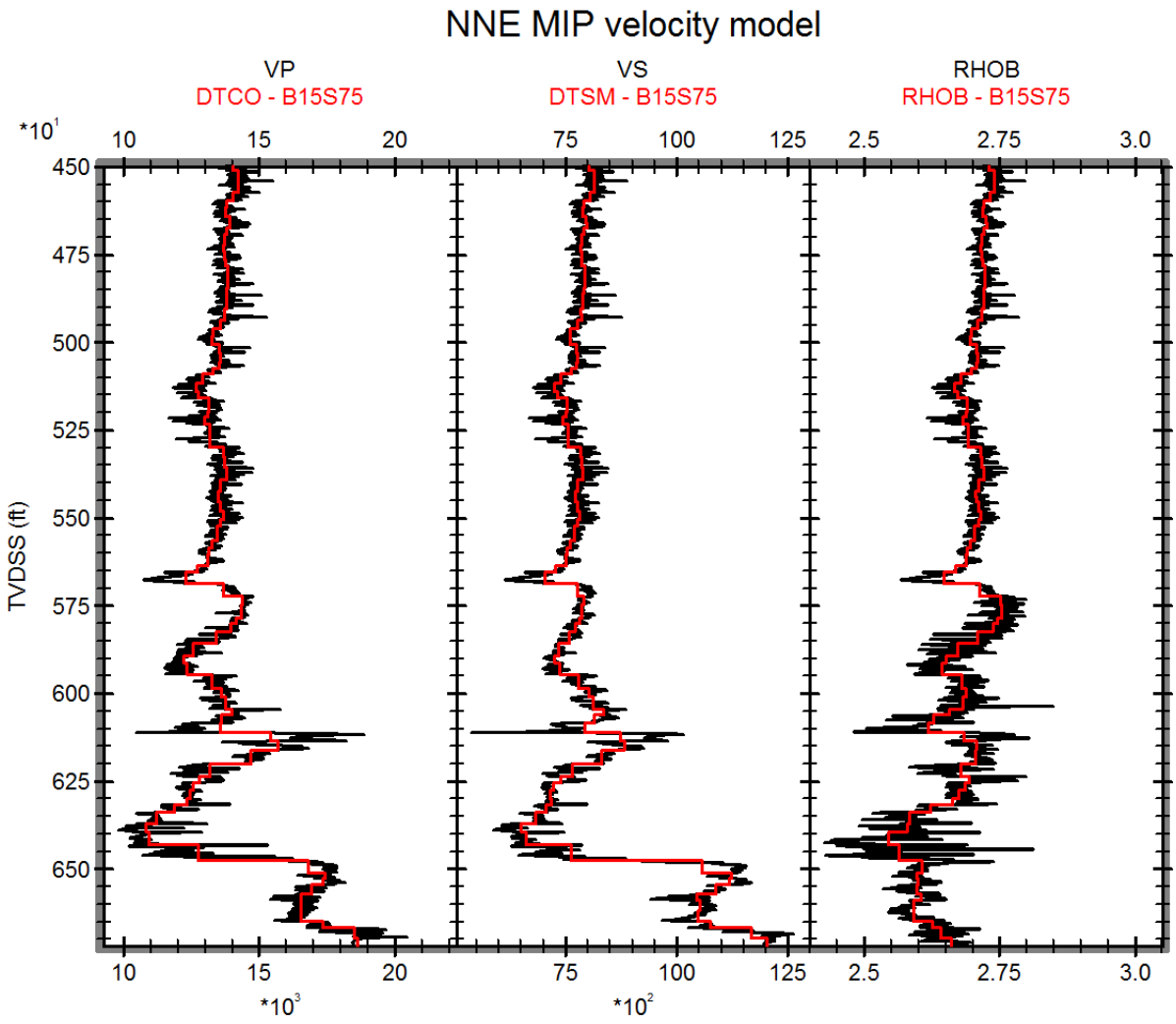



**Figure 6-5 – Raw sonic logs are shown for the P-wave and S-wave velocity profiles. Smoothing (75 ft) and blocking (15 ft) were applied to the velocity and density logs to produce the initial isotropic model. The smoothed and blocked values are shown by the red lines.**

## Velocity Model Calibration

Calibration of the earth model is accomplished by measurement of perforation shots or string shots from a known location(s), typically the treatment well. Time picks of the P, Sh, and optionally Sv arrivals as well as optional measurement of the t-zero are input to either a manual calibration technique or automated inversion. Model times are obtained by ray tracing with an exact 1D-VTI ray tracer engine. Mismatch between the measured times and model times (Residual Time) for each phase is minimized by manual adjustment or automated inversion for Thomsen parameters in the calibration process.

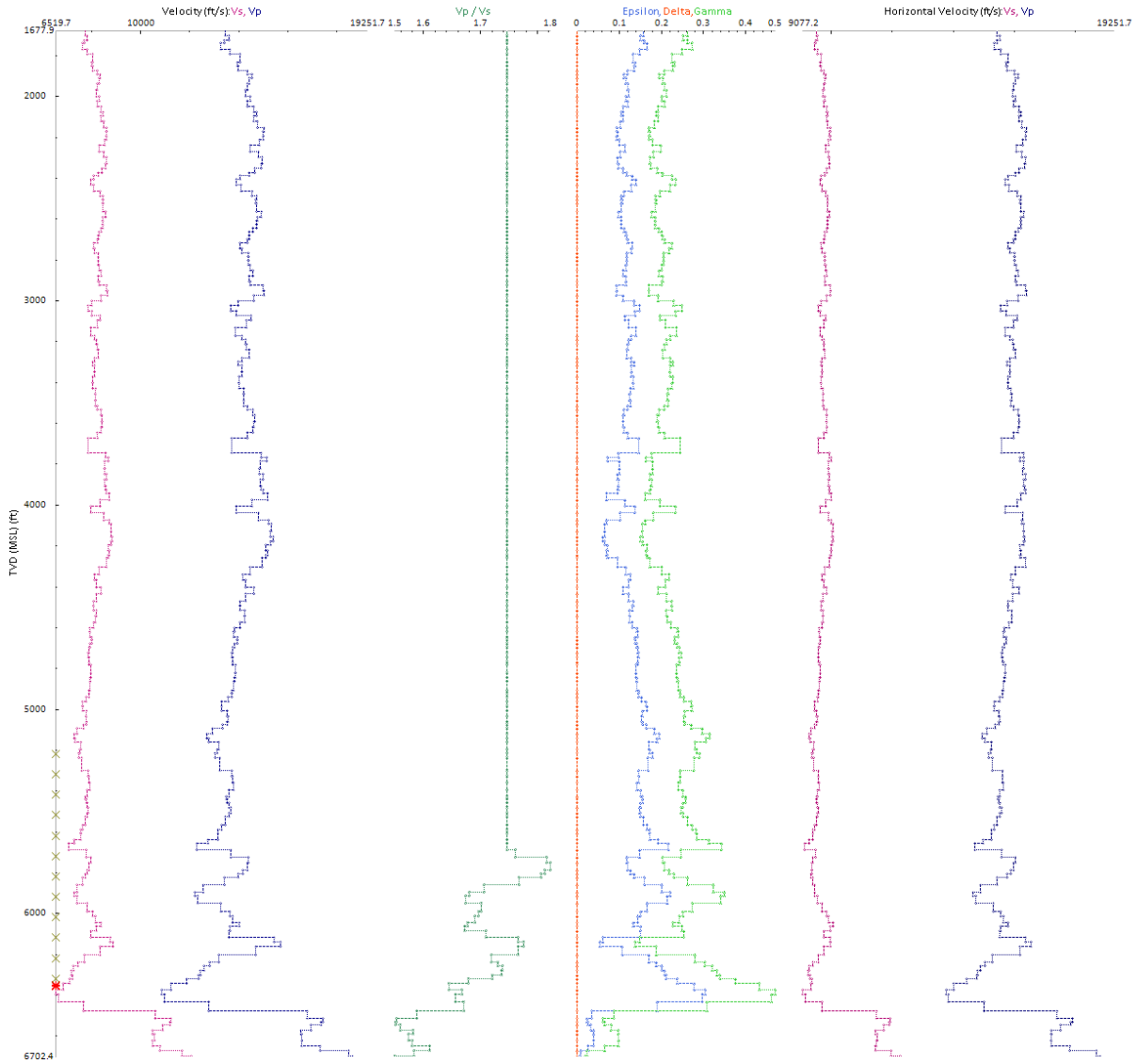



**Figure 6-6 – Calibrated 1D VTI velocity model. The left track shows Vs in pink, Vp in blue, and Vp/Vs in green. The middle track shows the Thomsen anisotropy parameters. The red stars on the depth axis indicate the subsea depths of the perforation shot locations. The crosses along the depth axis indicate the subsea depths of the tool strings. The velocity model was calibrated using the waveforms from perforation shot data.**

**Calibration Shot Waveform**

Within each waveform display, the left column of tadpoles contains information about P-wave arrivals. For each receiver, the long blue tadpoles that extends outside the circle is a map view projection indicating the polarization of particle motion detected at the receiver and pointing from receiver location to source location. Since P-waves are longitudinally polarized, the long tadpoles indicates source azimuth with respect to the receiver. The short blue tadpoles contained inside the circle shows a side view projection of the inclination of the P-wave arrival at a receiver.

Model times (predicted arrival times) are shown by the blue circles (P-wave), red circles (Sh-wave), and green circles (Sv-wave). However, the model times predicted for the waveforms match well to the onset of the recorded waveforms.

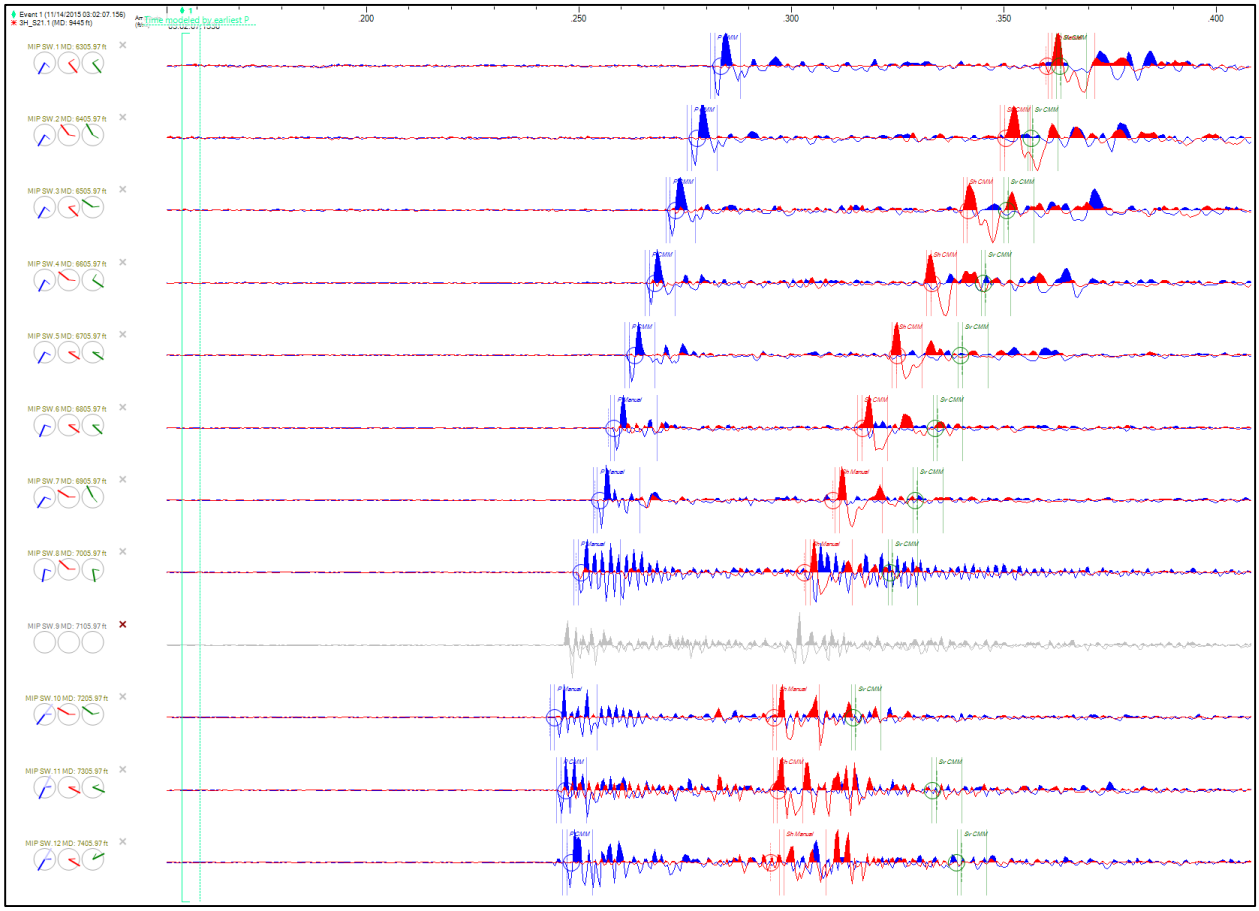


**Figure 6-7 – Example perforation shot waveform and modeled time picks for a perforation shot from stage 21 of the NNE MIP 3H. The circles indicate the predicted arrival times using the calibrated velocity model. There is good agreement between the arrivals on the P-wave and S-wave and the modeled times indicated by the circles.**

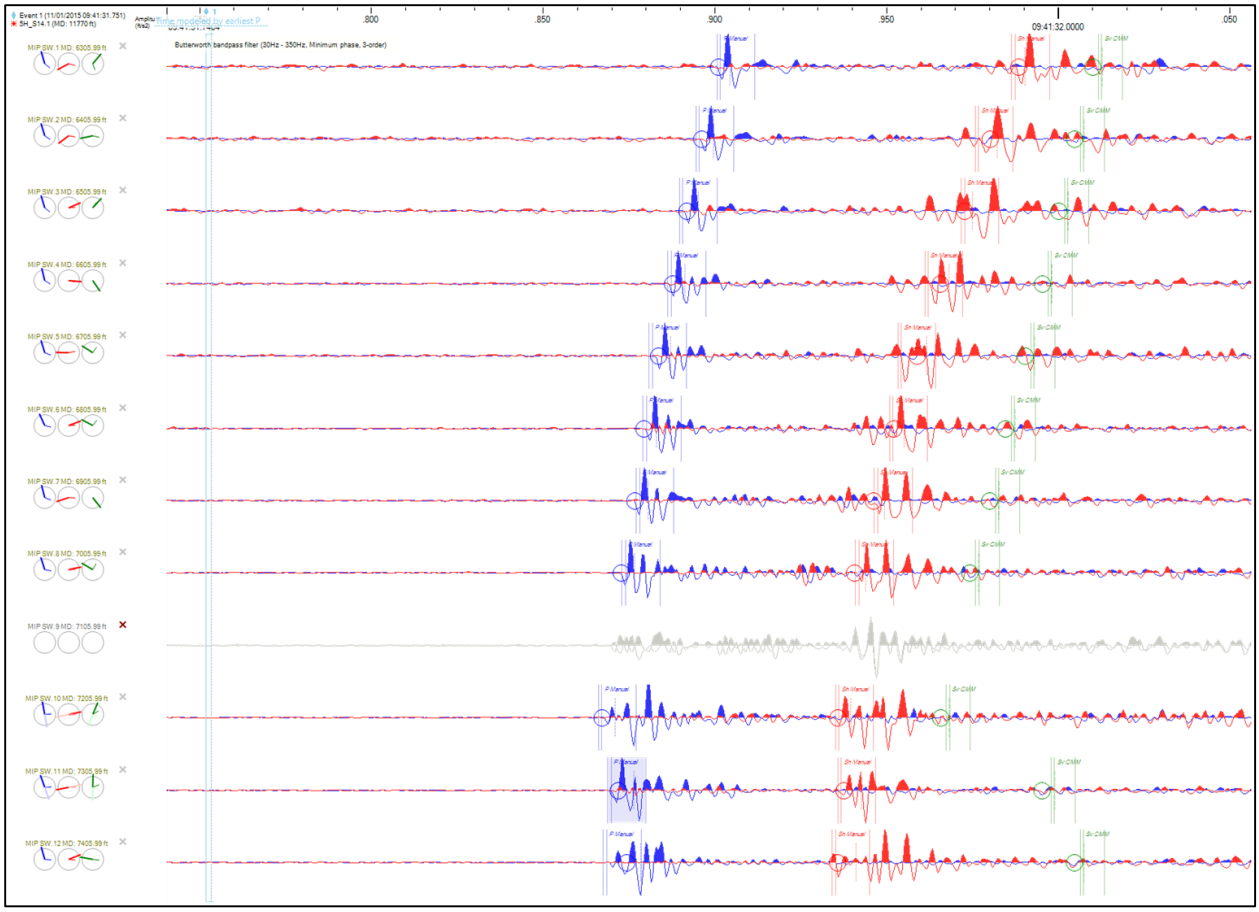


**Figure 6-8 – Example perforation shot waveform and modeled time picks for a perforation shot from stage 14 of the NNE MIP 5H. The circles indicate the predicted arrival times using the calibrated velocity model. There is good agreement between the arrivals on the P-wave and S-wave and the modeled times indicated by the circles.**

### Anisotropy Parameters

The microseismic data was processed with anisotropy parameters derived by velocity model calibration using the perforation shot data and t-zero data to constrain the inversion of travel times. The t-zero data consists of the electrical voltage acquired from the perforation shooting equipment. It is used to determine the moment the perforation guns were fired. This provides the beginning of the time sequence (i.e., t-zero) in which the seismic waveforms generated by the perforation shot travel from the source to the receiver array. A tabulation of the range of Thomsen anisotropy parameters for each stage is shown in Table 3.

**Table 159 - Summary of anisotropy parameters by stage**

| Stage | MIP 5H | MIP 3H |
|---|---|---|

| | | Epsilon (ε) | Delta (δ) | Gamma (γ) | Epsilon (ε) | Delta (δ) | Gamma (γ) |
|---|---|---|---|---|---|---|---|
| 1 | Min | 0.00 | 0.00 | 0.14 | | | |
| | Max | 0.17 | 0.00 | 0.29 | | | |
| | Delta | 0.17 | 0.00 | 0.16 | | | |
| 2 | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.30 | 0.00 | 0.47 | | | |
| | Delta | 0.30 | 0.00 | 0.47 | | | |
| 3 | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.47 | 0.00 | 0.56 | | | |
| | Delta | 0.47 | 0.00 | 0.56 | | | |
| 4 | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.51 | 0.00 | 0.65 | | | |
| | Delta | 0.51 | 0.00 | 0.65 | | | |
| 5 | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.51 | 0.00 | 0.65 | | | |
| | Delta | 0.51 | 0.00 | 0.65 | | | |
| 6 | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.51 | 0.00 | 0.65 | | | |
| | Delta | 0.51 | 0.00 | 0.65 | | | |
| 7 | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |
| | Delta | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |
| 8 | Min | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| | Max | 0.25 | 0.00 | 0.41 | 0.96 | 0.00 | 0.98 |
| | Delta | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |
| 9 | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |
| | Delta | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **10** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |
| | Delta | 0.23 | 0.00 | 0.39 | 0.96 | 0.00 | 0.98 |
| **11** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.25 | 0.00 | 0.48 | 0.94 | 0.00 | 0.96 |
| | Delta | 0.25 | 0.00 | 0.48 | 0.94 | 0.00 | 0.96 |
| **12** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.25 | 0.00 | 0.48 | 0.35 | 0.00 | 0.57 |
| | Delta | 0.25 | 0.00 | 0.48 | 0.35 | 0.00 | 0.57 |
| **13** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.25 | 0.00 | 0.48 | 0.35 | 0.00 | 0.57 |
| | Delta | 0.25 | 0.00 | 0.48 | 0.35 | 0.00 | 0.57 |
| **14** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.36 | 0.00 | 0.55 | 0.35 | 0.00 | 0.57 |
| | Delta | 0.36 | 0.00 | 0.55 | 0.35 | 0.00 | 0.57 |
| **15** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.36 | 0.00 | 0.55 | 0.35 | 0.00 | 0.54 |
| | Delta | 0.36 | 0.00 | 0.55 | 0.35 | 0.00 | 0.54 |
| **16** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.36 | 0.00 | 0.55 | 0.35 | 0.00 | 0.54 |
| | Delta | 0.36 | 0.00 | 0.55 | 0.35 | 0.00 | 0.54 |
| **17** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.36 | 0.00 | 0.55 | 0.32 | 0.00 | 0.53 |
| | Delta | 0.36 | 0.00 | 0.55 | 0.32 | 0.00 | 0.53 |
| **18** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.36 | 0.00 | 0.55 | 0.32 | 0.00 | 0.53 |
| | Delta | 0.36 | 0.00 | 0.55 | 0.32 | 0.00 | 0.53 |
| **19** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.52 | 0.00 | 0.59 | 0.32 | 0.00 | 0.53 |
| | Delta | 0.52 | 0.00 | 0.59 | 0.32 | 0.00 | 0.53 |
| **20** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.52 | 0.00 | 0.59 | 0.30 | 0.00 | 0.47 |
| | Delta | 0.52 | 0.00 | 0.59 | 0.30 | 0.00 | 0.47 |
| **21** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.38 | 0.00 | 0.54 | 0.25 | 0.00 | 0.40 |
| | Delta | 0.38 | 0.00 | 0.54 | 0.25 | 0.00 | 0.40 |
| **22** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.35 | 0.00 | 0.43 | 0.25 | 0.00 | 0.40 |
| | Delta | 0.35 | 0.00 | 0.43 | 0.25 | 0.00 | 0.40 |
| **23** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.26 | 0.00 | 0.33 | 0.25 | 0.00 | 0.40 |
| | Delta | 0.26 | 0.00 | 0.33 | 0.25 | 0.00 | 0.40 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **24** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.26 | 0.00 | 0.33 | 0.73 | 0.00 | 0.63 |
| | Delta | 0.26 | 0.00 | 0.33 | 0.73 | 0.00 | 0.63 |
| **25** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| | Delta | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| **26** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| | Delta | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| **27** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| | Delta | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| **28** | Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| | Delta | 0.19 | 0.00 | 0.32 | 0.73 | 0.00 | 0.63 |
| **29** | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.19 | 0.00 | 0.32 | | | |
| | Delta | 0.19 | 0.00 | 0.32 | | | |
| **30** | Min | 0.00 | 0.00 | 0.00 | | | |
| | Max | 0.19 | 0.00 | 0.32 | | | |
| | Delta | 0.19 | 0.00 | 0.32 | | | |

**Calibration Shot Results**

Calculation of perforation shot event locations shows that the perforation shots located very close to the actual source points. The calculated locations are located on depth and close to the actual perforation shot locations. The location results also give further confirmation of the accuracy of the tool orientation.

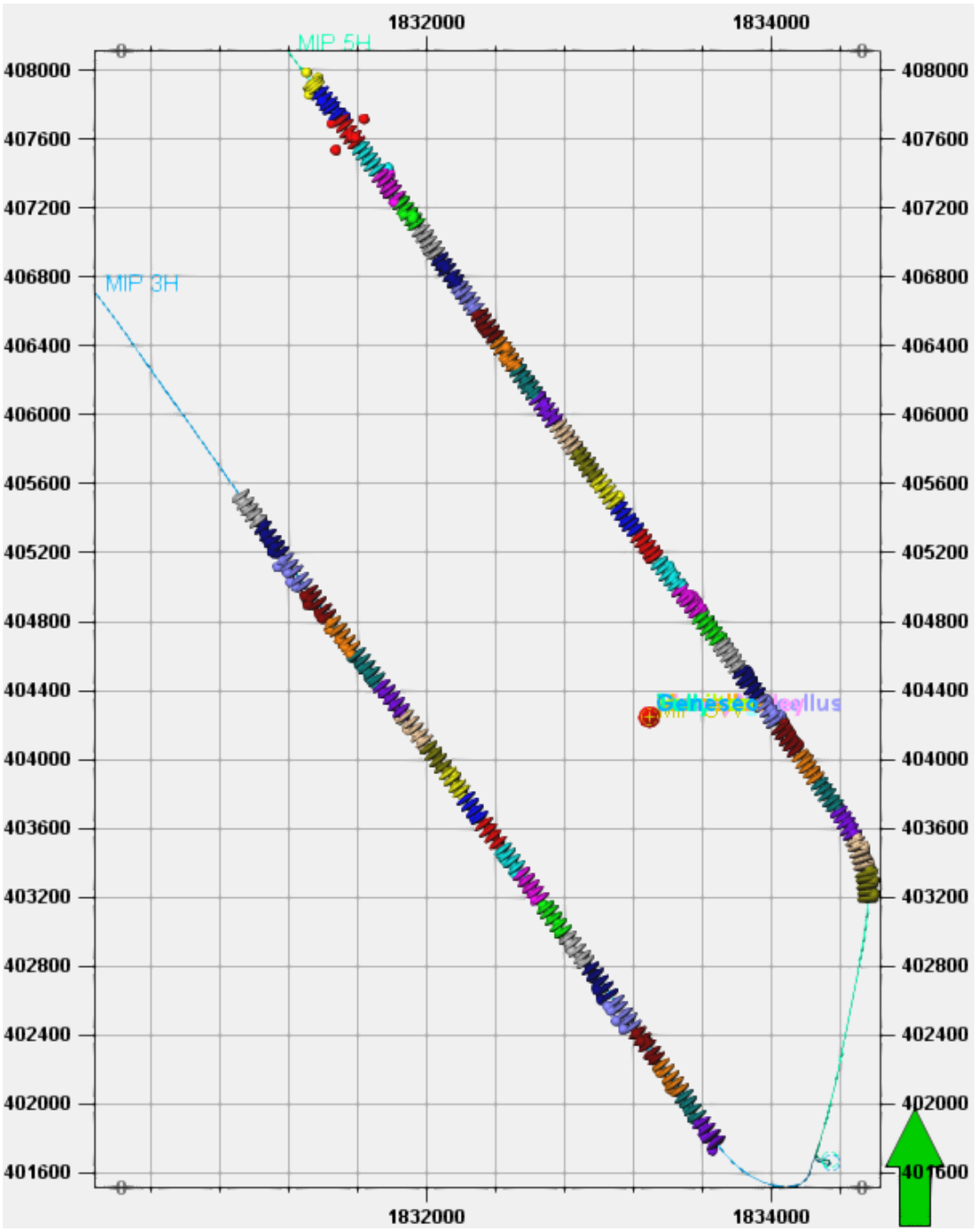



**Figure 6-9 – Map view of perforation shot locations for all stages in the NNE MIP 5H and 3H wells recorded by the array in the NNE MIP SW well.**

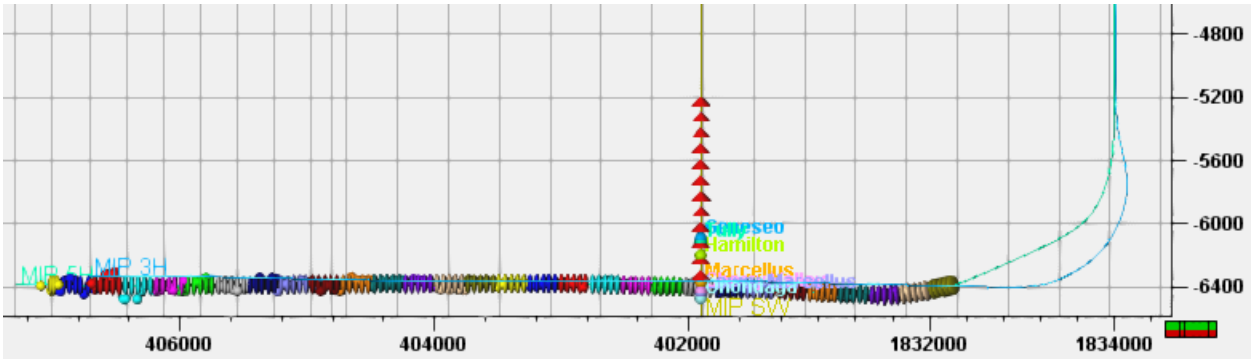



**Figure 6-10 – Cross-section view of perforation shot locations for all stages in the NNE MIP 5H well recorded by the arrays in the NNE MIP SW well.**

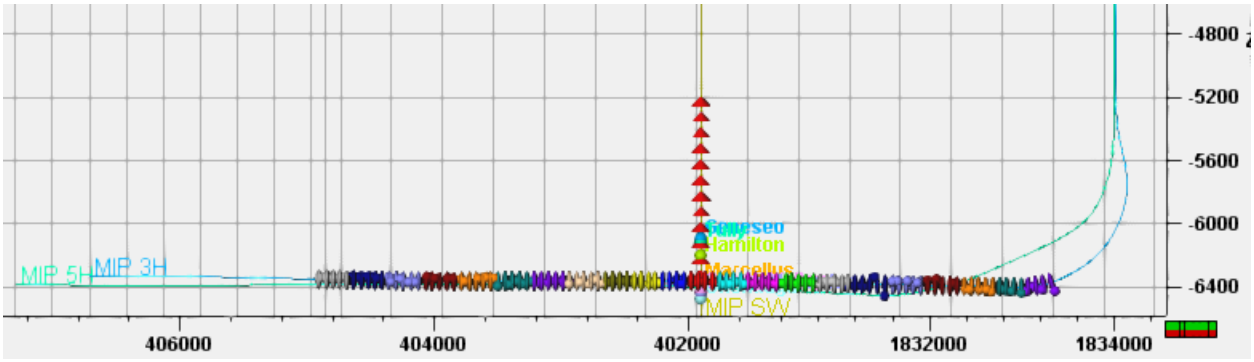



**Figure 6-11 – Cross-section view of perforation shot locations for all stages in the NNE MIP 3H well recorded by the arrays in the NNE MIP SW well.**

### Velocity Model and Event Distribution

Hypocenters are plotted with the velocity model as background. View is along the model strike.

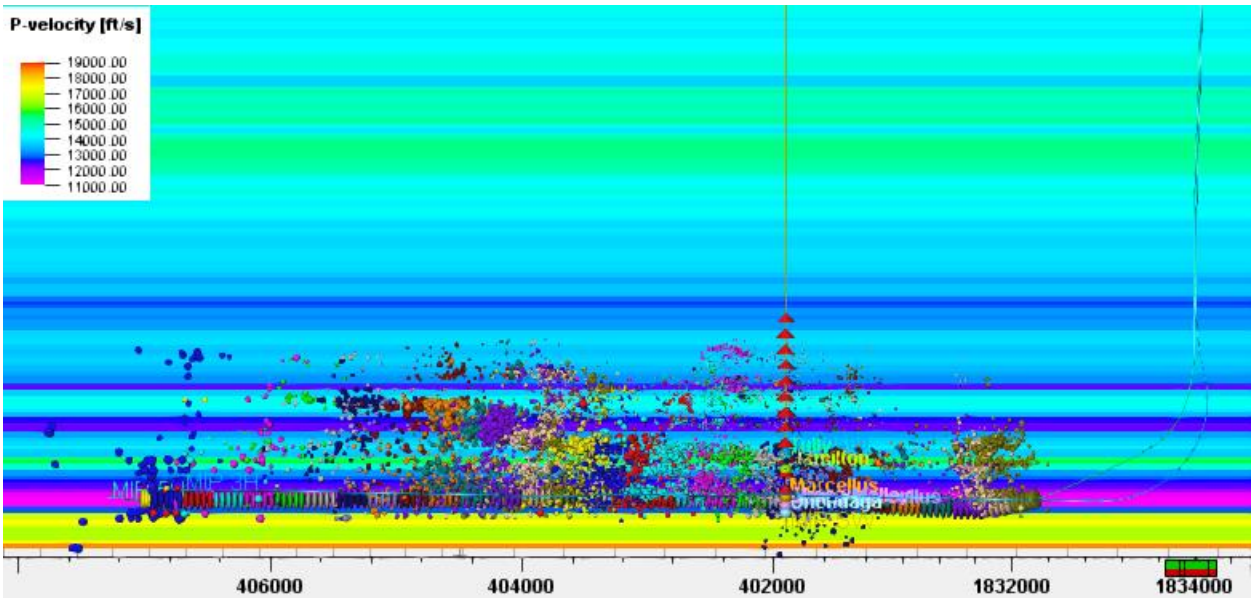


**Figure 6-12 – Cross-section view of all events for all stages monitored on the MIP 5H well sized by magnitude with the velocity model as the background.**

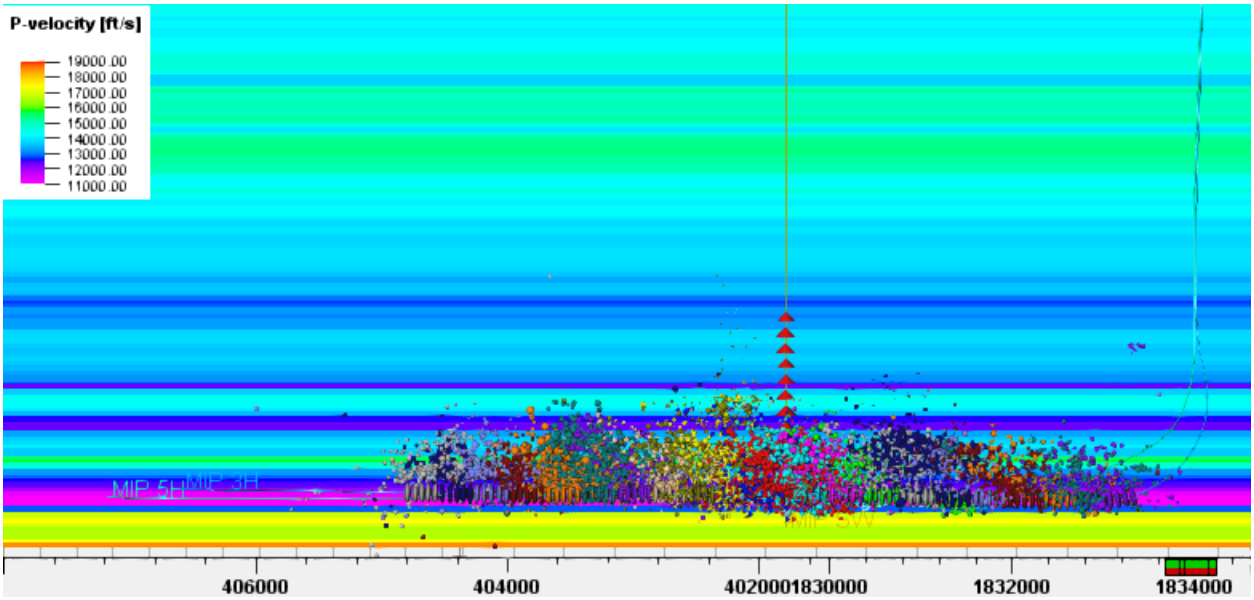



**Figure 6-13 – Cross-section view of all events for all stages monitored on the MIP 3H well sized by magnitude with the velocity model as the background.**

## Quality Indicators

**SNR** – Measurement of the peak value of the CMM objective function. SNR typically ranges from 2.0 to 15.0. Generally higher values correlate to higher data quality.

**Magnitude** – Estimated moment magnitude for a microseismic event.

**Max Error** – Length of the major axis of the location uncertainty ellipsoid.

**Mid Error** – Length of the mid axis of the location uncertainty ellipsoid.

**Min Error** – Length of the minor axis of the location uncertainty ellipsoid.

**Radius** – Radius of the source rupture.

**Confidence Factor** – Data quality indicator ranging from 0 to 5. Higher values indicate higher confidence levels. Confidence factor is a composite of P trace quality, S trace quality, P time pick residual, S time pick residual, and polarization quality.

**Table 4 – Quality indicators for data acquired using the NNE MIP SW monitor well**

| Treatment stage | Monitor Well | | SNR | Magnitude | Max Error (ft) | Mid Error (ft) | Min Error (ft) | Confidence |
|---|---|---|---|---|---|---|---|---|
| MIP 5H – Stages 1-30 | MIP SW | Min | 2.00 | -3.28 | 8.25 | 8.07 | 0.33 | 2.01 |
| | | Max | 60.94 | -0.37 | 594.43 | 432.33 | 285.01 | 4.89 |
| MIP 3H – Stages 7-28 | MIP SW | Min | 2.00 | -3.15 | 27.84 | 10.04 | 0.92 | 2.00 |
| | | Max | 79.56 | -0.05 | 592.60 | 425.43 | 239.78 | 4.88 |

**Signal-to-Noise Ratio**

Location confidence improves as the signal-to-noise ratio (SNR) increases. A minimum SNR threshold value is used when evaluating and interpreting microseismic events located while fracturing. Microseismic events with lower SNR values are disabled during the evaluation and are not displayed. For purposes of event detection and location, a minimum signal-to-noise ratio of 2.0 was used.

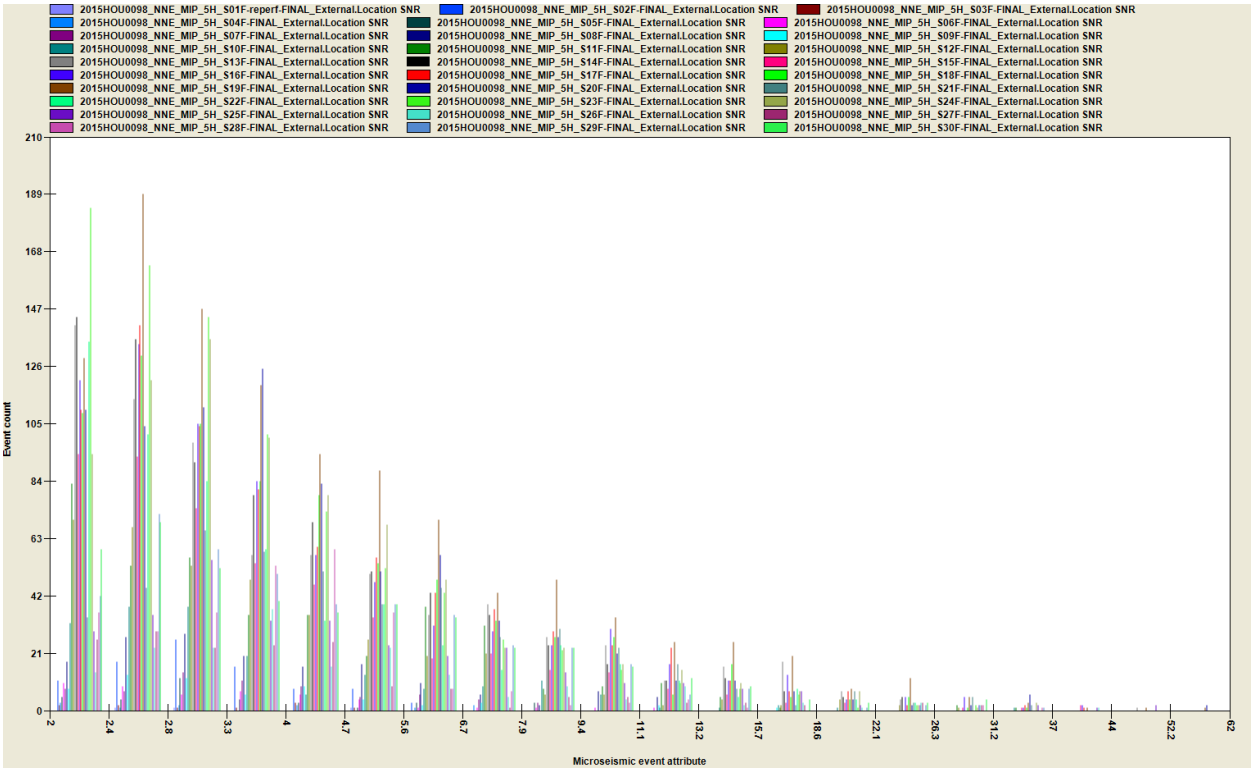



**Figure 6-14 – SNR histograms for all stages as monitored on the NNE MIP 5H well.**

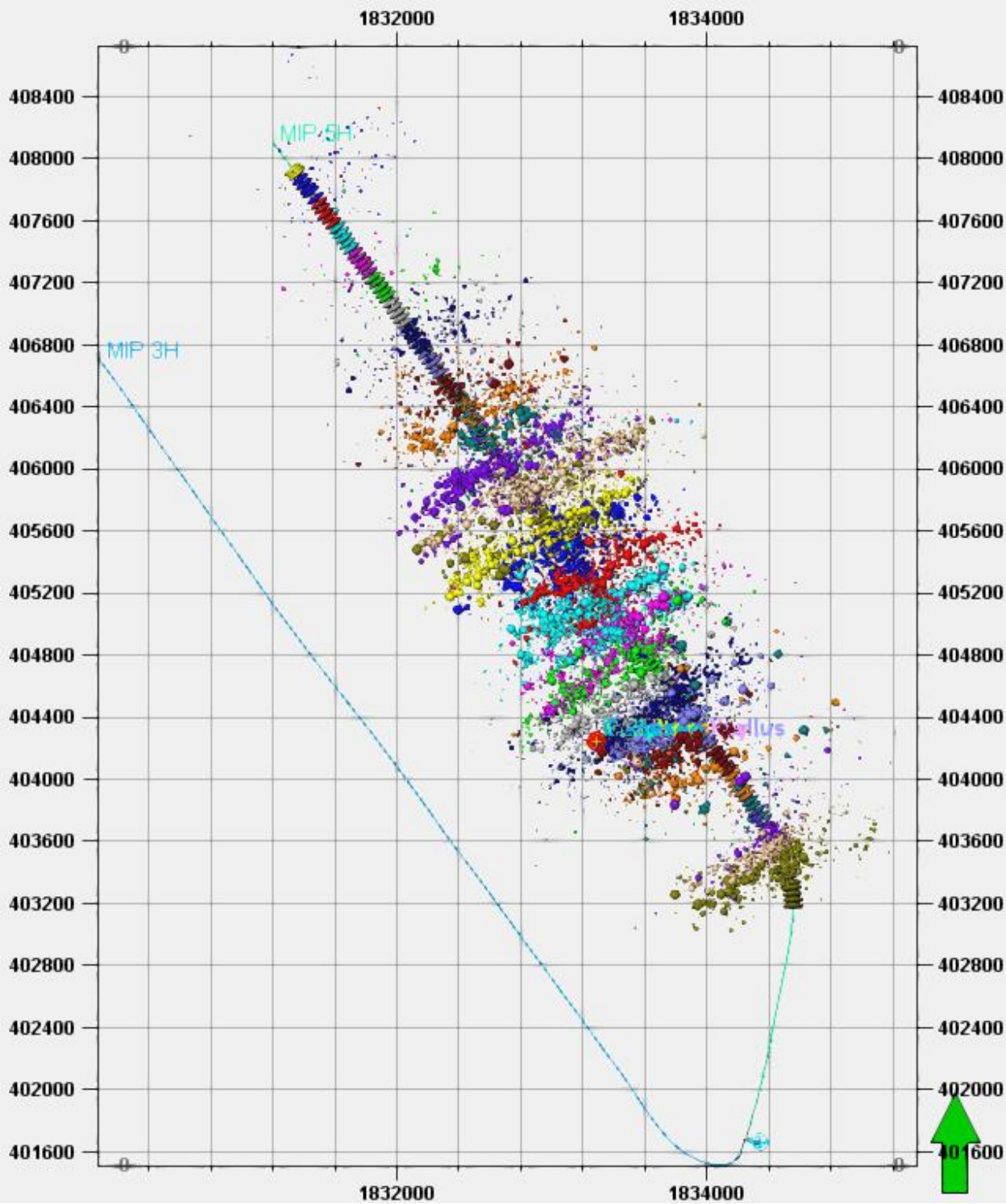



**Figure 6-15 – Map view of events for all stages monitored on the NNE MIP 5H well sized by SNR.**

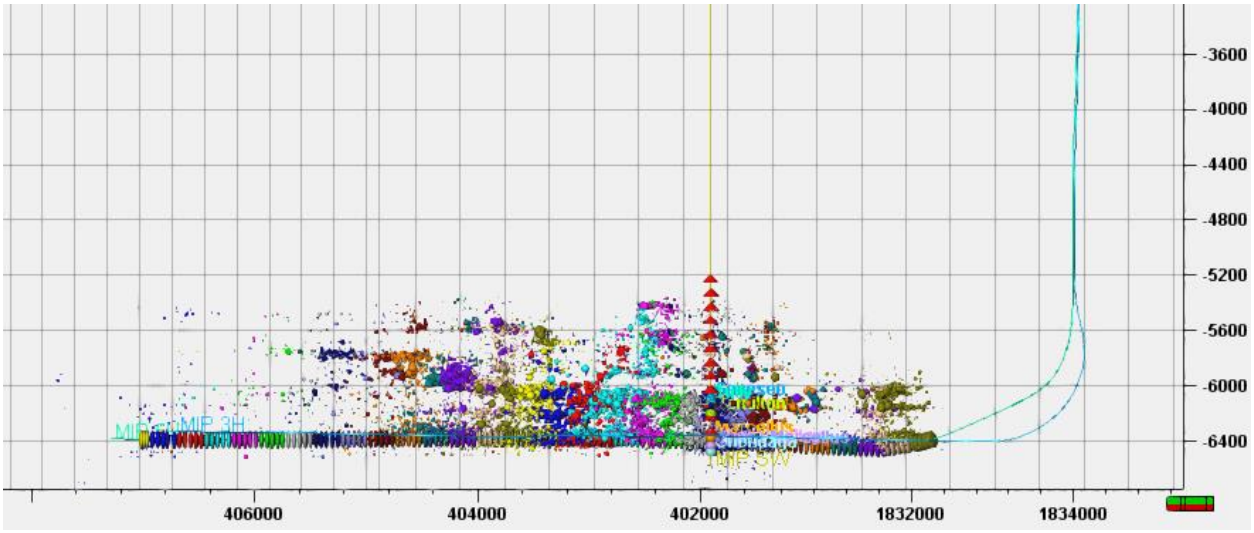



**Figure 6-16 – Cross-section view of events for all stages monotored on the NNE MIP 5H well sized by SNR.**

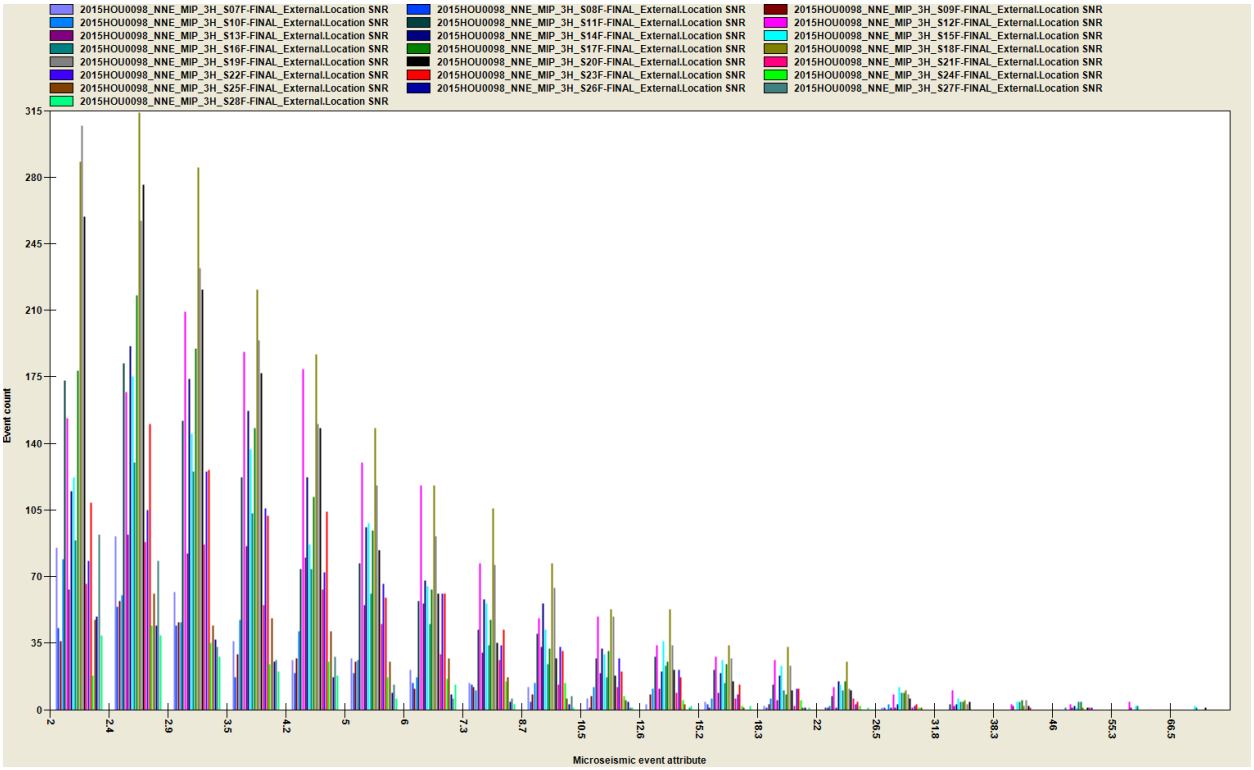



**Figure 6-17 – SNR histograms for all stages as monitored on the NNE MIP 3H well.**

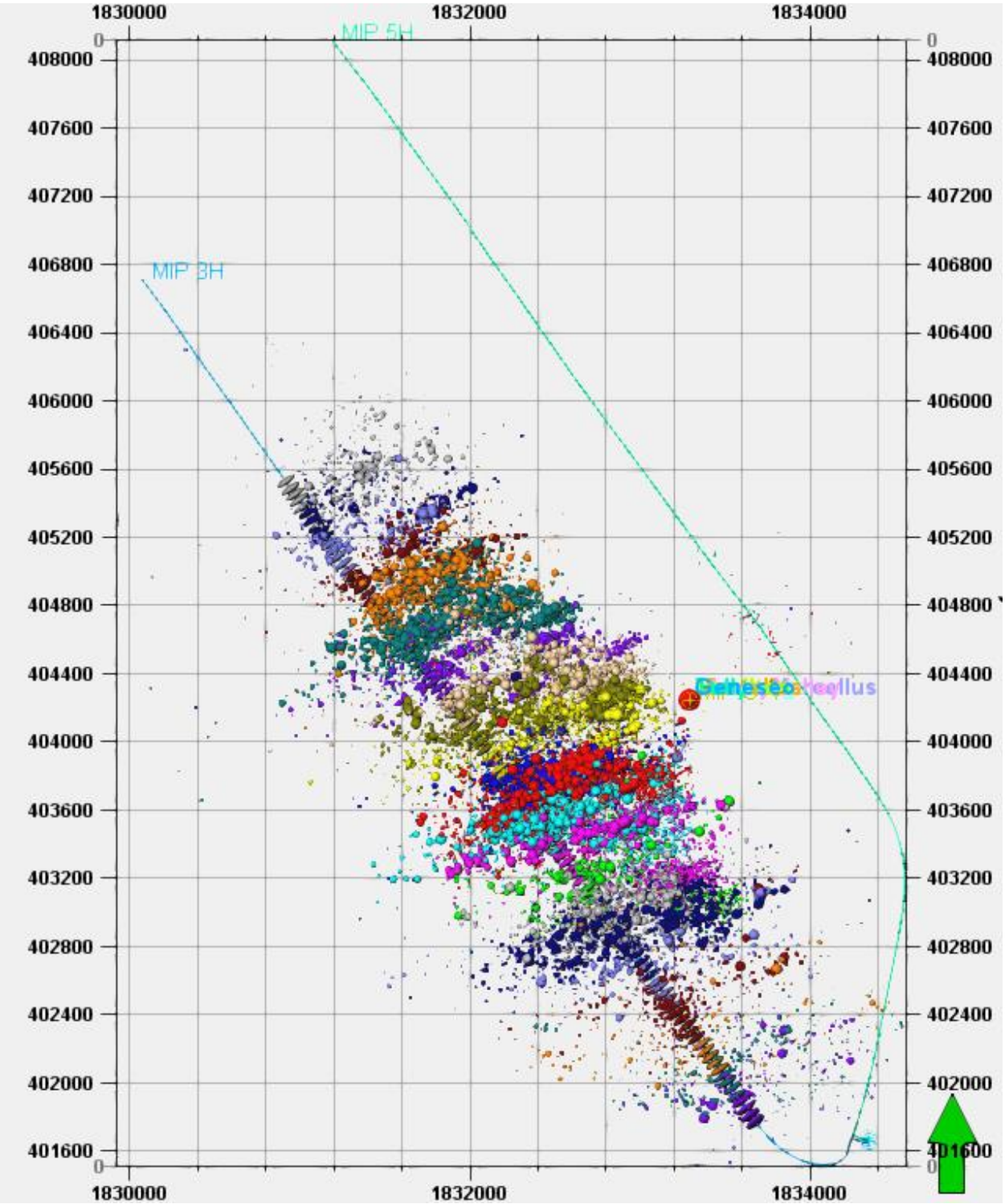



**Figure 6-18 – Map view of events for all stages monitored on the NNE MIP 3H well sized by SNR.**

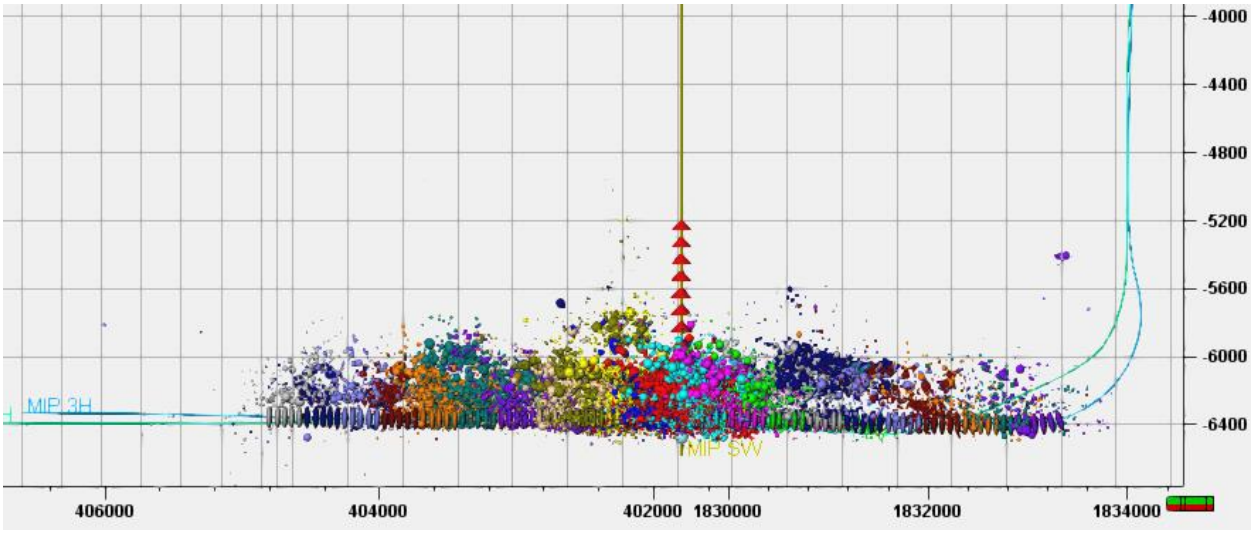



**Figure 6-19 – Cross-section view of events for all stages monitored on the NNE MIP 3H well sized by SNR.**

## Magnitude

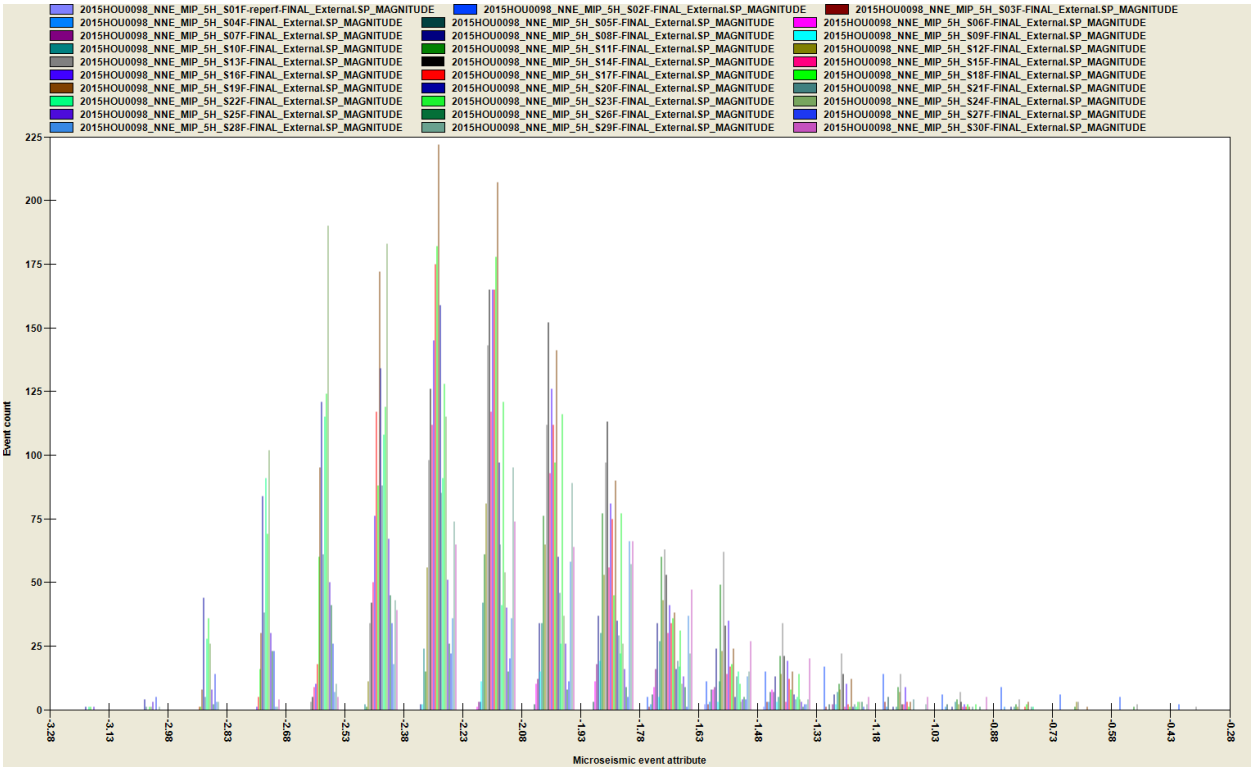



**Figure 6-20 – Moment magnitude histograms for all stages monitored on the NNE MIP 5H well.**

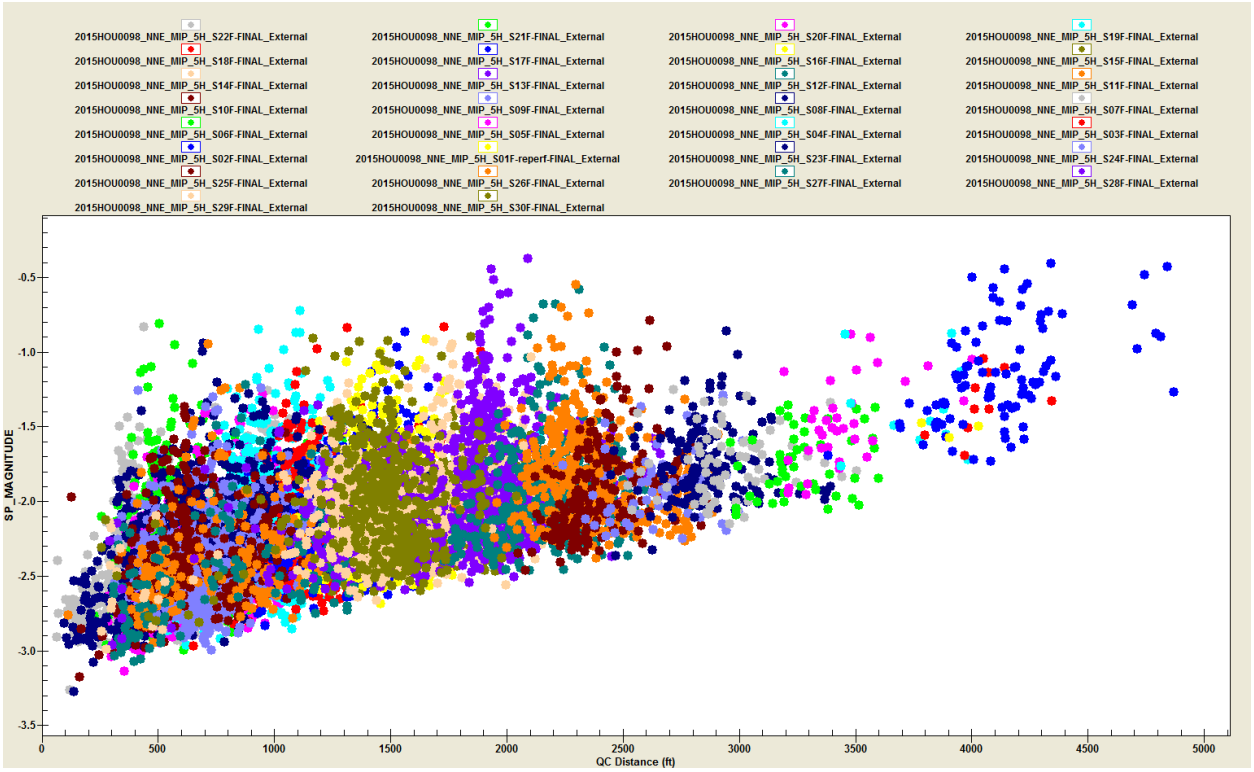



**Figure 6-21 – Moment magnitude versus distance plot for all stages monitored on the NNE MIP 5H well.**

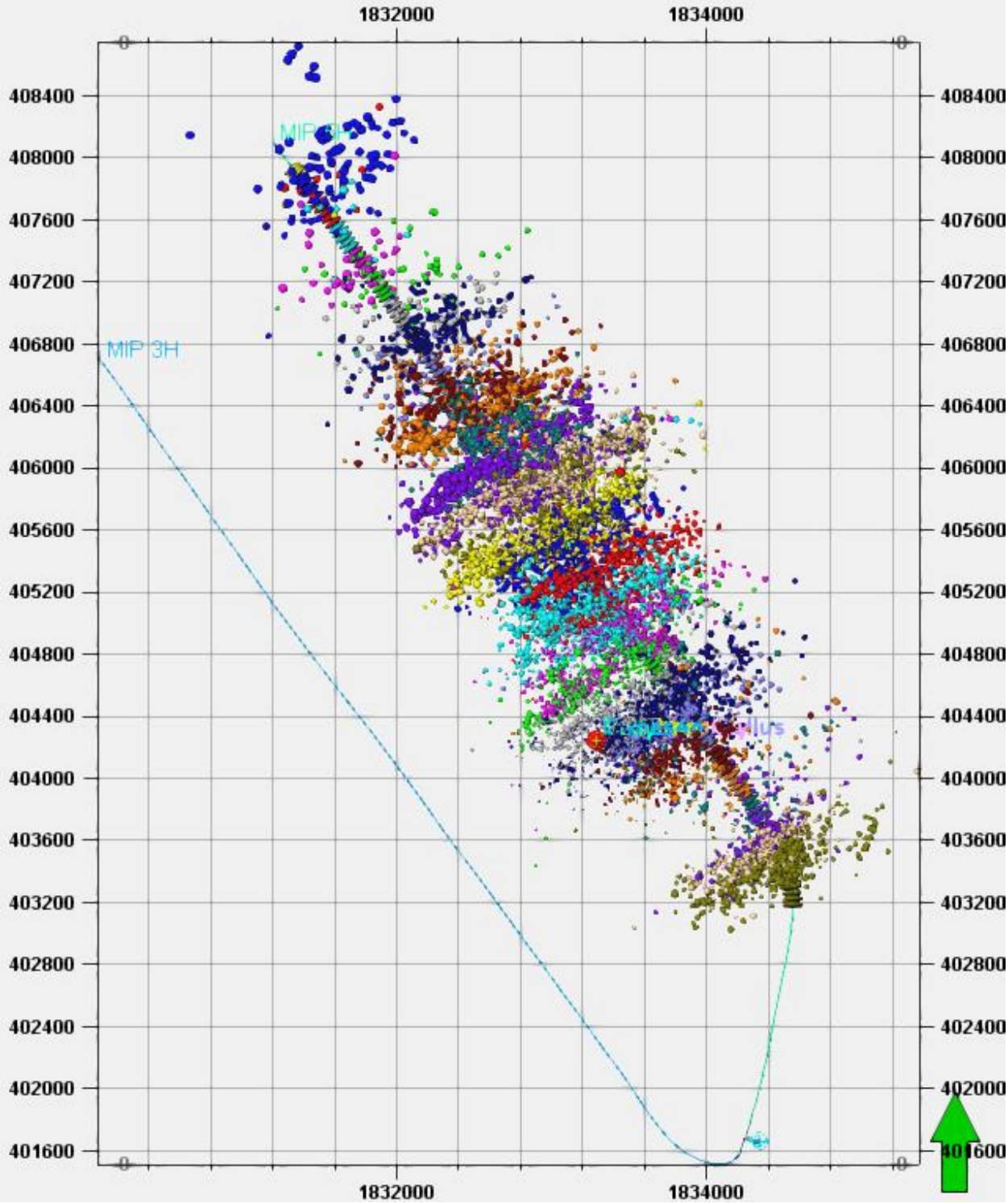



**Figure 6-22 – Map view of all events for all stages monitored on the NNE MIP 5H well sized by magnitude.**

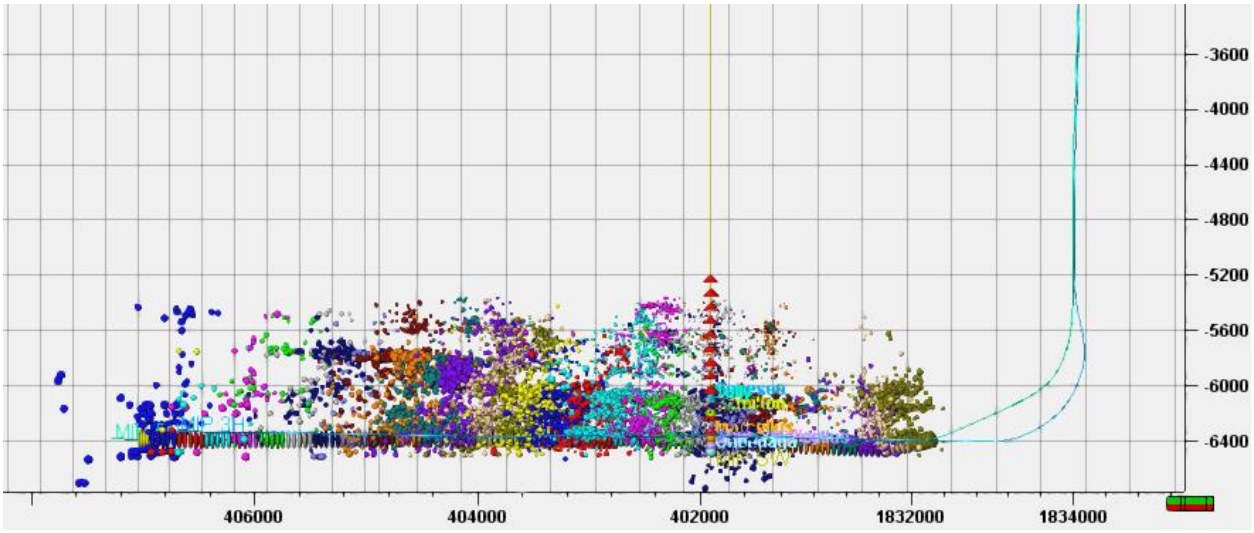



**Figure 6-23 – Cross-section view of all events for monitored on the NNE MIP 5H well sized by magnitude.**

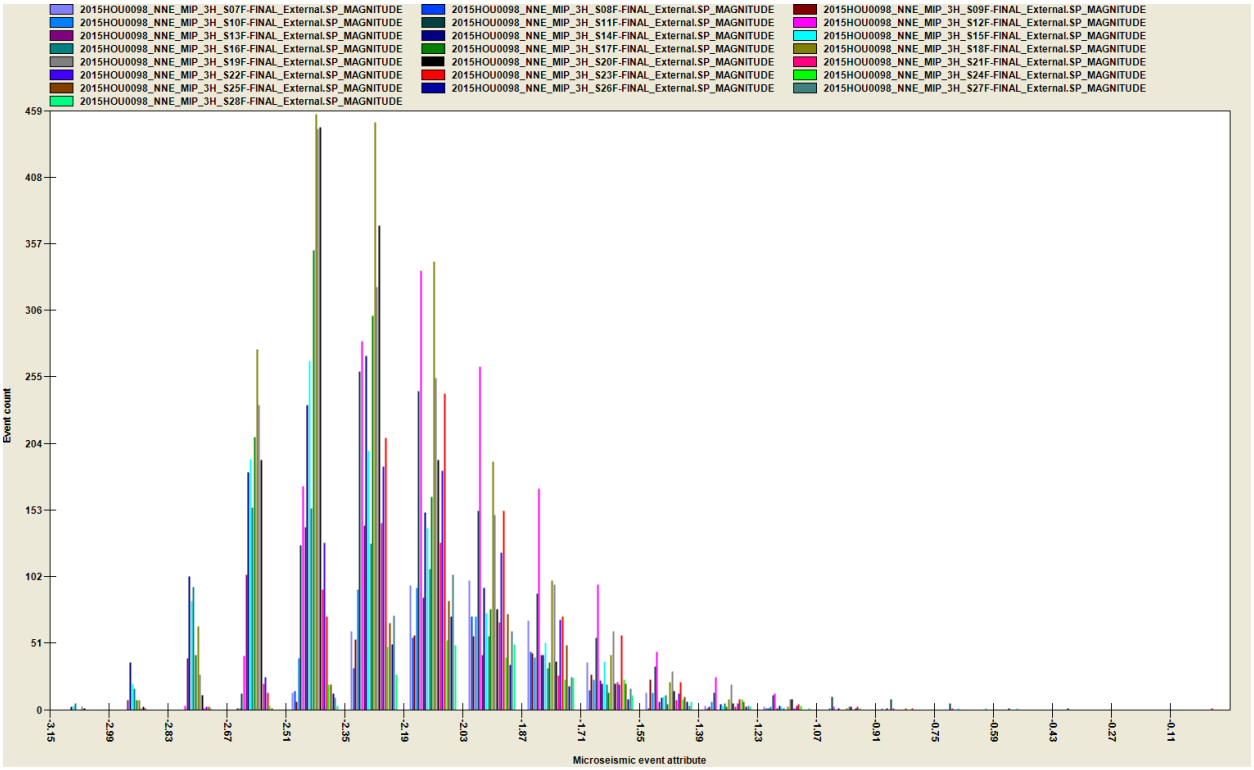



**Figure 6-24 – Moment magnitude histograms for all stages monitored on the NNE MIP 3H well.**

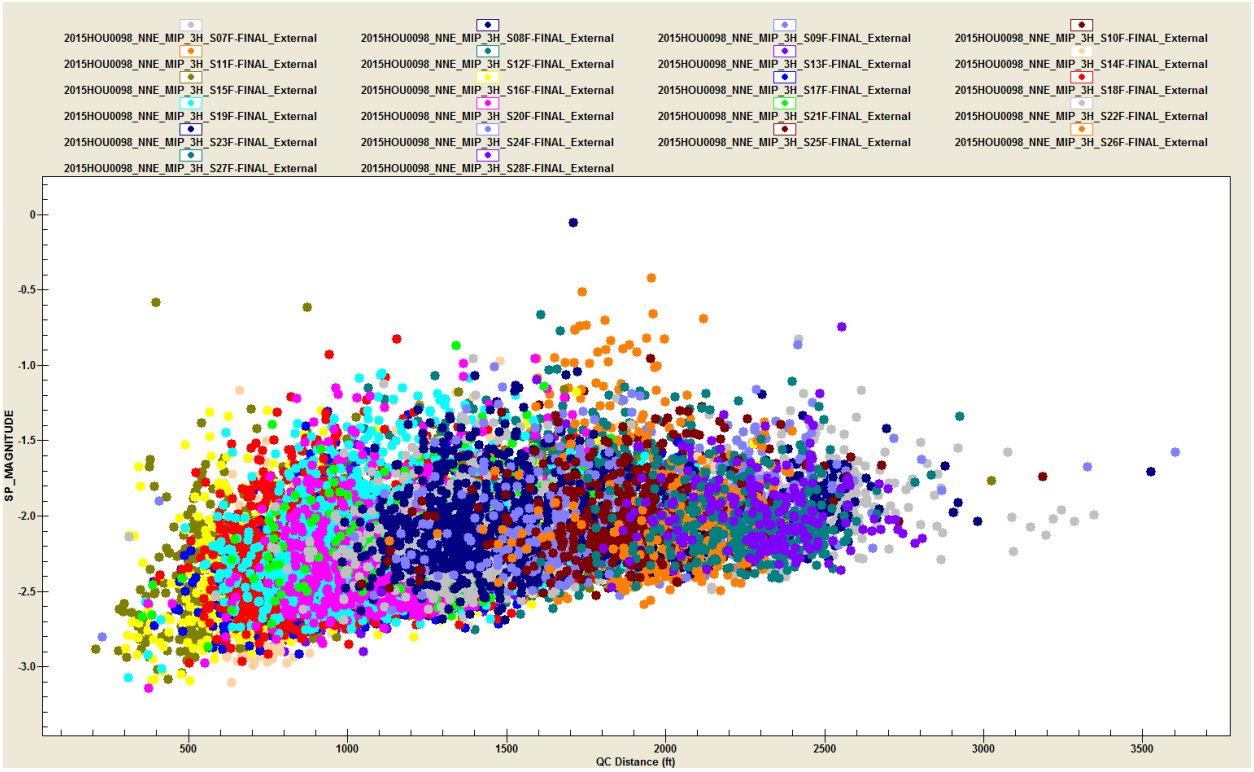



**Figure 6-25 – Moment magnitude versus distance plot for all stages monitored on the NNE MIP 3H well.**

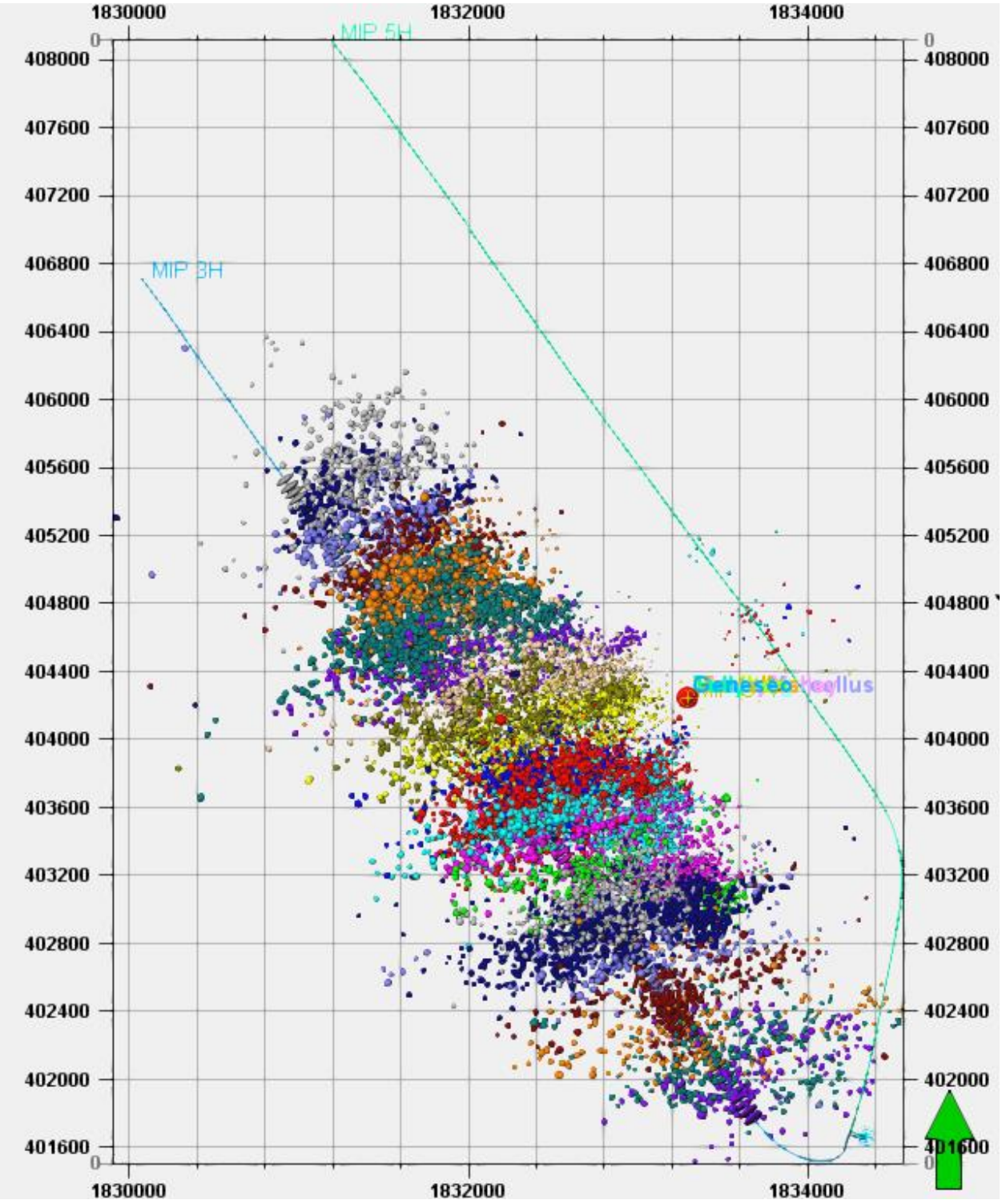



**Figure 6-26 – Map view of all events for all stages monitored on the NNE MIP 3H well sized by magnitude.**

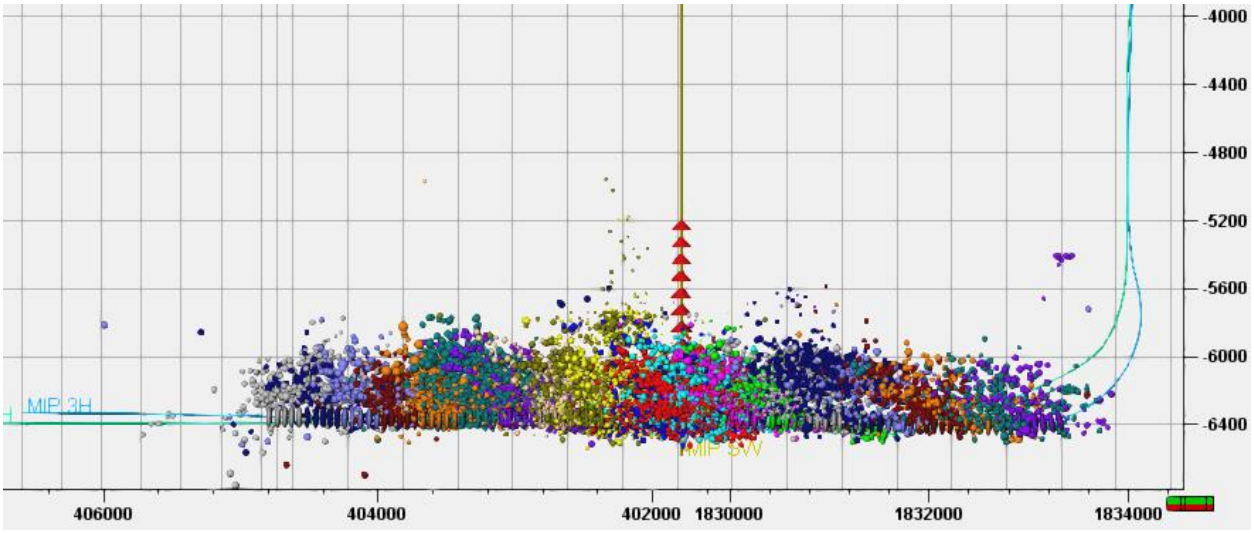



**Figure 6-27 – Cross-section view of all events for all stages monitored on the NNE MIP 3H well sized by magnitude.**

**Confidence Factor**

Quality indicators are computed for each receiver measuring factors such as P and S trace quality, time pick accuracy, and hodogram angles. Quality indicators across the receiver arrays are combined to form seven quality indicators for each microseismic event. The seven indicators are further reduced to a confidence factor ranging from 0 to 5, where higher values indicate higher confidence levels.

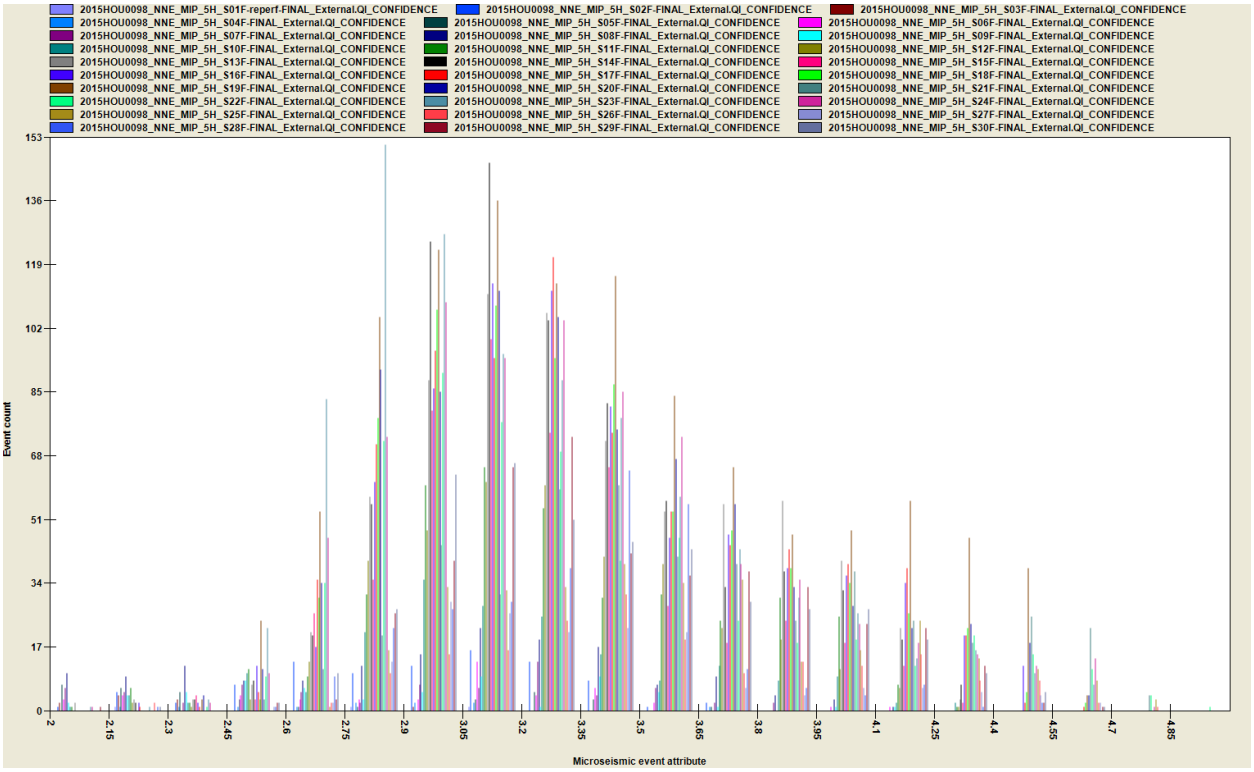



**Figure 6-28 – Confidence factor histograms for all events from all stages monitored on the NNE MIP 5H well.**

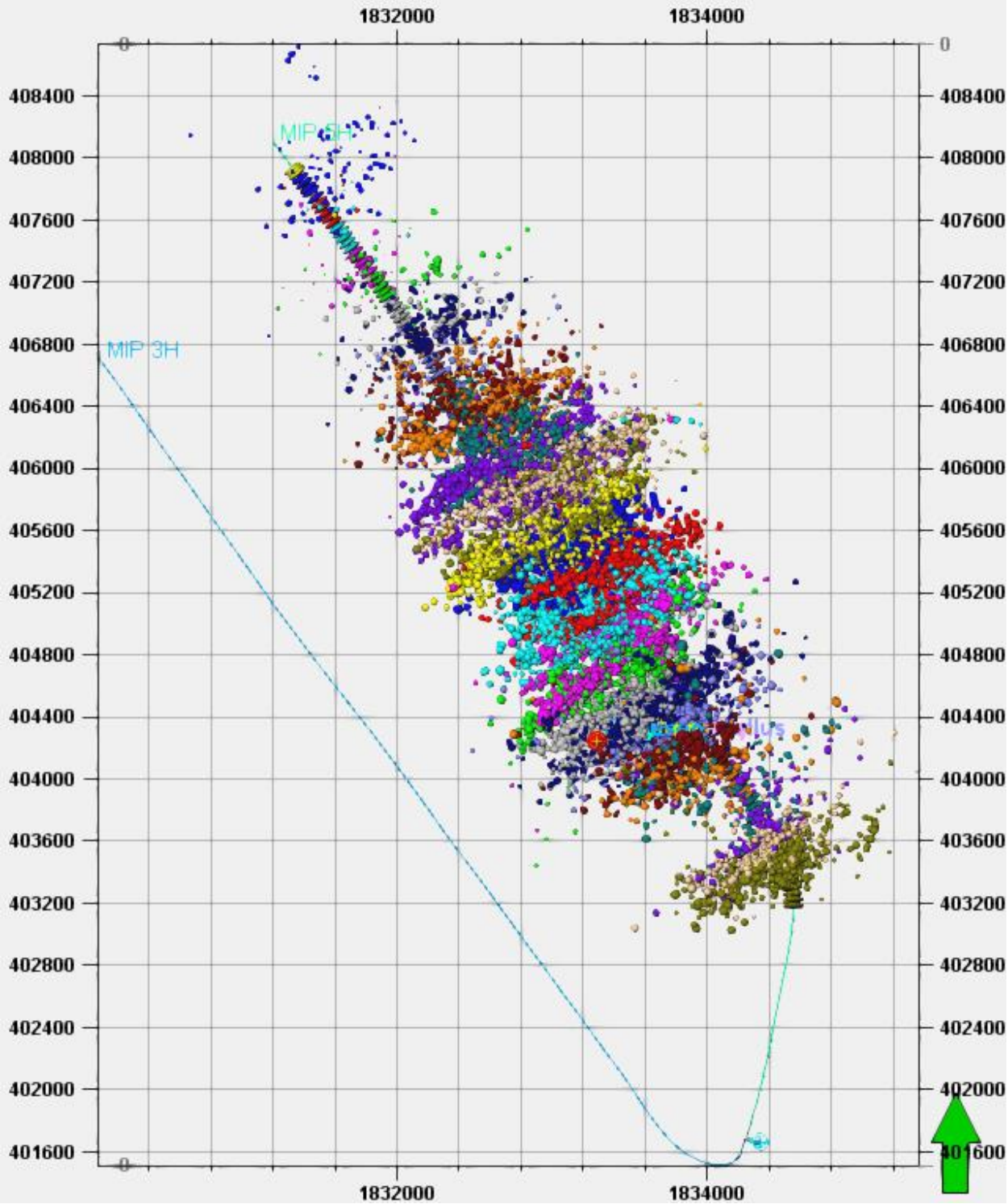



**Figure 6-29 – Map view of all events for stages monitored on the NNE MIP 5H well sized by confidence factor. Lower values are represented by smaller spheres while higher values are represented by larger spheres.**

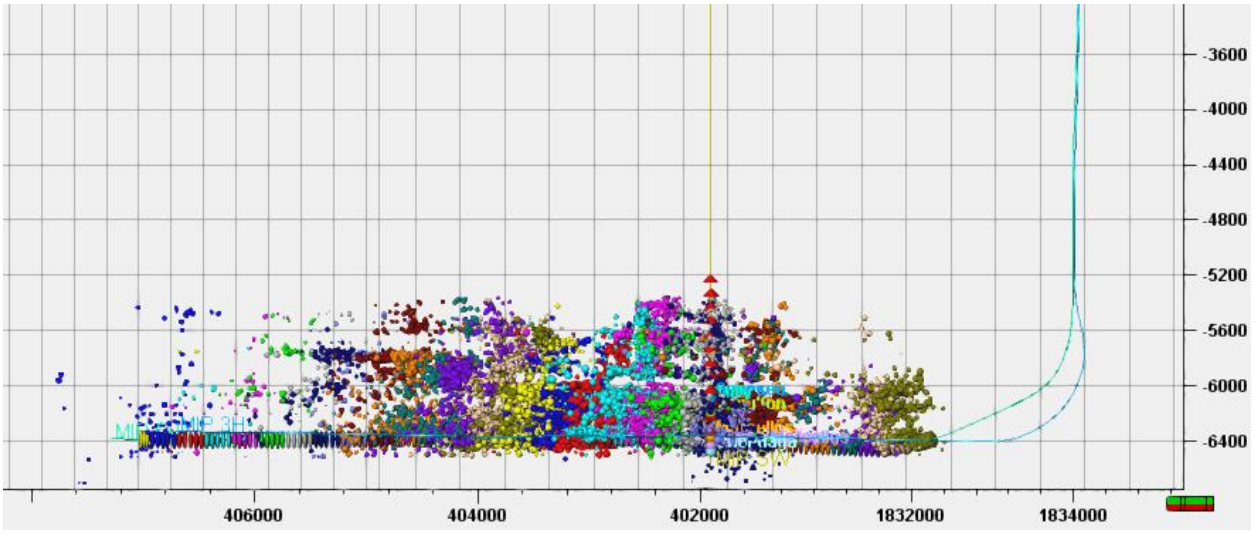



**Figure 6-30 – Cross-section view of all events for stages monotored on the NNE MIP 5H well sized by confidence factor. Lower values are represented by smaller spheres while higher values are represented by larger spheres.**

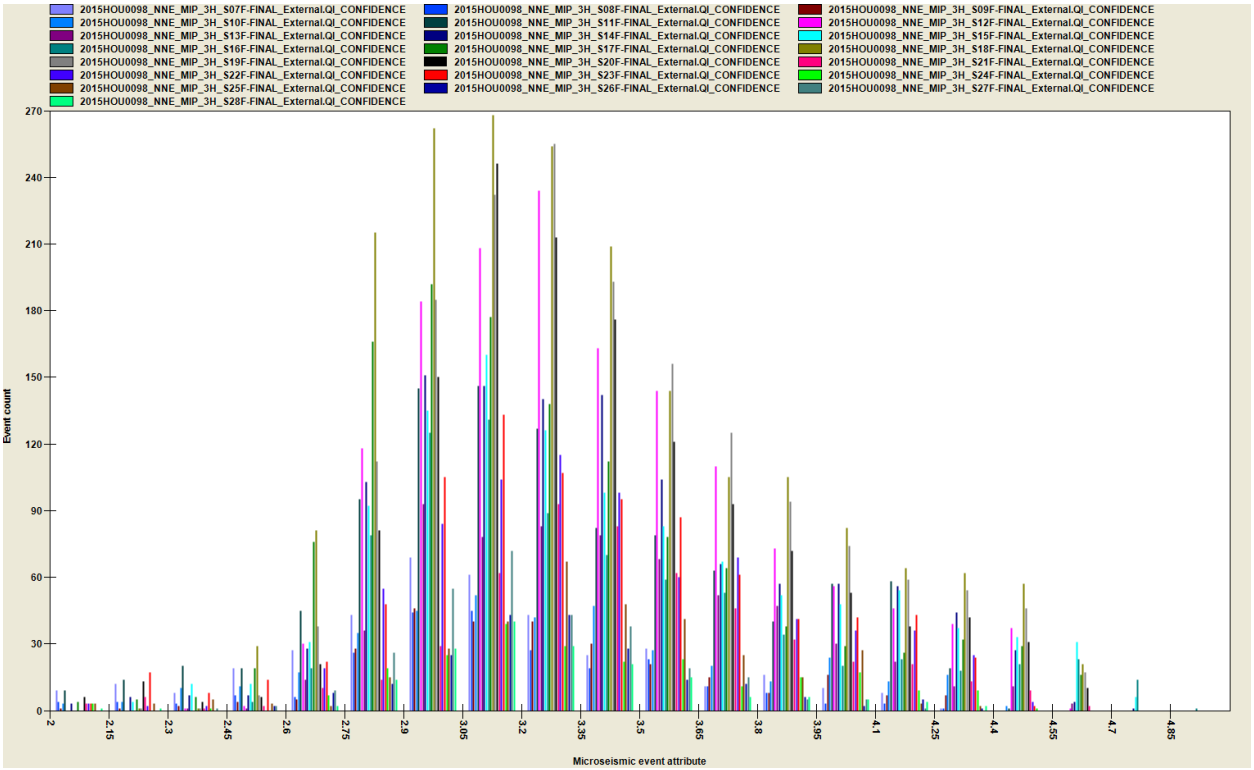



**Figure 6-31 – Confidence factor histograms for all events from all stages monitored on the NNE MIP 3H well.**

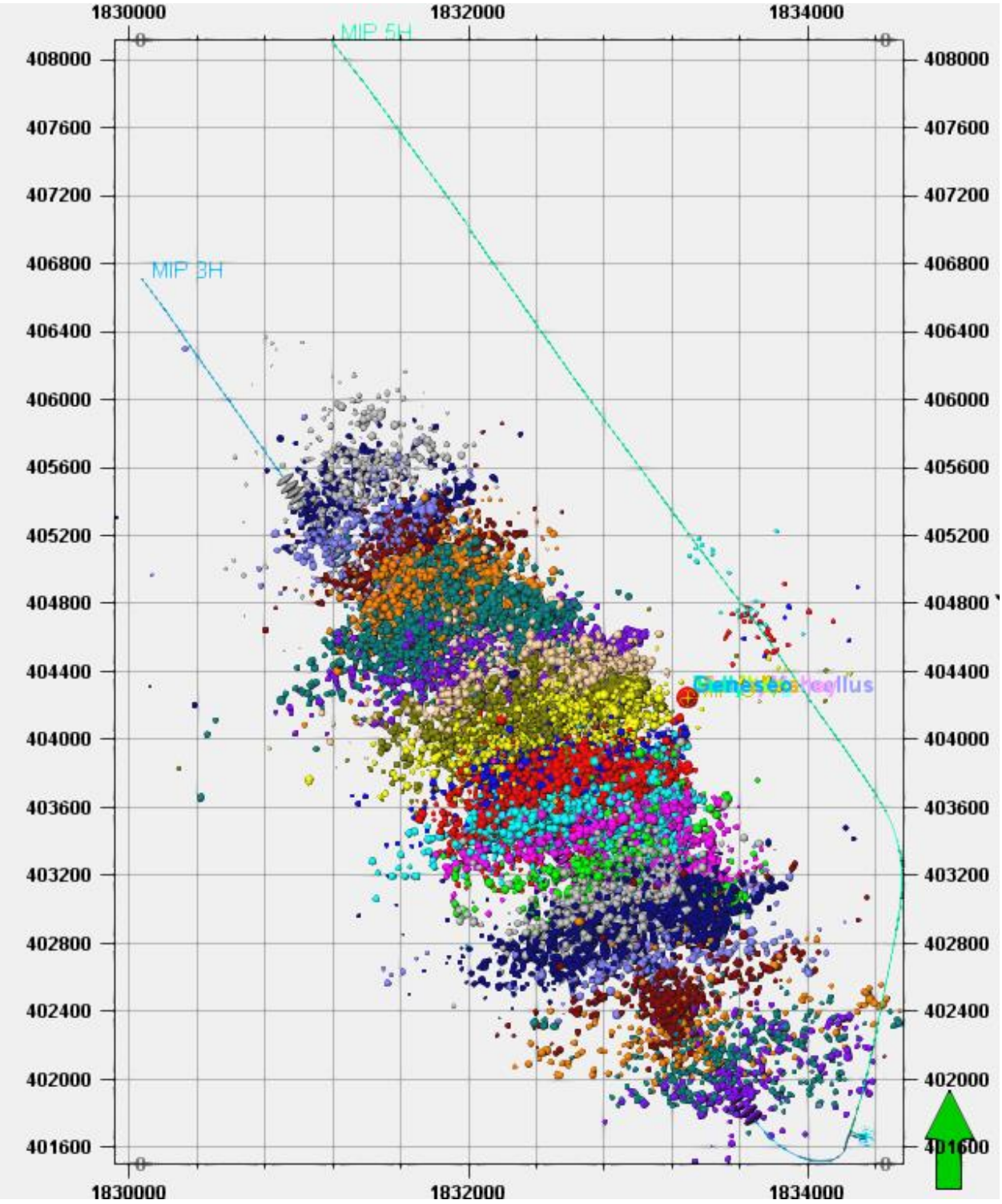



**Figure 6-32 – Map view of all events for stages monitored on the NNE MIP 3H well sized by confidence factor. Lower values are represented by smaller spheres while higher values are represented by larger spheres.**

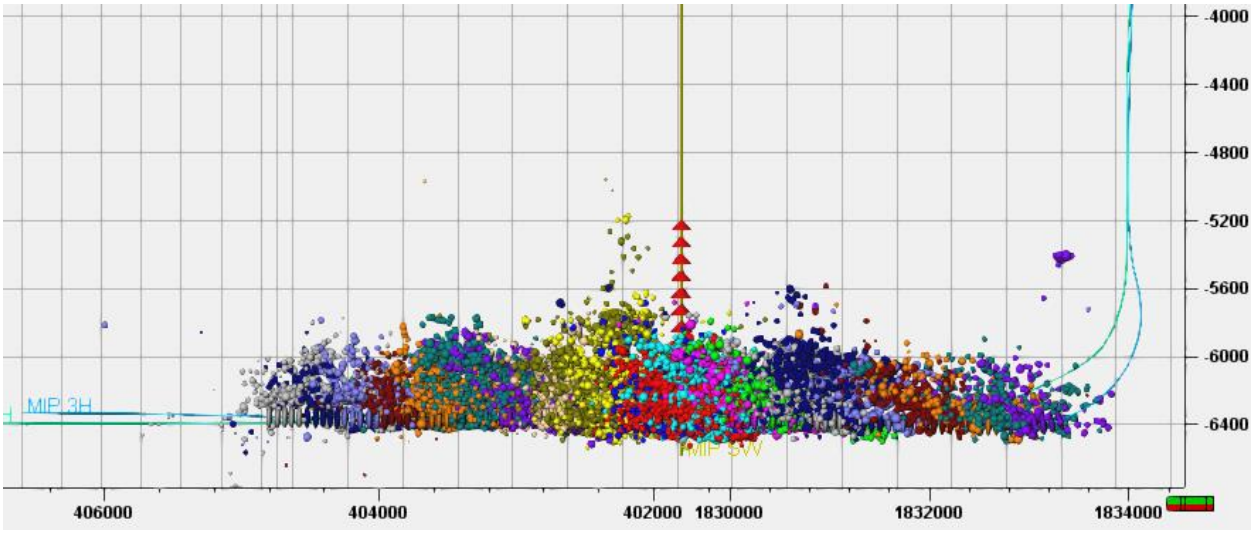



**Figure 6-33 – Cross-section view of all events for stages monitored on the NNE MIP 3H well sized by confidence factor. Lower values are represented by smaller spheres while higher values are represented by larger spheres.**

## Example Waveforms by Confidence Factor

The following series of waveforms show selected screen shots of actual data from the project for events with different degrees of quality as designated by their confidence factor. A higher number indicates greater confidence in the event location and a lower ellipsoid of uncertainty for the event. The maximum possible value for confidence factor is 5.000.

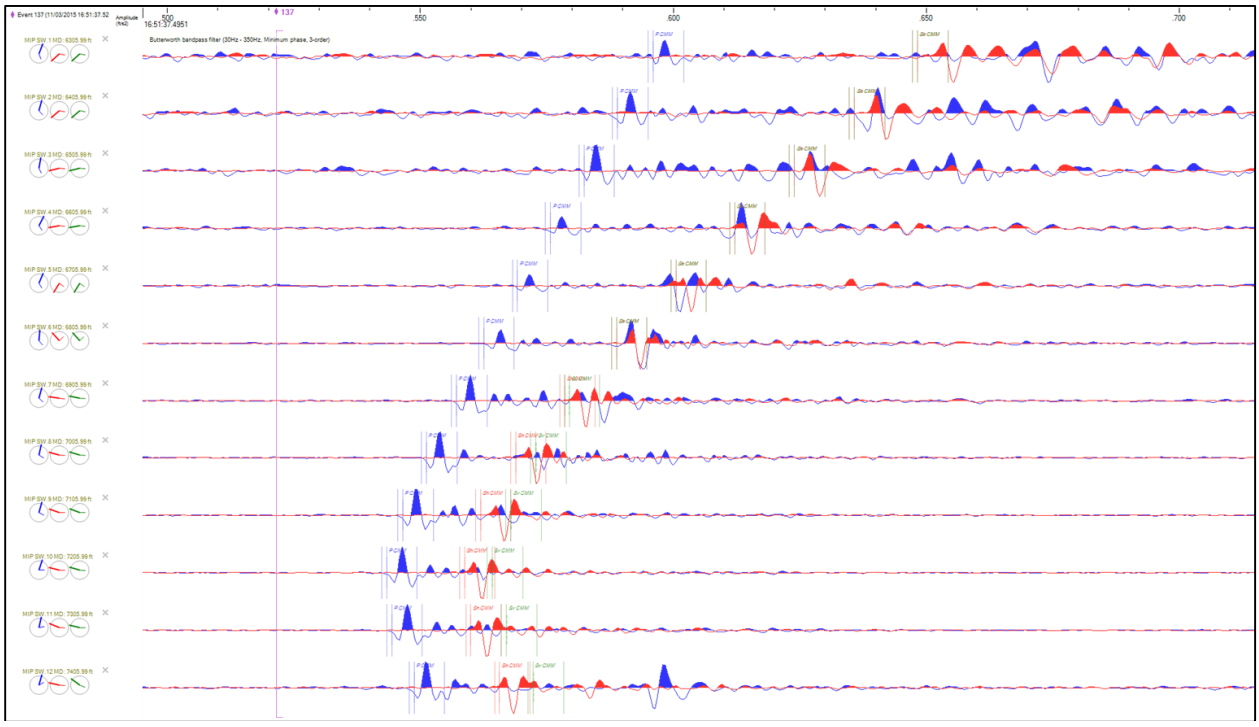


**Figure 6-34 – Example waveform with confidence factor 4.4.**

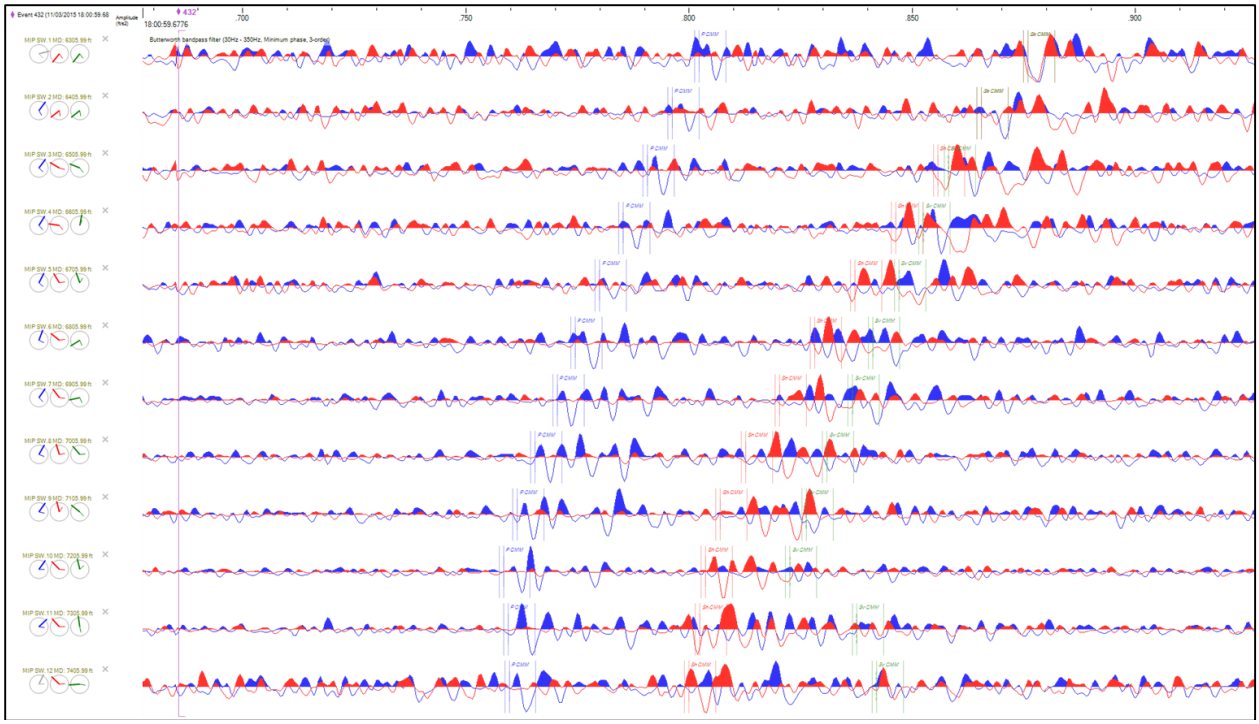


**Figure 6-35 – Example waveform with confidence factor 3.5.**

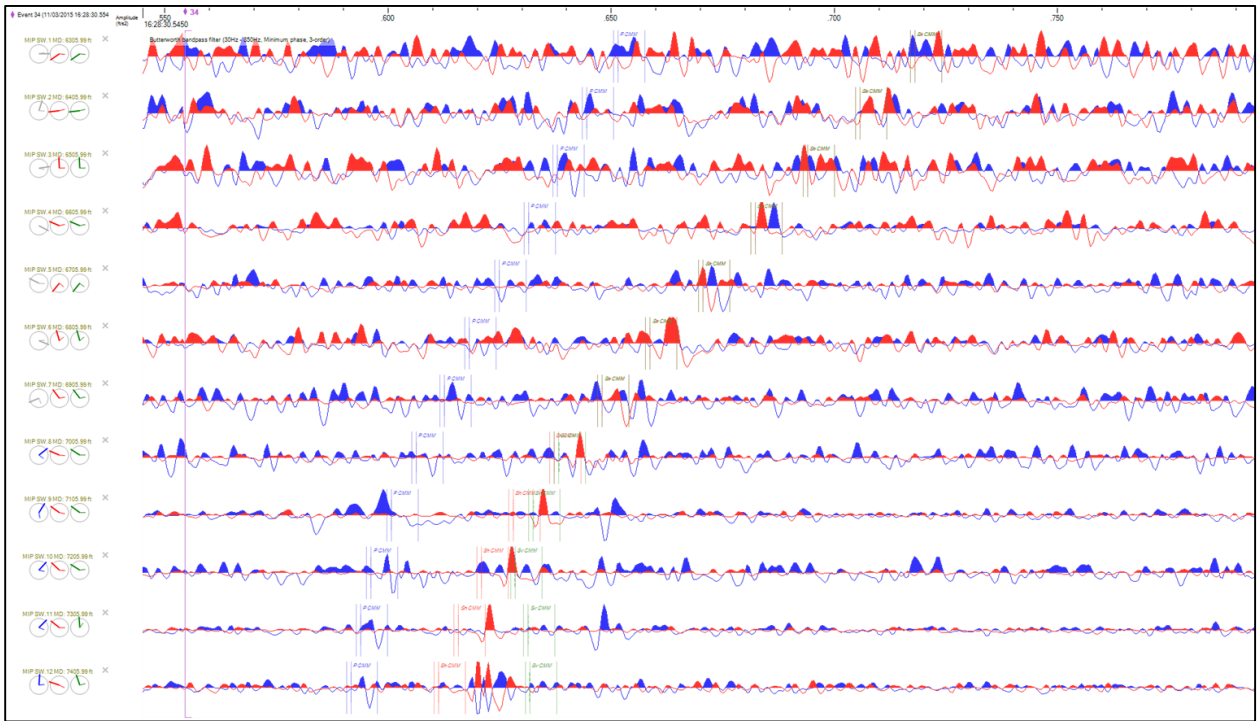


**Figure 6-36 – Example waveform with confidence factor 2.7.**

### Uncertainty

All location estimates have an associated uncertainty due to a variety of factors, including uncertainties in time picks, wellbore location, and velocity model. During processing this

uncertainty is estimated for each event. The uncertainty can be represented as the ellipsoid in space whose major axis represents the magnitude of the estimated maximum uncertainty for an event location. The major axis orientation indicates the direction that uncertainty applies.

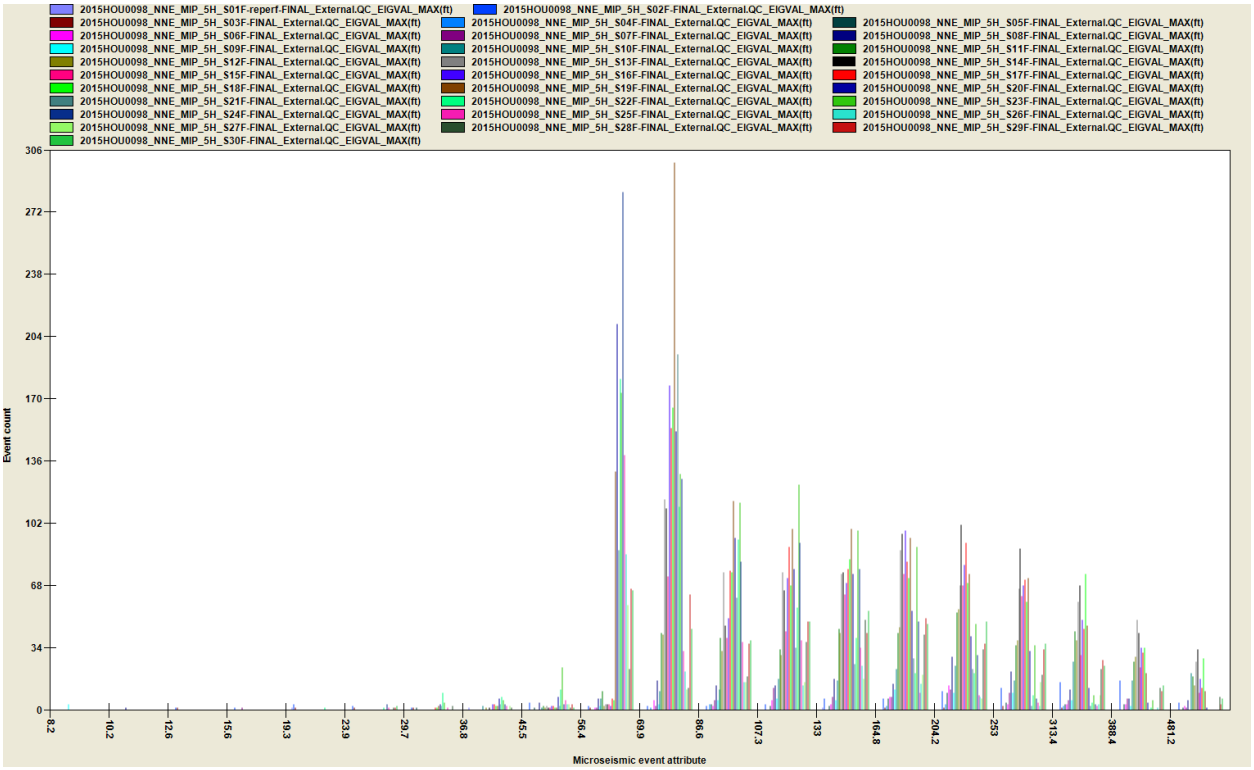



**Figure 6-37 – Maximum uncertainty histograms for all events from stages monitored on the NNE MIP 5H well.**

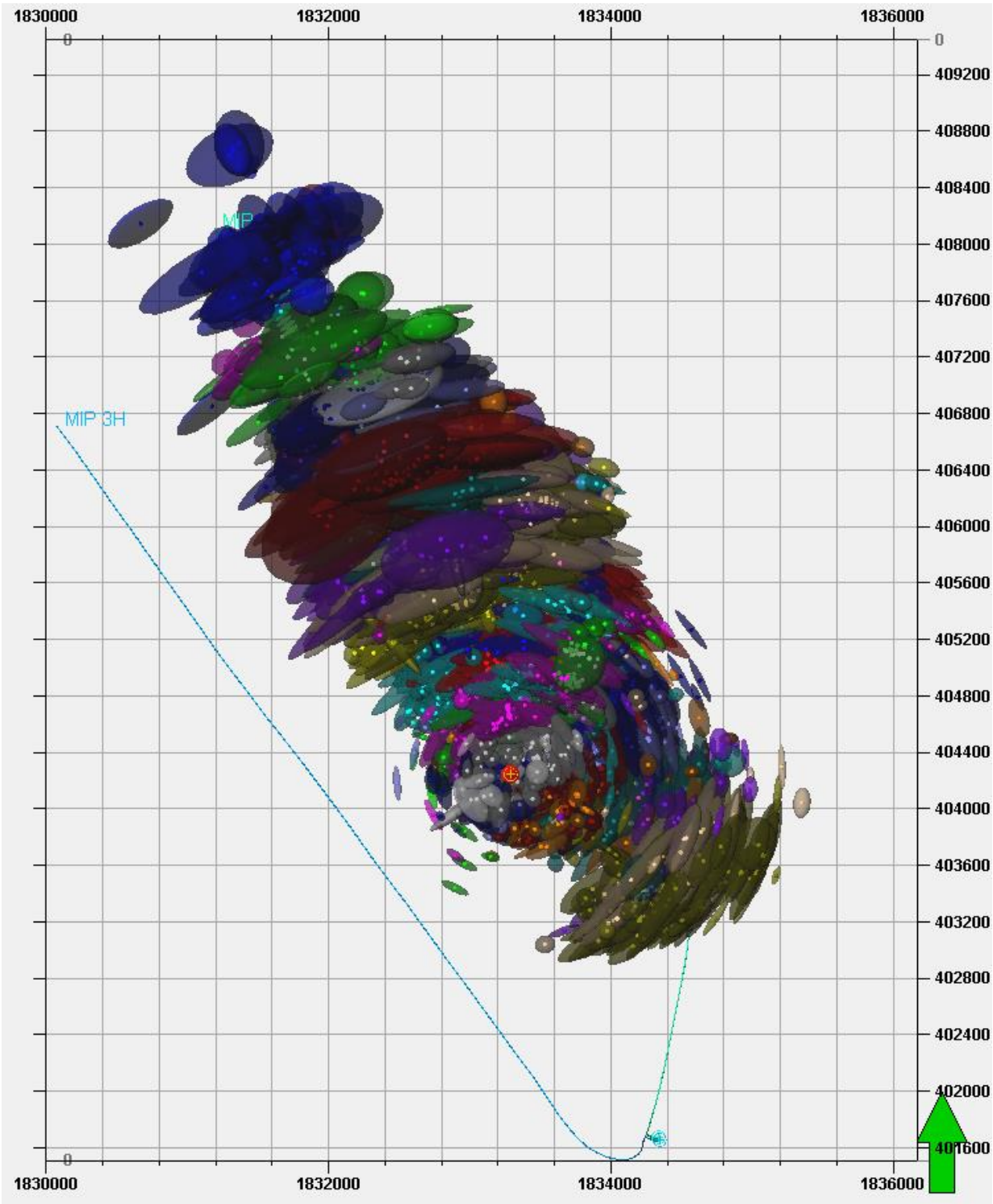



**Figure 6-38 – Map view of all events with uncertainty ellipsoids for stages monitored on the NNE MIP 5H well. Lower values are represented by smaller ellipsoids while higher values are represented by larger ellipsoids.**

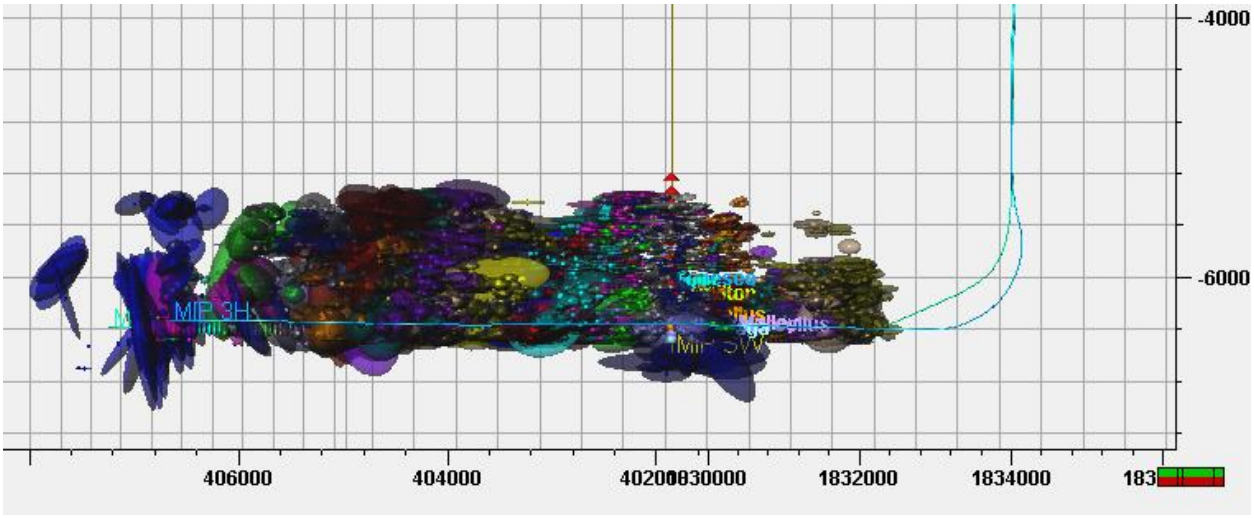



**Figure 6-39 – Cross-section view of all events with uncertainty ellipsoids for all stages monitored on the NNE MIP 5H well. Lower values are represented by smaller ellipsoids while higher values are represented by larger ellipsoids.**

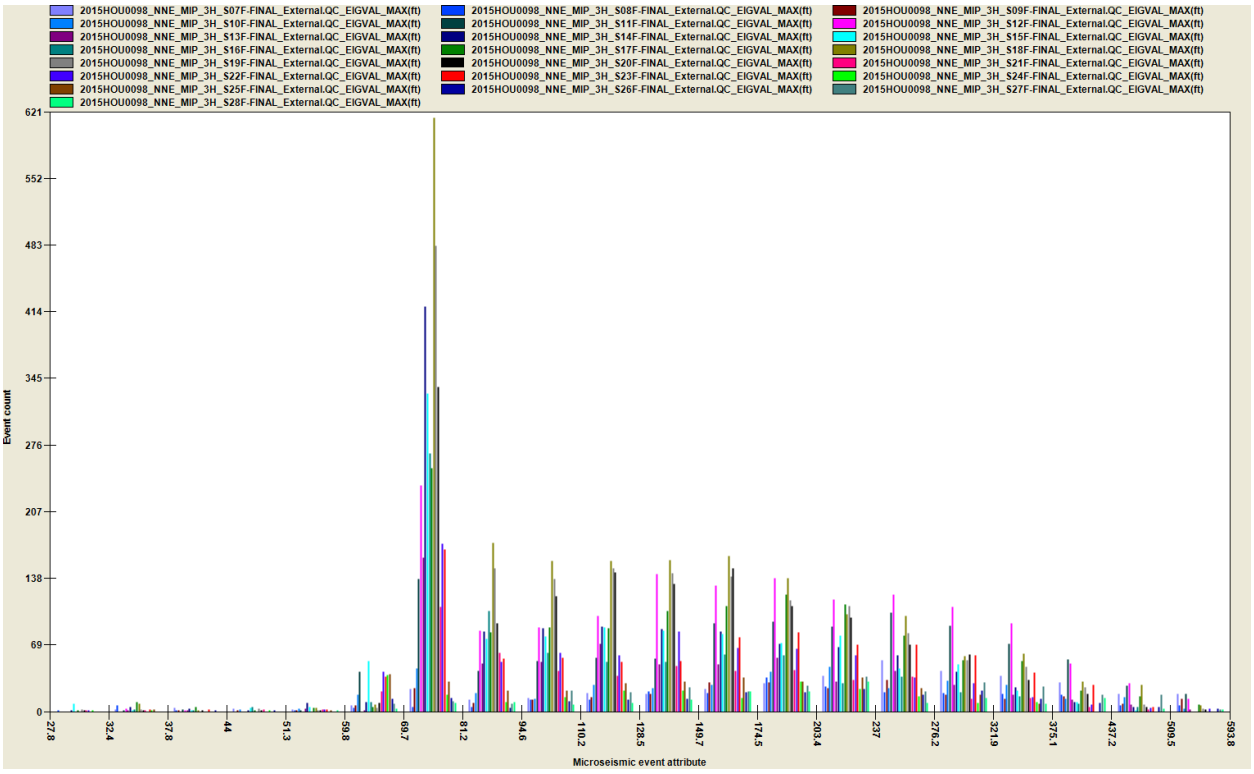



**Figure 6-40 – Maximum uncertainty histograms for all events from stages monitored on the NNE MIP 3H well.**

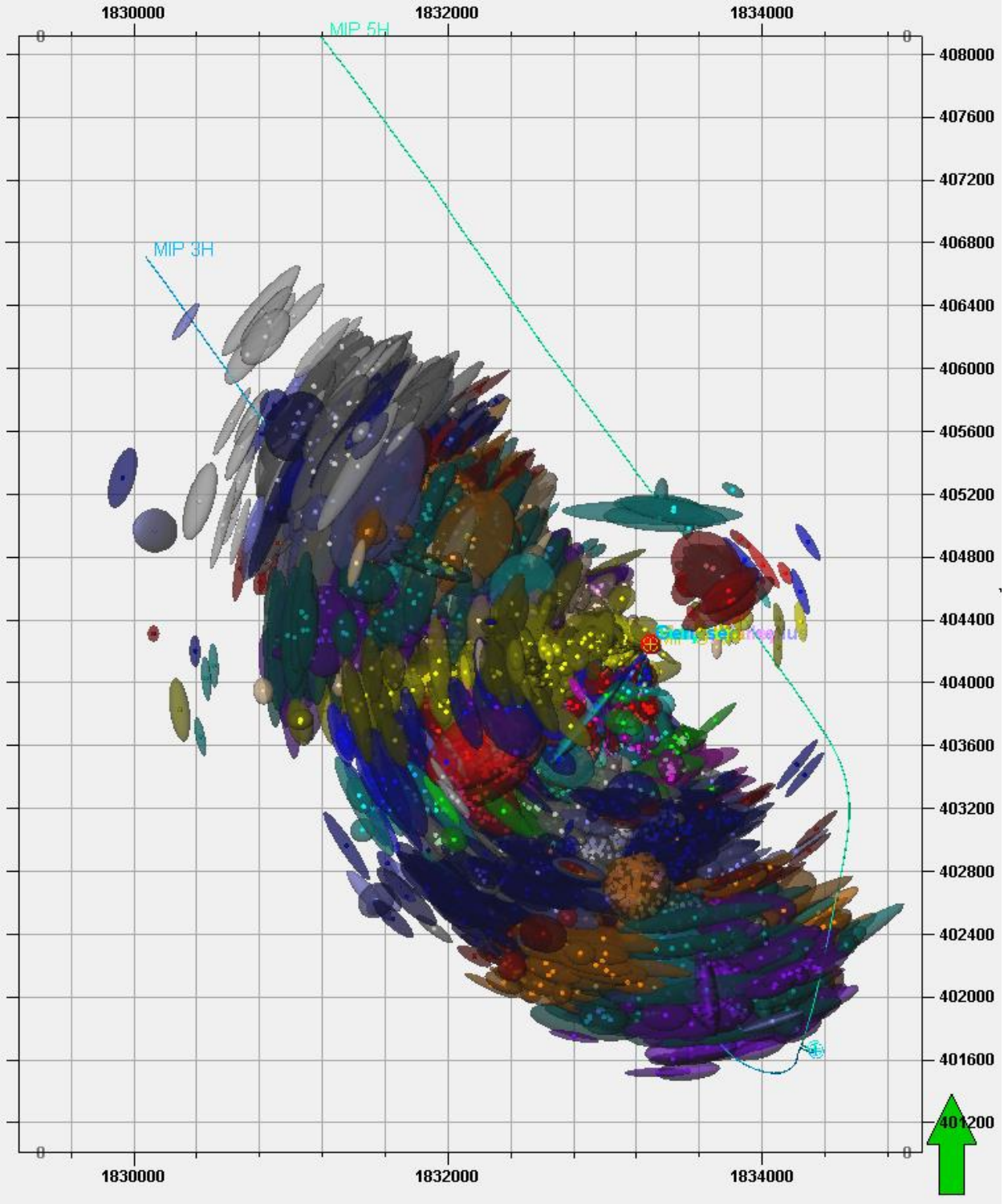



**Figure 6-41 – Map view of all events with uncertainty ellipsoids for stages monitored on the NNE MIP 3H well. Lower values are represented by smaller ellipsoids while higher values are represented by larger ellipsoids.**

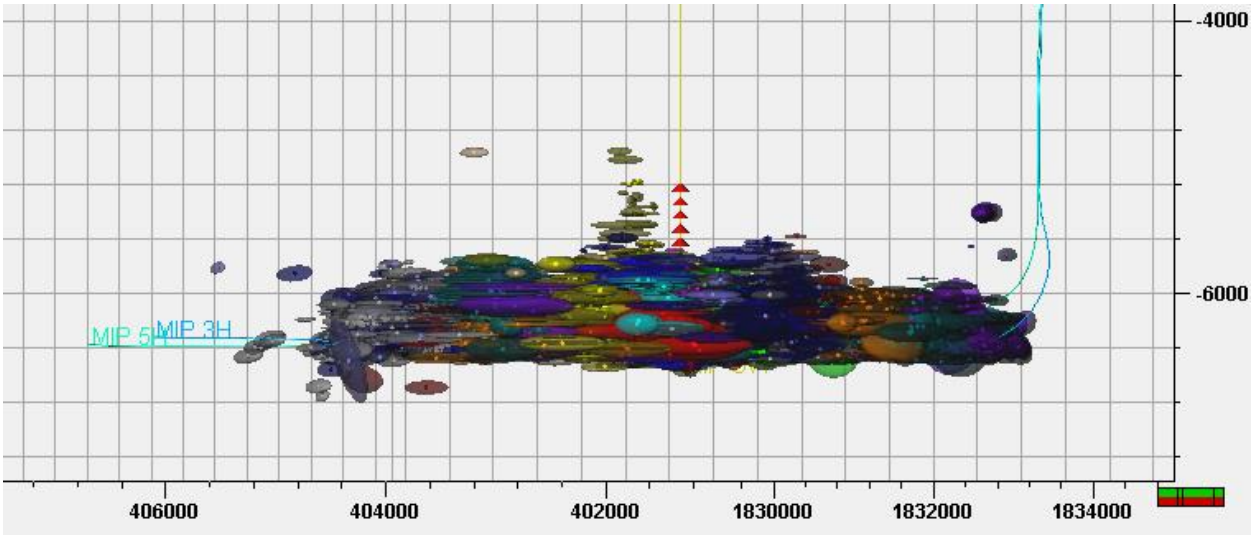



**Figure 6-42 – Cross-section view of all events with uncertainty ellipsoids for all stages monitored on the NNE MIP 3H well. Lower values are represented by smaller ellipsoids while higher values are represented by larger ellipsoids.**