

OPM Flow MULT Sensitivity Cases

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E I P C OPM Flow MULT Sensitivity Cases

- Objective:

- Derived simple test cases to verify implementation of MULT series of keywords in OPM Flow and to act as developer test cases.

- Work Flow

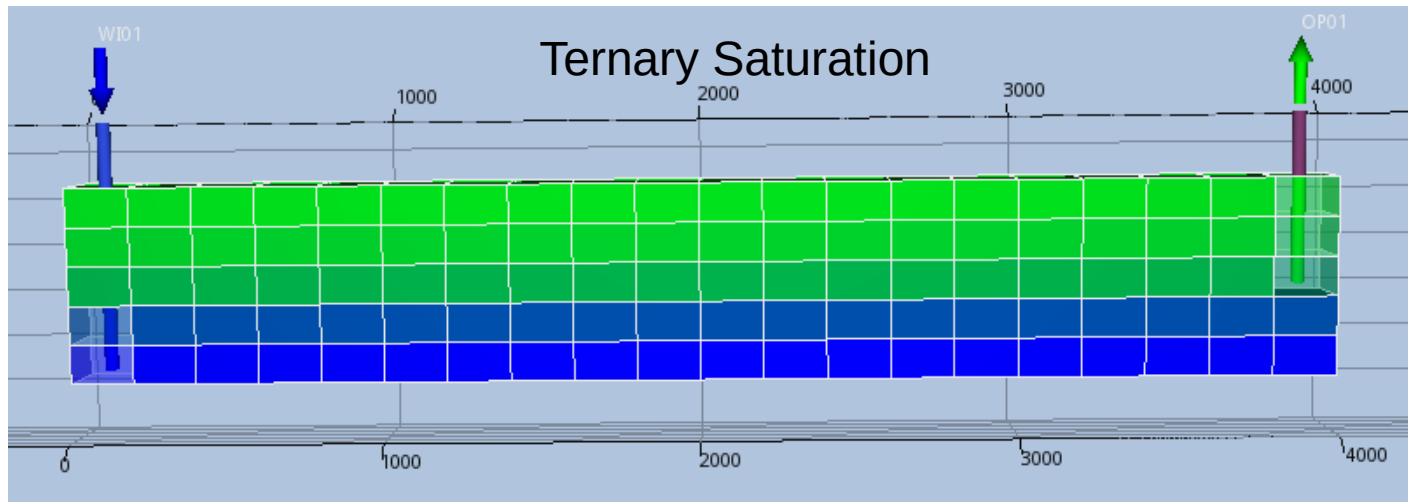
- Built a two dimensional, two phase model based on MODEL1, with simplified properties (MULT1), also built 3D model (MULT2) due to issues found with the 2D model. Both models run in less than one second.
- Ran various test cases and documented the results (this presentation).

- Summary and Conclusions

- Using the MULT keywords in the GRID section, only the last entry is applied in both the commercial simulator and OPM Flow. Results are the same as 2019-04 release.
- Multiple MULT keywords applied in the EDIT section are applied cumulatively - only the last entry is applied in both the commercial simulator and OPM Flow 2019-04 in both the GRID and EDIT sections.
- Visualization of TRANX, TRANY and TRANY in current and previous release is incorrect for 2D models, but correct for 3D models.
- MULT keywords applied in the SCHEDULE section results in an error message and the run stopping, which is the correct way to handle this as OPM Flow does not have this feature implemented.
- Omitting PERM arrays in the GRID section but including TRAN arrays in EDIT section results in OPM Flow starting and failing; instead the simulator should stop with a message saying insufficient data to compute transmissibilities.
- Exporting the simulator calculated permeabilities from the commercial simulator and loading them back into OPM Flow gives significantly different results, as there appears to be an issue with entering transmissibilities in the EDIT section with 2D models only.
- Generated a 3D model (MULT2) and re-ran using TRANs in the EDIT section gives consistent results, confirming the issue is with 2D models only. However, there is still an issue with the MULT keywords applied cumulatively in the EDIT section.

E I P C OPM Flow Model Description

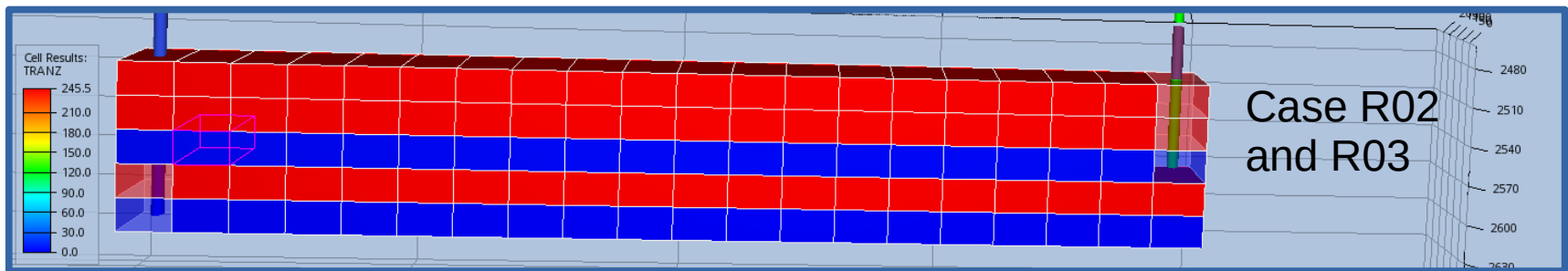
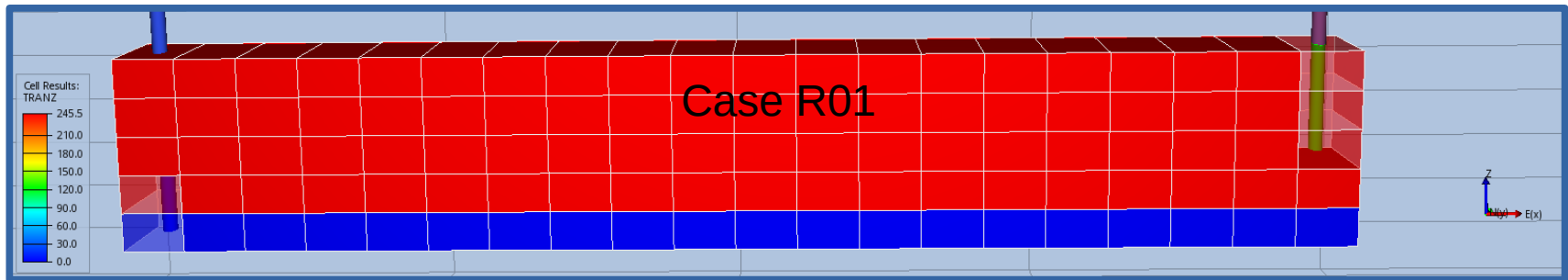
- Based on on MODEL01, two dimensional cross section model 20 x 1 x 5 (x, y, z) with field average permeability values.



- Two Phase heavy oil PVT with oil viscosity set to 50 instead of 835 cP, to get reasonable oil rate production.

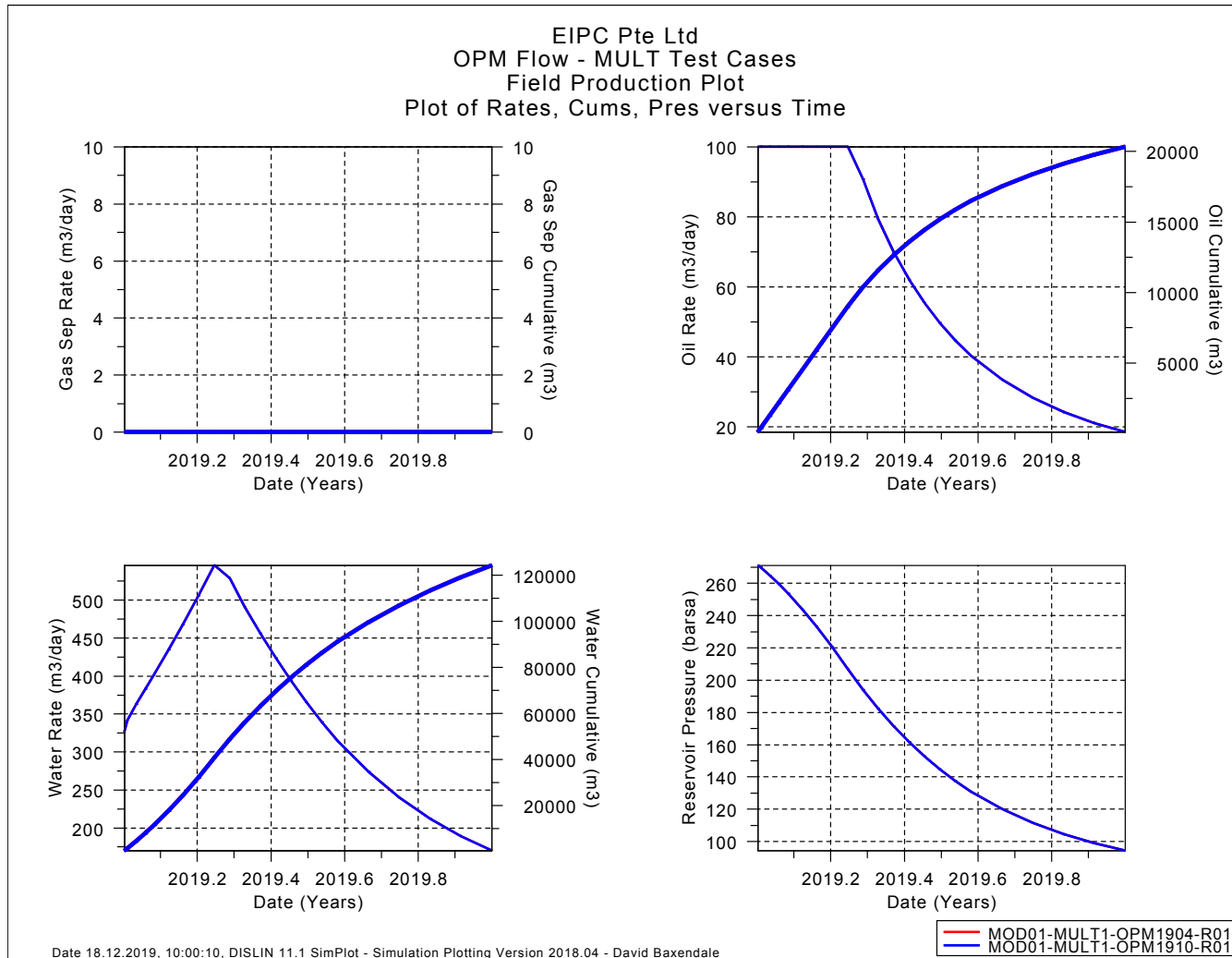
E I P C OPM Flow Grid Section MULT Cases

No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
2	MULT1~R02	Test basic functionality of MULTZ	(1) Layer 3 MULTZ x 0.000
3	MULT1~R03	Check if MULTZ is applied cumulatively, or only the last entry	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01



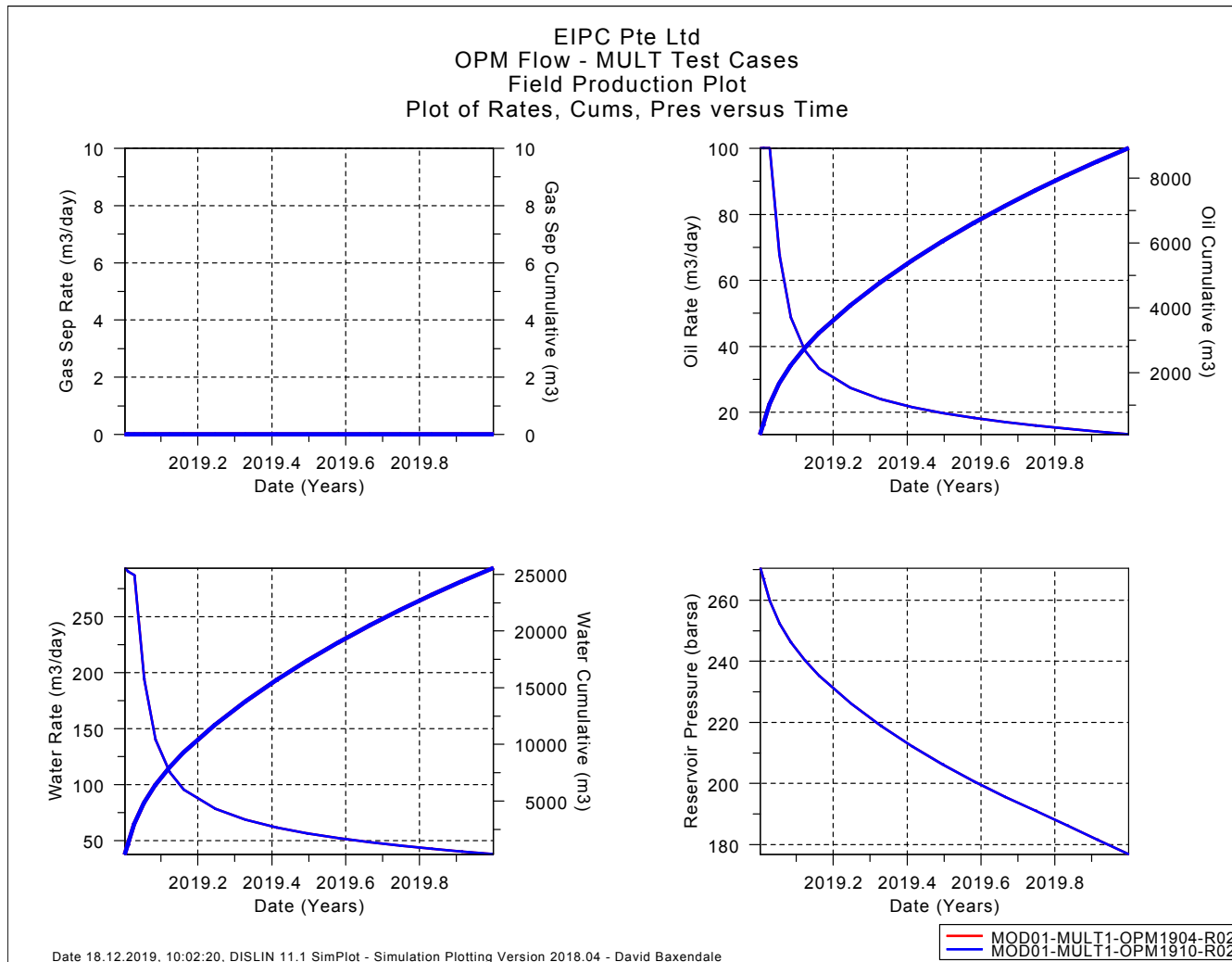
OPM Flow Grid Section MULT Results

OPM Flow 2019-10 Versus 2019-04



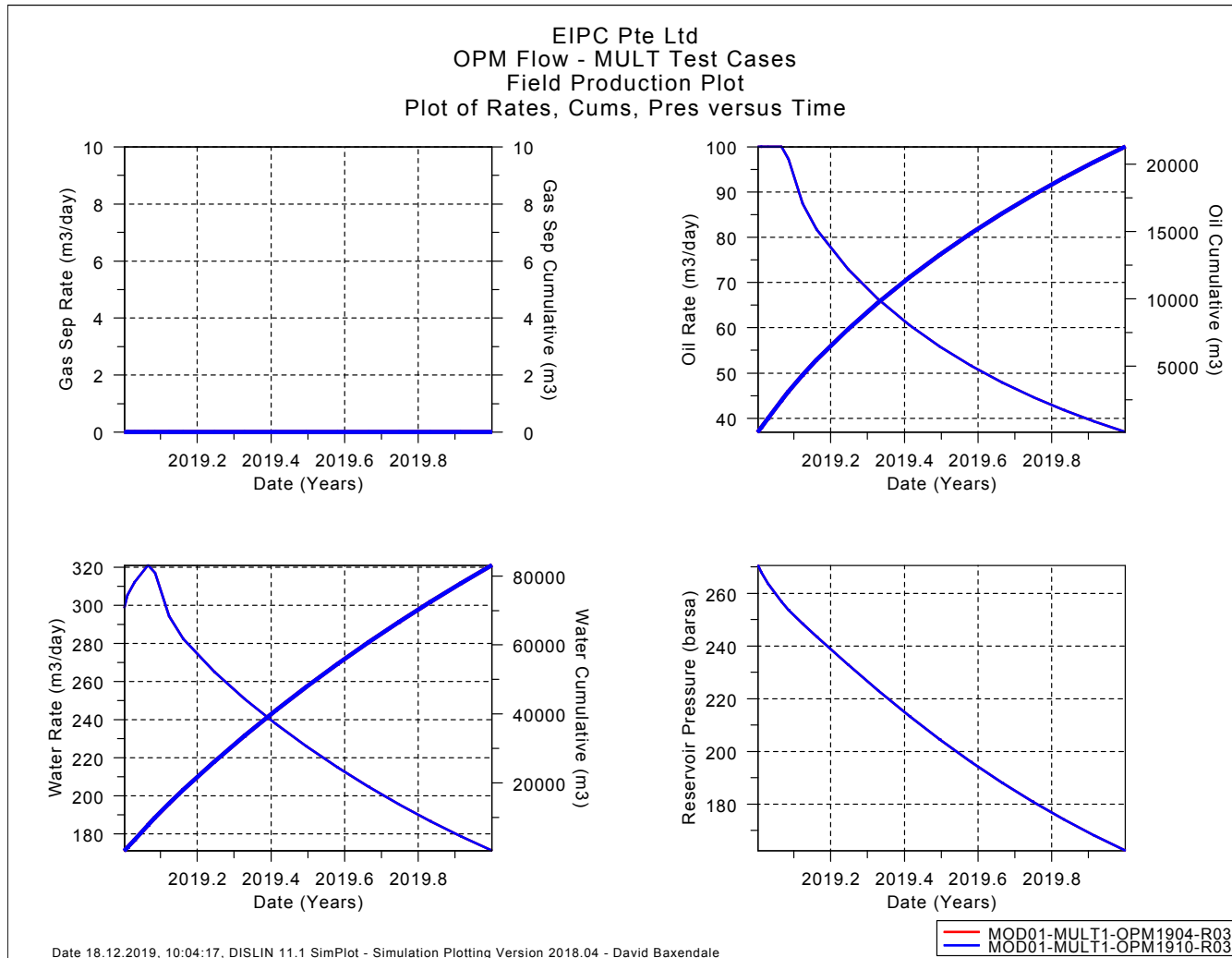
OPM Flow Grid Section MULT Results

OPM Flow 2019-10 Versus 2019-04



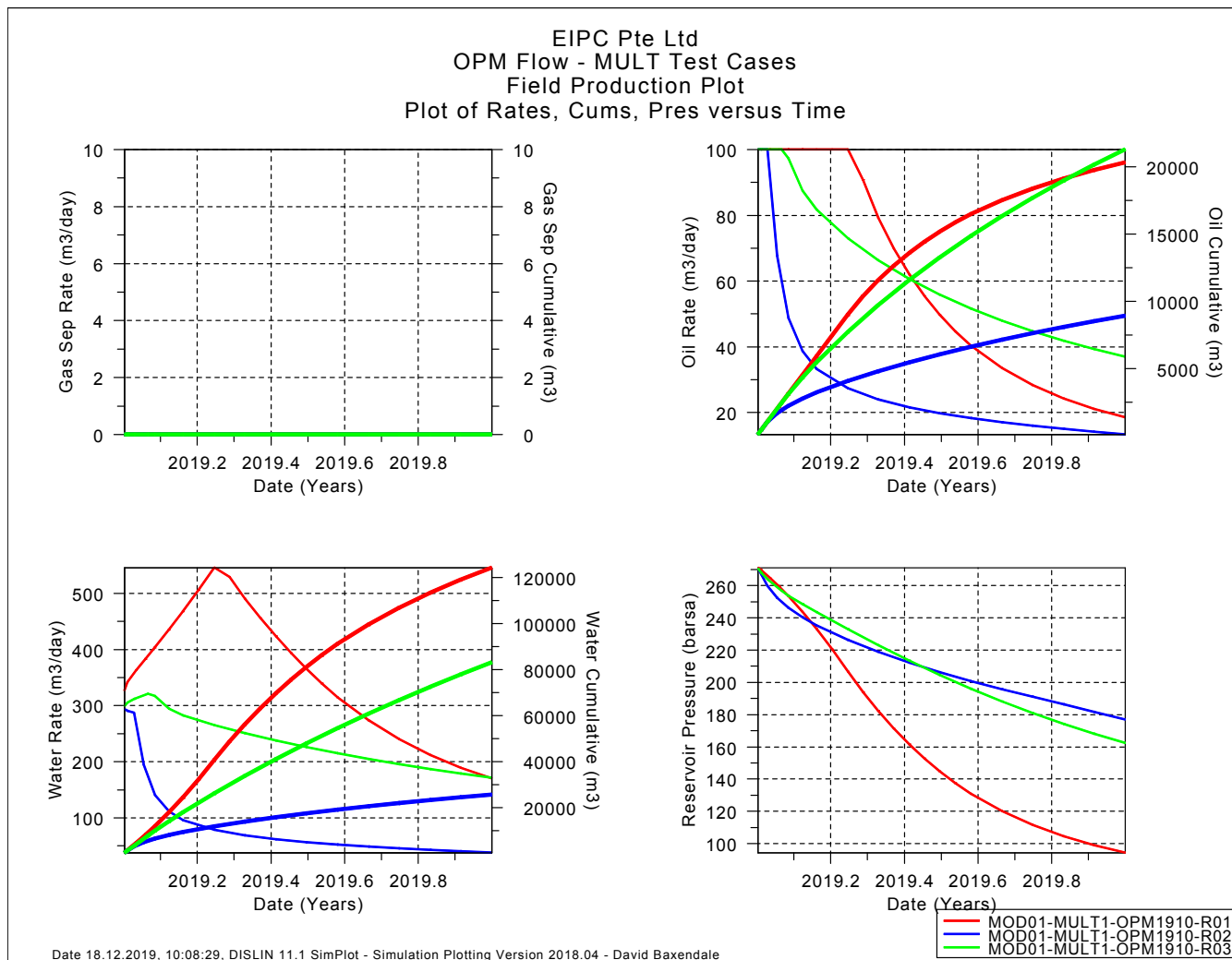
OPM Flow Grid Section MULT Results

OPM Flow 2019-10 Versus 2019-04



OPM Flow Grid Section MULT Results

OPM Flow 2019-10

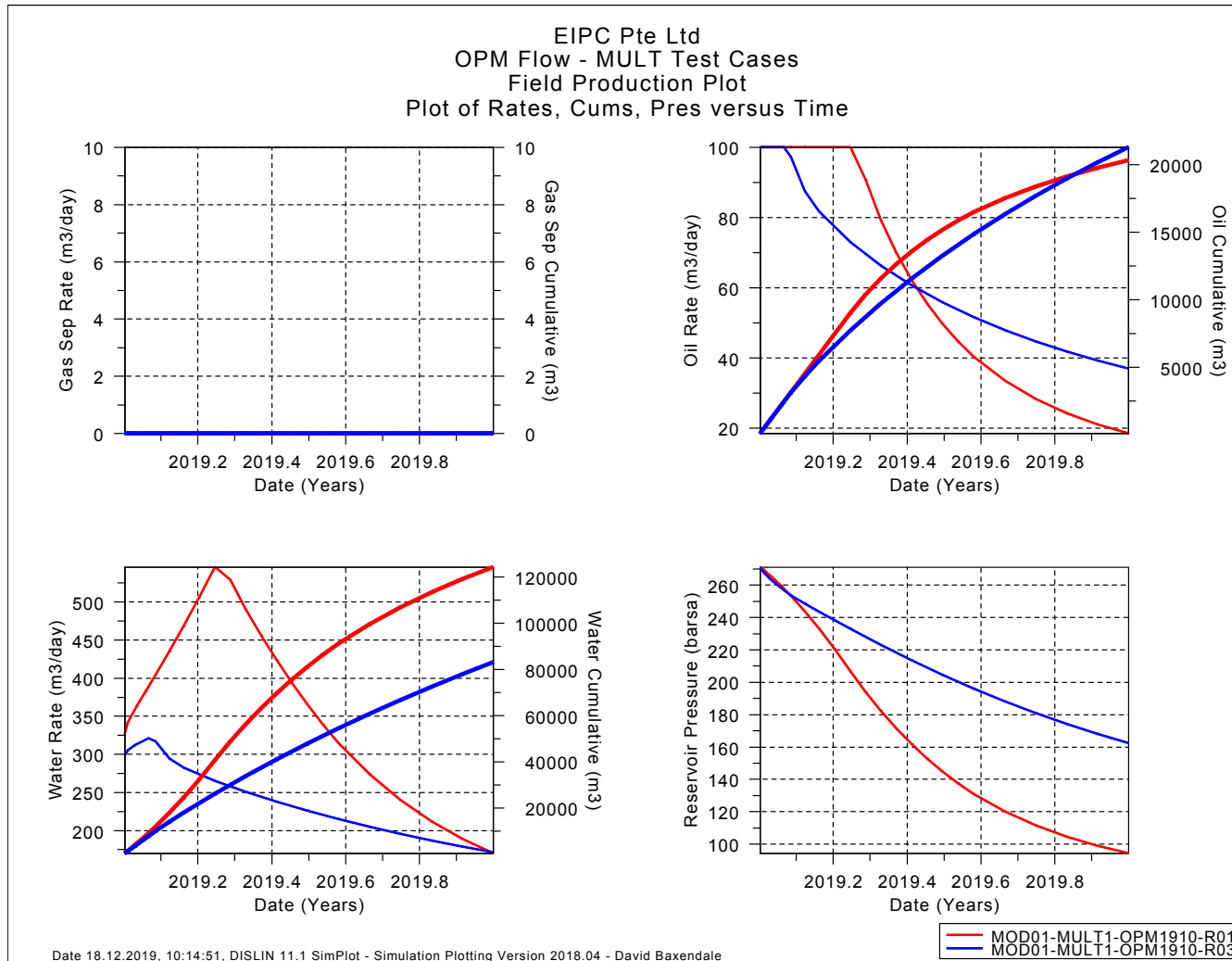


No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
2	MULT1~R02	Test basic functionality of MULTZ in the GRID section.	(1) Layer 3 MULTZ x 0.000
3	MULT1~R03	Check if MULTZ is applied cumulatively, or only the last entry in the Grid section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01 Only last modification applied – correct.
4	MULT1~R04	Test basic functionality of MULTZ in EDIT section	(1) Layer 3 MULTZ x 0.000
5	MULT1~R05	Check if MULTZ is applied cumulatively, or only the last entry in the EDIT section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01

Using the MULT keywords in the GRID section (R03) gives different results to the base case (R01), meaning only the last modification is applied, same as the commercial simulator.

OPM Flow Grid Section MULT Results

OPM Flow 2019-10: GRID Modifications

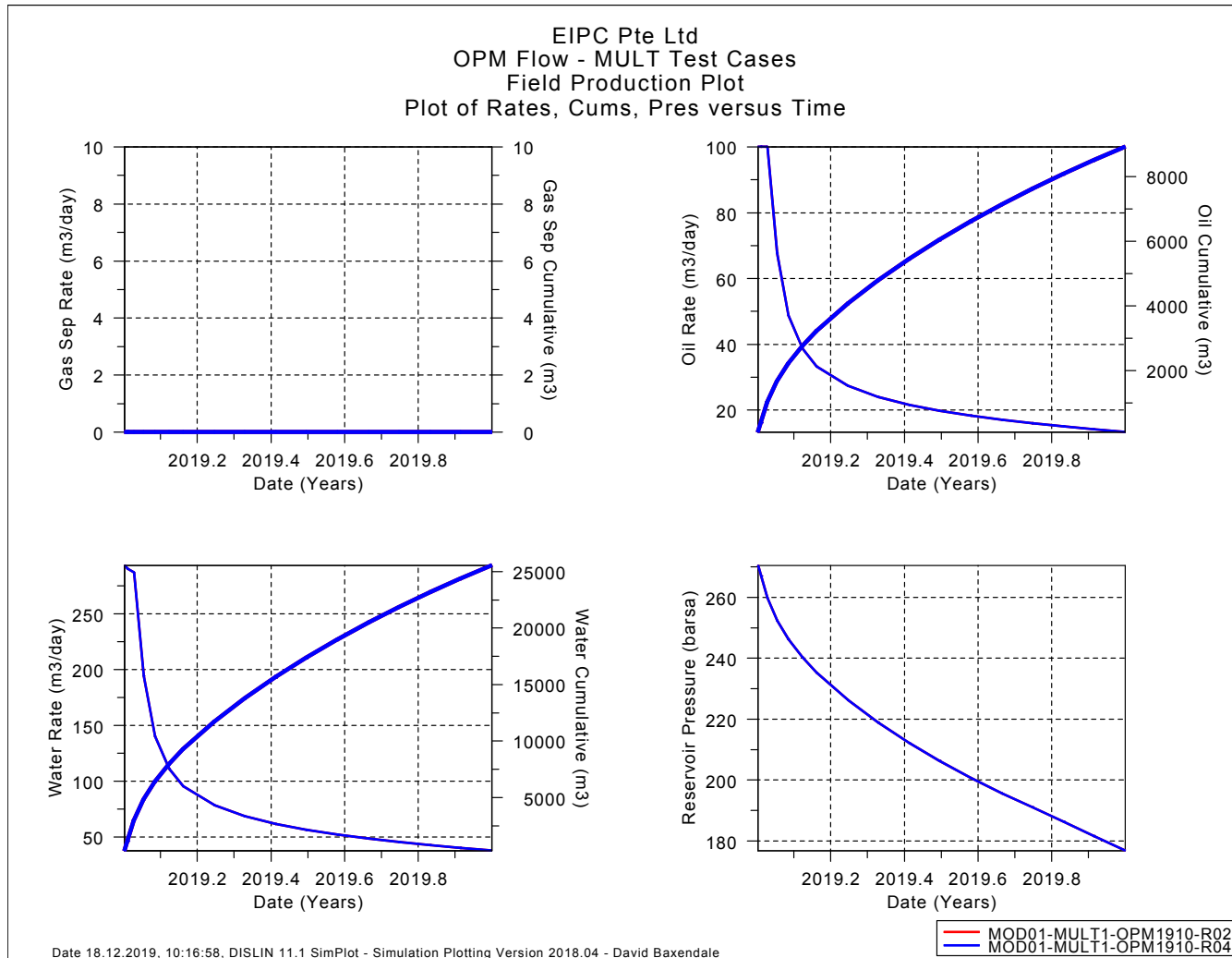


No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
2	MULT1~R02	Test basic functionality of MULTZ in the GRID section.	(1) Layer 3 MULTZ x 0.000 Same results for GRID and EDIT sections
3	MULT1~R03	Check if MULTZ is applied cumulatively, or only the last entry in the Grid section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01
4	MULT1~R04	Test basic functionality of MULTZ in EDIT section	(1) Layer 3 MULTZ x 0.000 Same results for GRID and EDIT sections
5	MULT1~R05	Check if MULTZ is applied cumulatively, or only the last entry in the EDIT section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01

Applying the same single MULT keyword in the GRID and EDIT section gives the same results – correct.

OPM Flow Grid Section MULT Results

OPM Flow 2019-10: GRID Versus EDIT Modifications



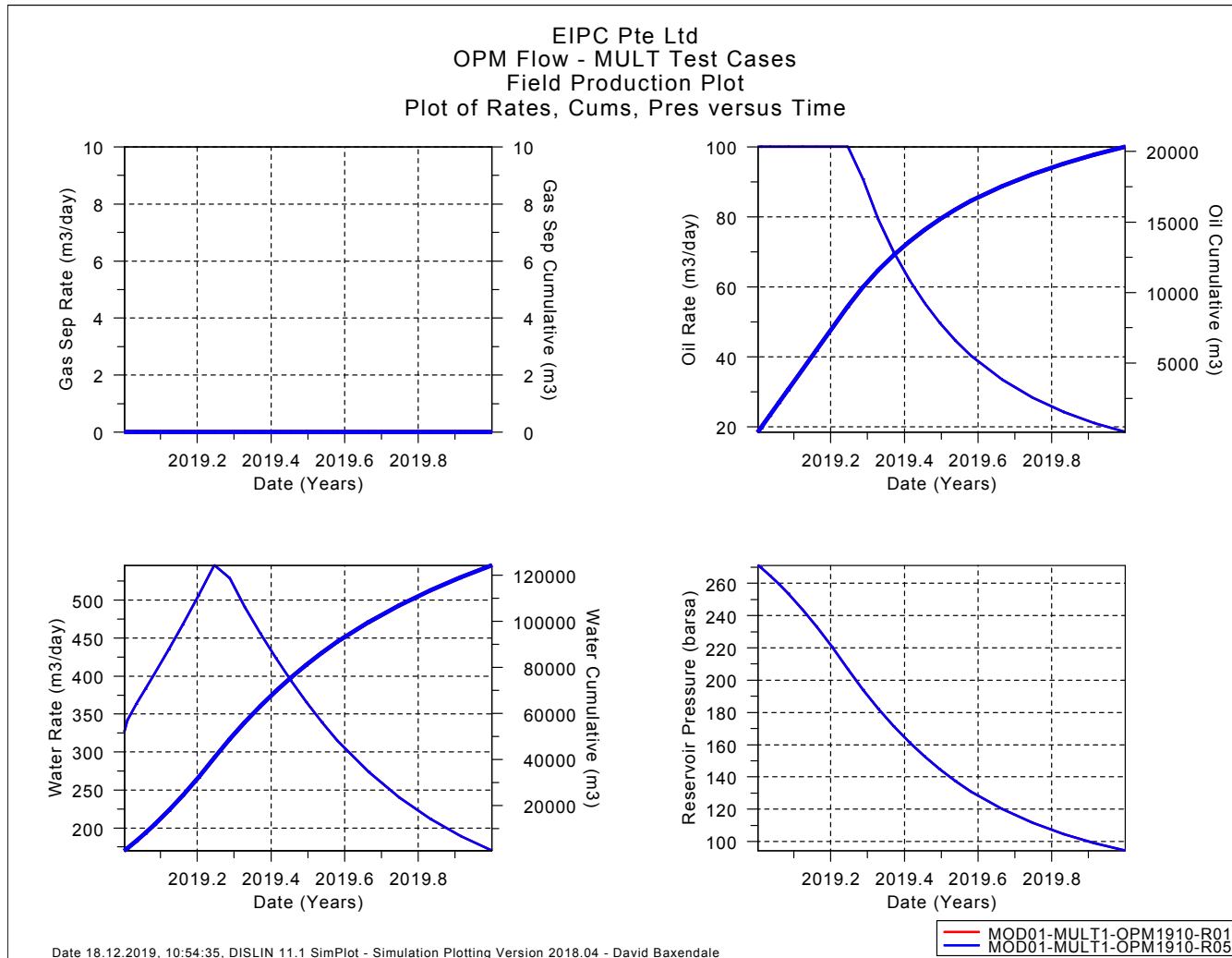
No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
2	MULT1~R02	Test basic functionality of MULTZ in the GRID section.	(1) Layer 3 MULTZ x 0.000
3	MULT1~R03	Check if MULTZ is applied cumulatively, or only the last entry in the Grid section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01 Last Entry
4	MULT1~R04	Test basic functionality of MULTZ in EDIT section	(1) Layer 3 MULTZ x 0.000
5	MULT1~R05	Check if MULTZ is applied cumulatively, or only the last entry in the EDIT section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01 Cumulatively

Multiple MULT keywords applied in the EDIT section (R05) give the same results to the base case (R01), meaning MULT is applied cumulatively - only the last entry is applied in both the commercial simulator and OPM Flow 2019-04 in both the GRID and EDIT sections.

In OPM Flow 2019-10 MULT is Applied Cumulatively in the EDIT Section

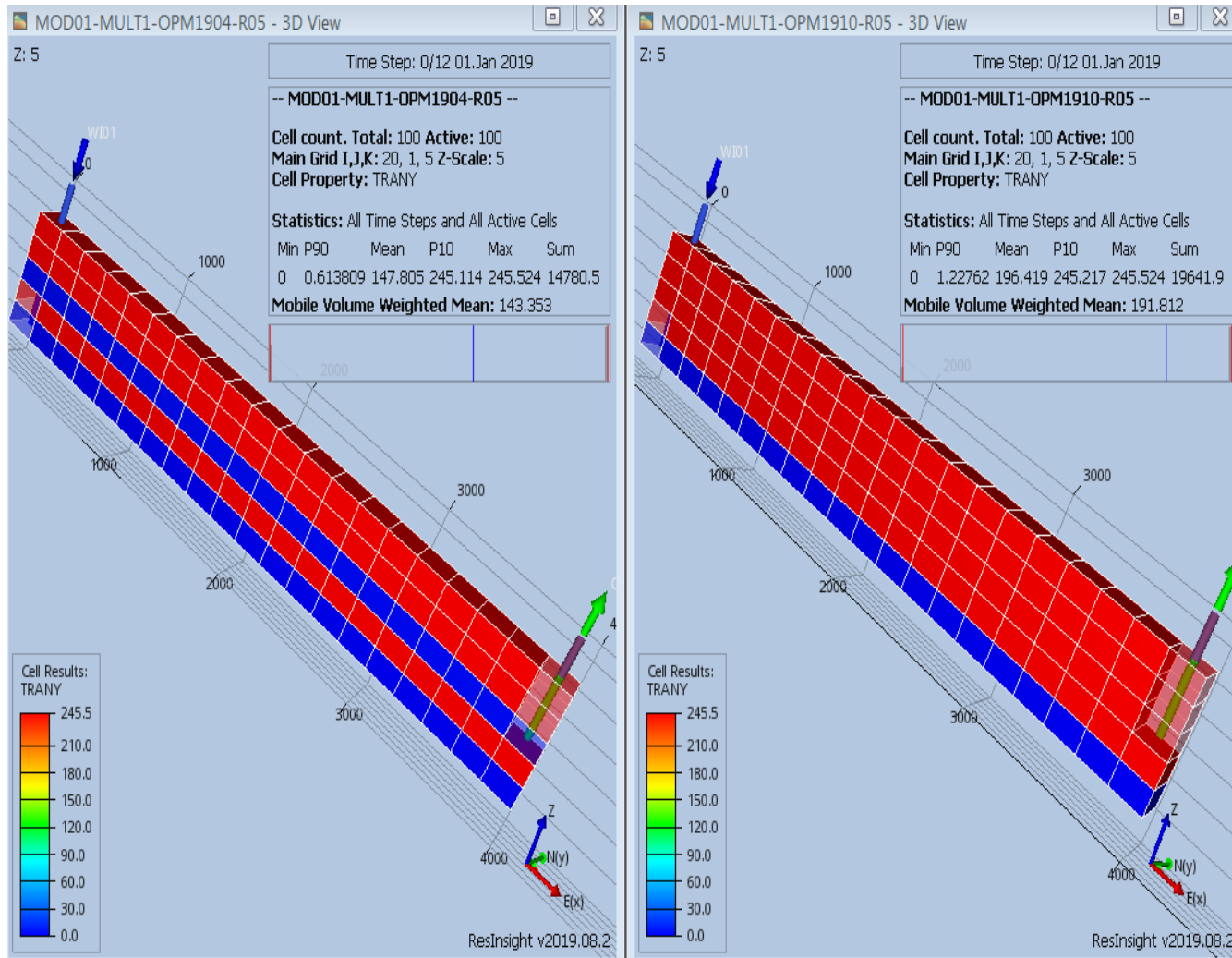
OPM Flow Grid Section MULT Results

OPM Flow 2019-10: GRID And EDIT MULTZ Error



OPM Flow Grid Section MULT Results

OPM Flow 2019-10: Note TRANZ = TRANY (Flipped)



OPM Flow SCHEDULE Section MULT Cases

OPM Flow 2019-10

No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
2	MULT1~R02	Test basic functionality of MULTZ	(1) Layer 3 MULTZ x 0.000
3	MULT1~R03	Check if MULTZ is applied cumulatively, or only the last entry	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01 Last Entry
4	MULT1~R04	Test basic functionality of MULTZ in EDIT section	(1) Layer 3 MULTZ x 0.000
5	MULT1~R05	Check if MULTZ is applied cumulatively, or only the last entry in the EDIT section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01 Last Entry
6	MULT1~R06	Test basic functionality of MULTZ in SCHEDULE section.	(1) Layer 3 MULTZ x 0.000 Not Available in OPM Flow - Stops Available in Commercial Simulator
7	MULT1~R07	Check if MULTZ is applied cumulatively, or only the last entry in the SCHEDULE section.	(1) Layer 3 MULTZ x 100.0 (2) Layer 3 MULTZ x 0.01 Not Available in OPM Flow - Stops Cumulative in Commercial Simulator

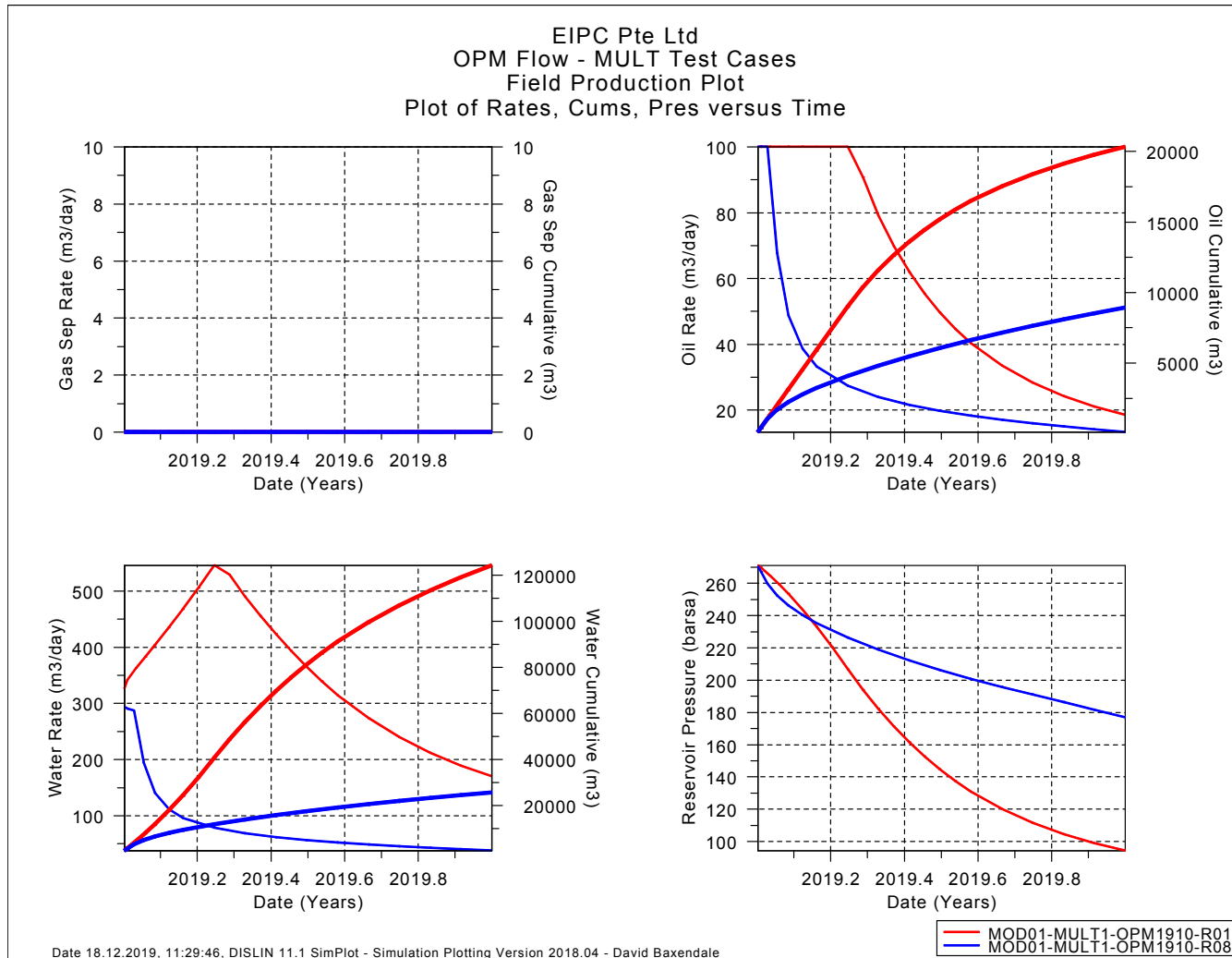
No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
8	MULT1~R08	Check if MULTZ is applied cumulatively, or only the last entry in the GRID and EDIT sections combined. Should give same results as Base (R01)	GRID Section (1) Layer 3 MULTZ x 0.0 (2) Layer 3 MULTZ x 0.01 EDIT Section (1) Layer 3 MULTZ x 0.0 (2) Layer 3 MULTZ x 100.0

For multiple MULT keywords, only the last entry is applied in both the commercial simulator and OPM Flow 2019-04 in both the GRID and Edit sections.

In OPM Flow 2019-10 MULT is Applied Cumulatively in the EDIT Section

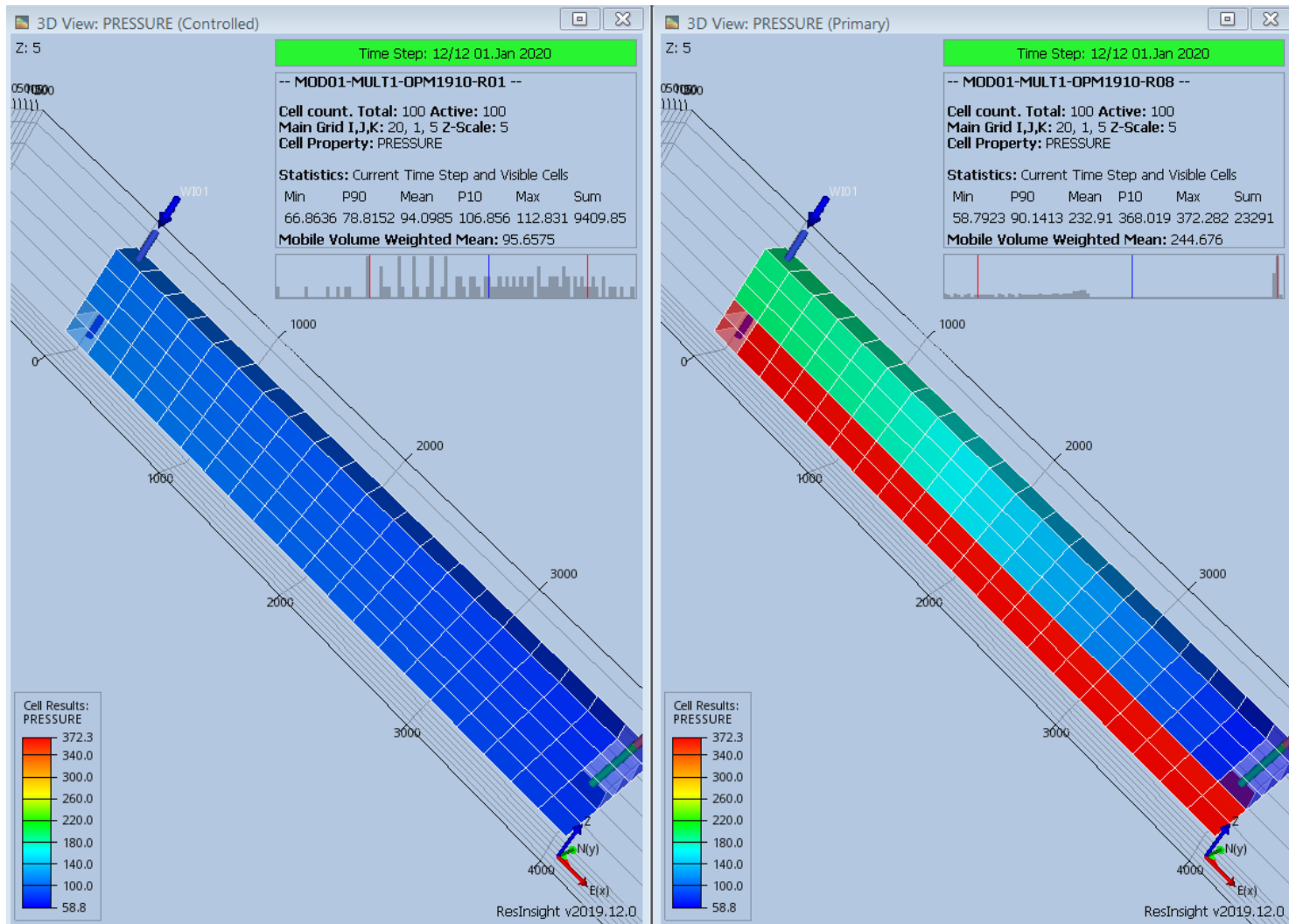
OPM Flow Grid Section MULT Results

OPM Flow 2019-10



OPM Flow Grid Section MULT Results

OPM Flow 2019-10: Final Pressures For R01 And R08 Cases

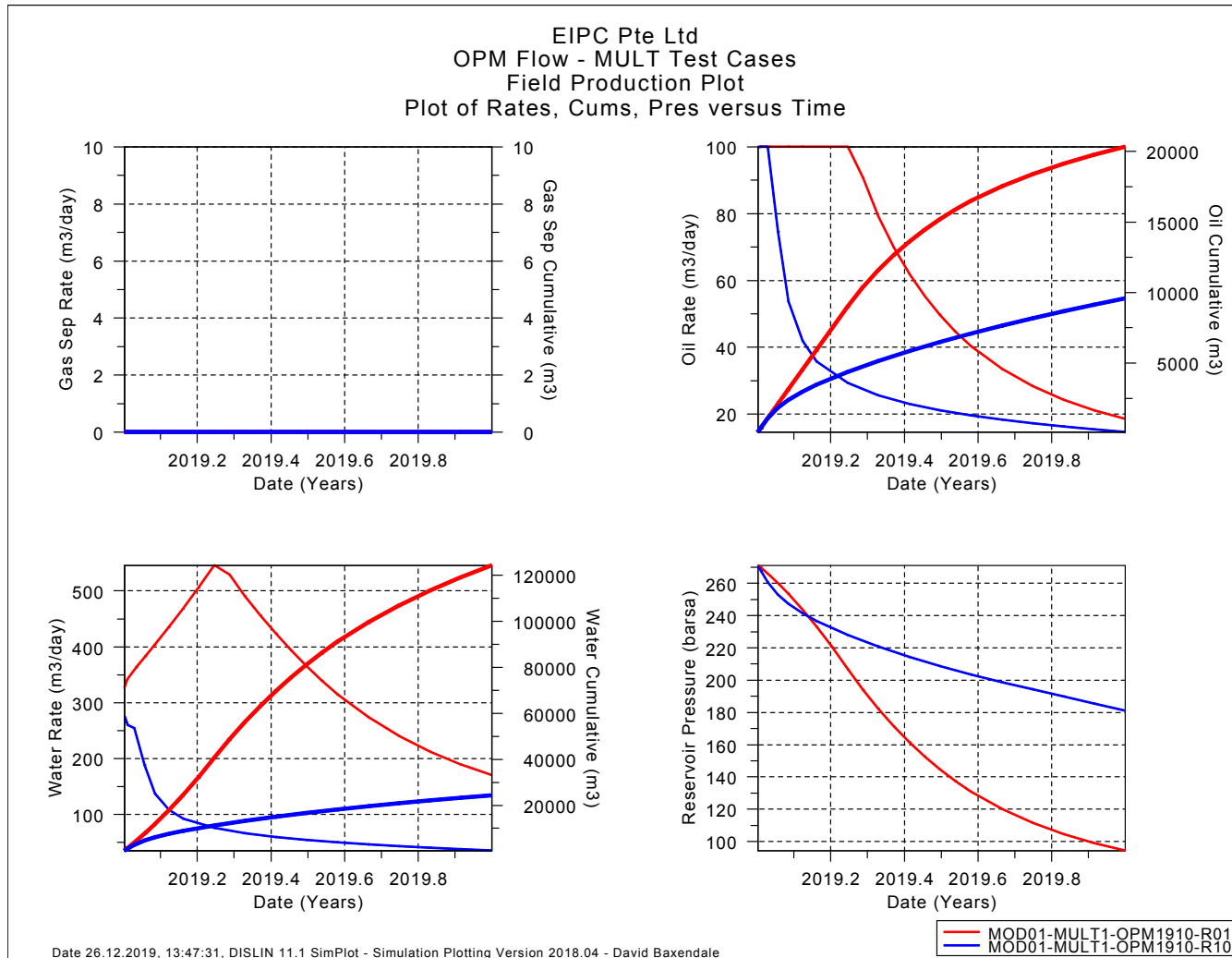


No	Case Name	Objective	Description
1	MULT1~R01	Base	Base Case
9	MULT1~R09	Check if TRANX, TRANY, TRANZ arrays are applied and used in the EDIT section	GRID Section: (1) No Permeability Data EDIT Section: (1) Base Case TRANX, TRANY and TRANZ Run starts and fails but should stop with a message saying insufficient data to compute transmissibilities.
10	MULT1~R10	Check if TRANX, TRANY, TRANZ arrays are applied and used in the EDIT section	GRID Section: (1) Base Permeability Data EDIT Section: (1) Base Case TRANX, TRANY and TRANZ exported from commercial simulator to avoid OPM Flow potential transmissibility issue.

In OPM Flow R01 and R10 cases give different results – should be the same.

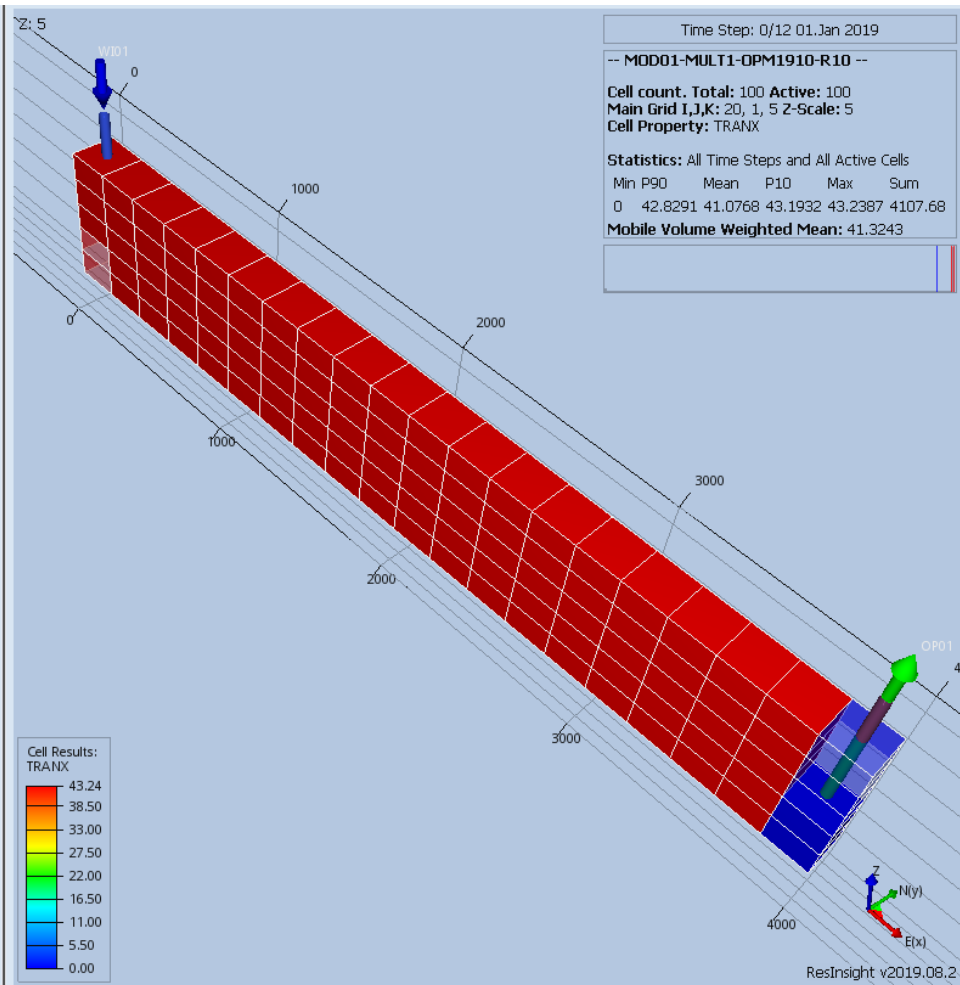
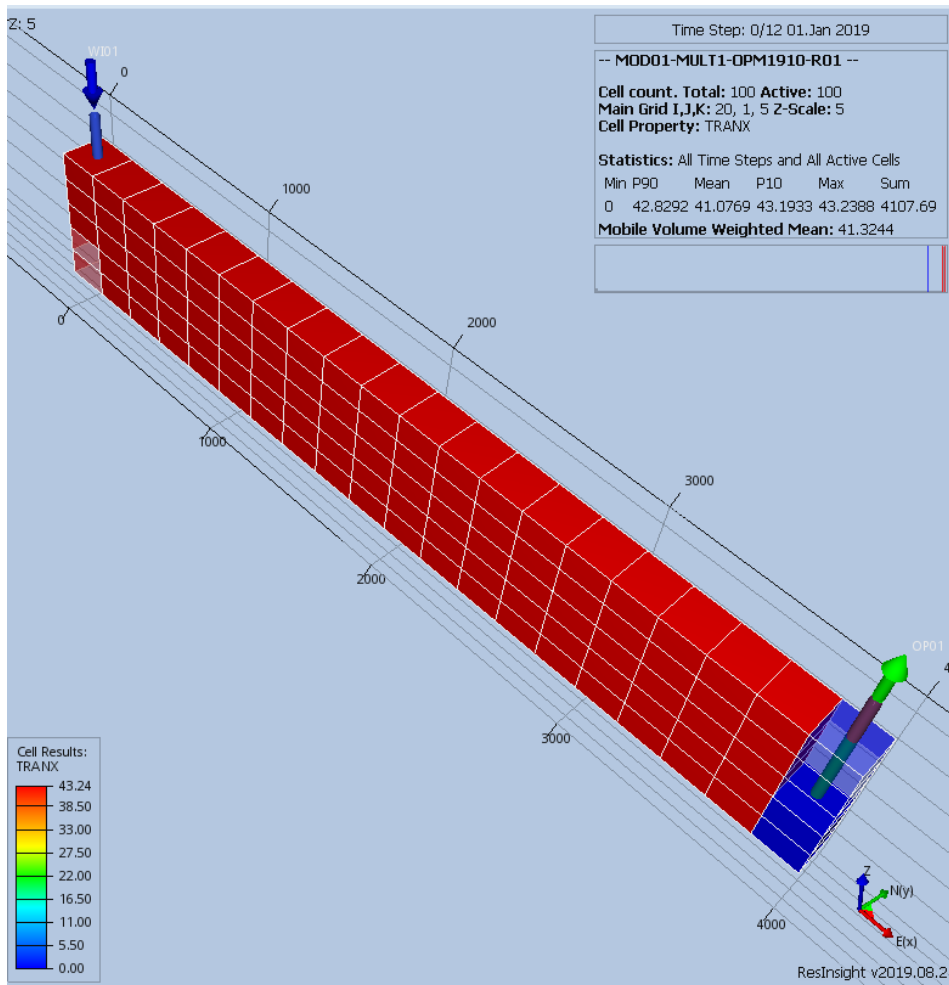
OPM Flow Grid Section MULT Results

OPM Flow 2019-10: TRANX, TRANY And TRANZ



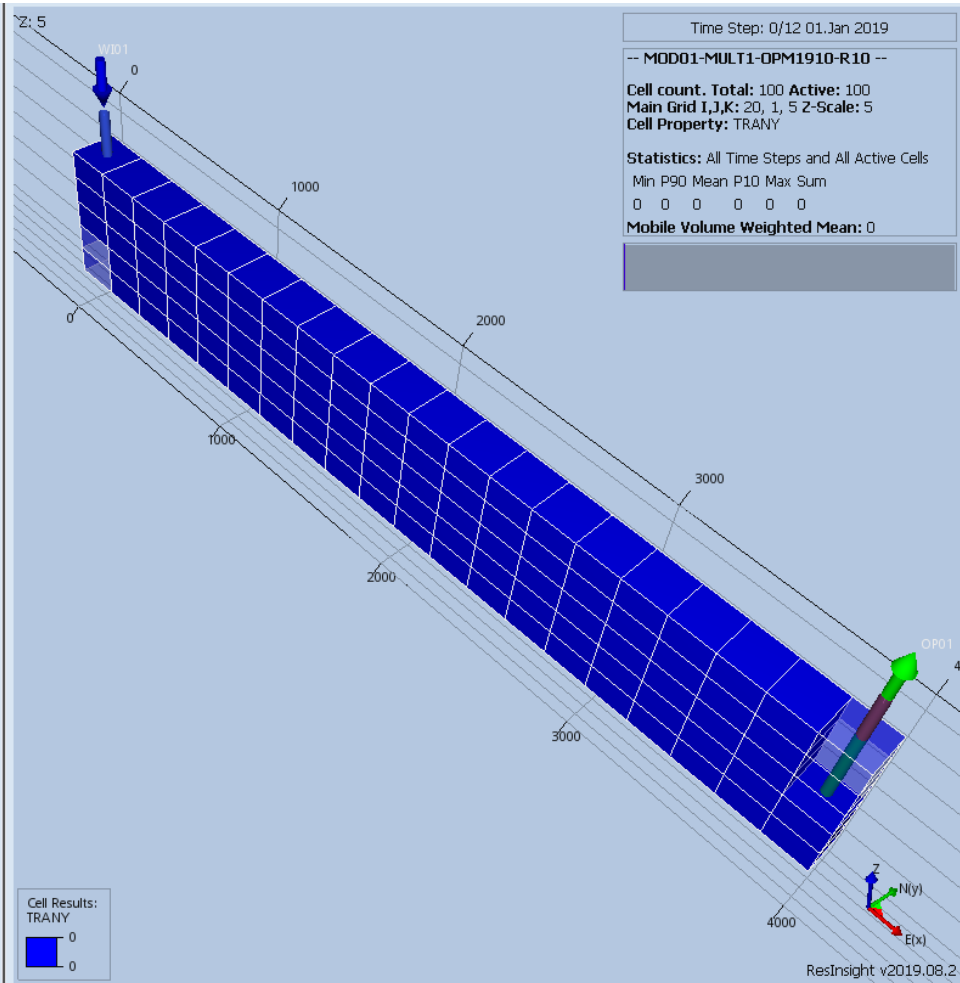
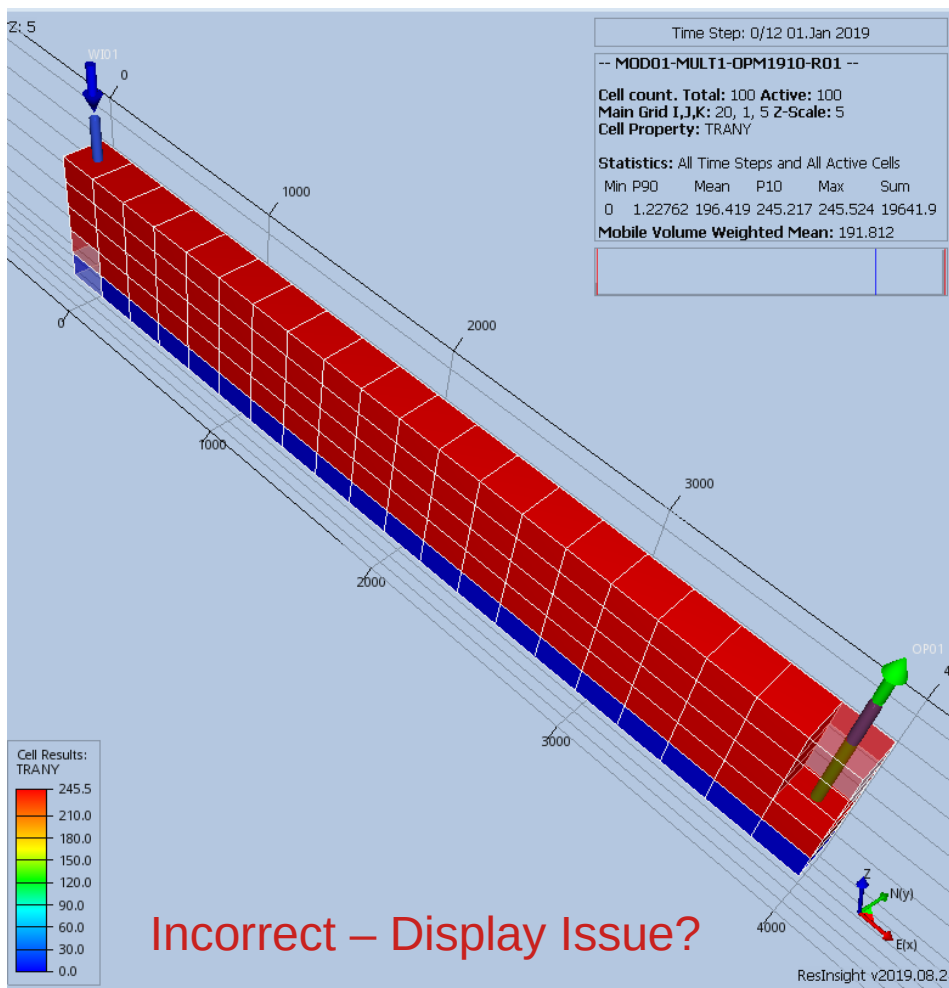
OPM Flow Grid Section MULT Results

OPM Flow 2019-10: TRANX (Same Values)



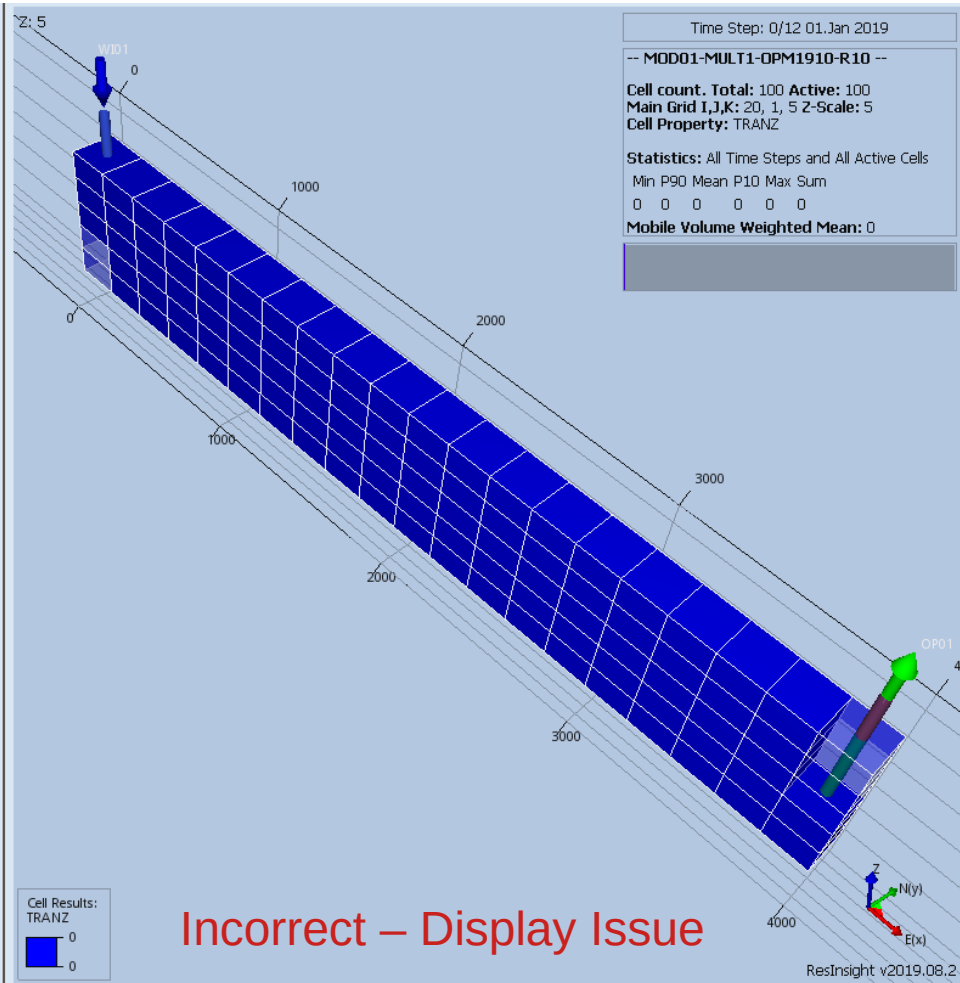
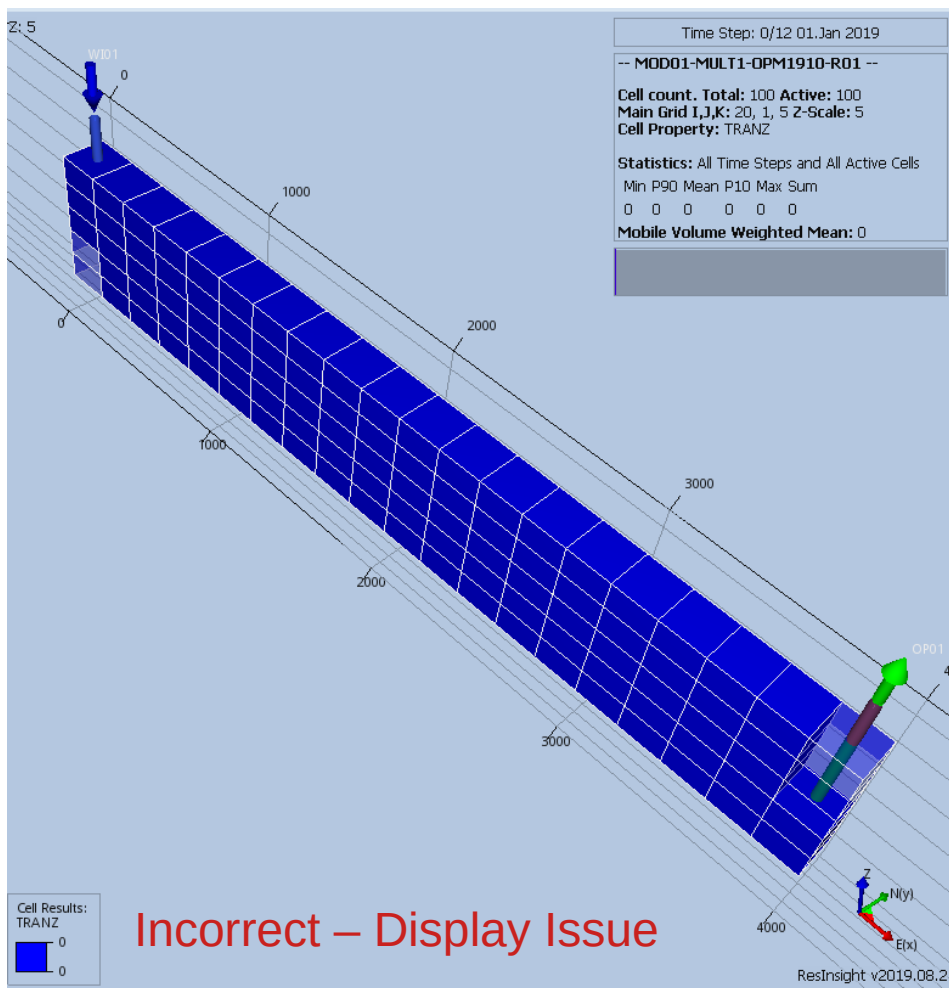
OPM Flow Grid Section MULT Results

OPM Flow 2019-10: TRANY (Not The Same – Display Issue?)



OPM Flow Grid Section MULT Results

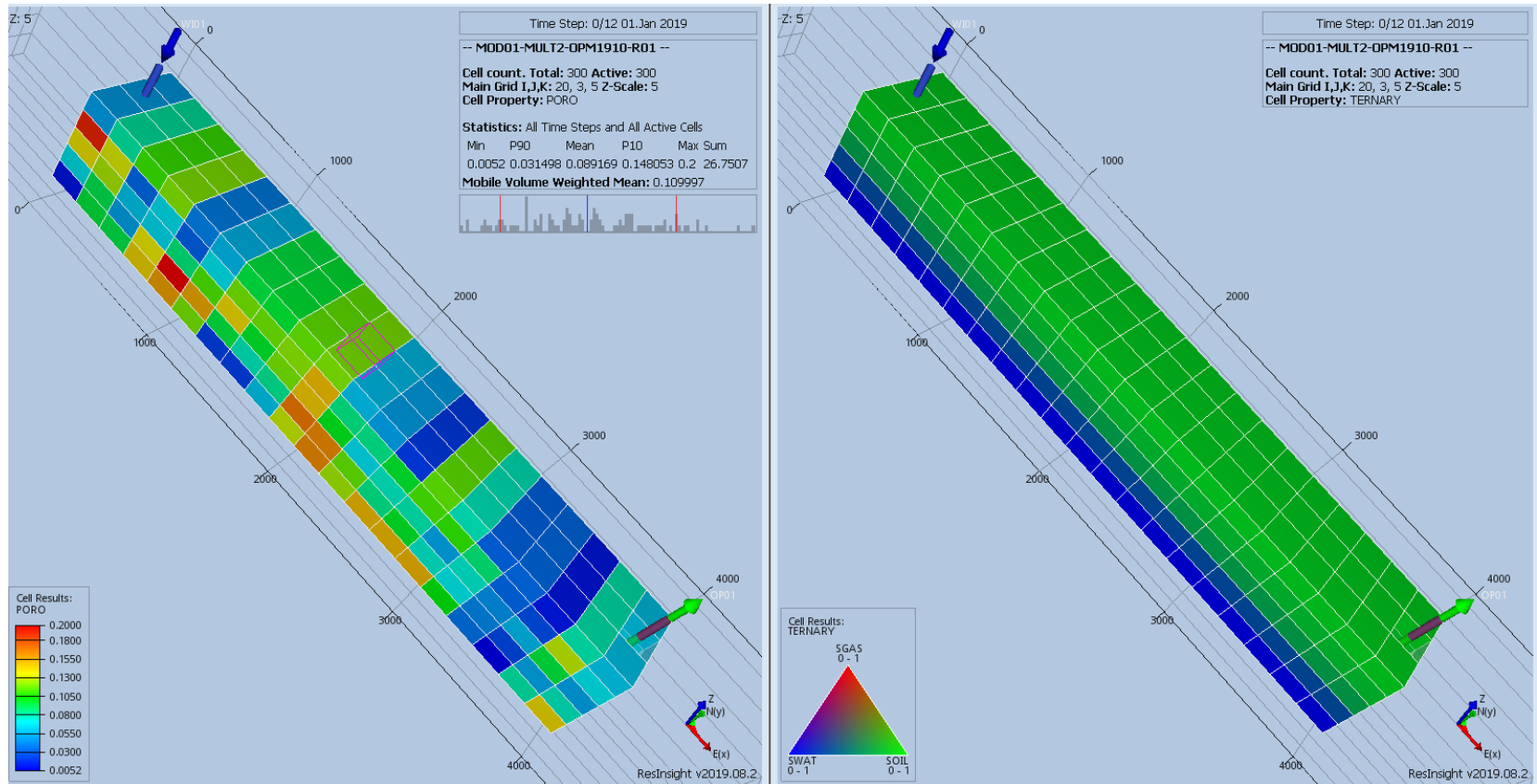
OPM Flow 2019-10: TRANZ (Same But Incorrect – Display Issue?)

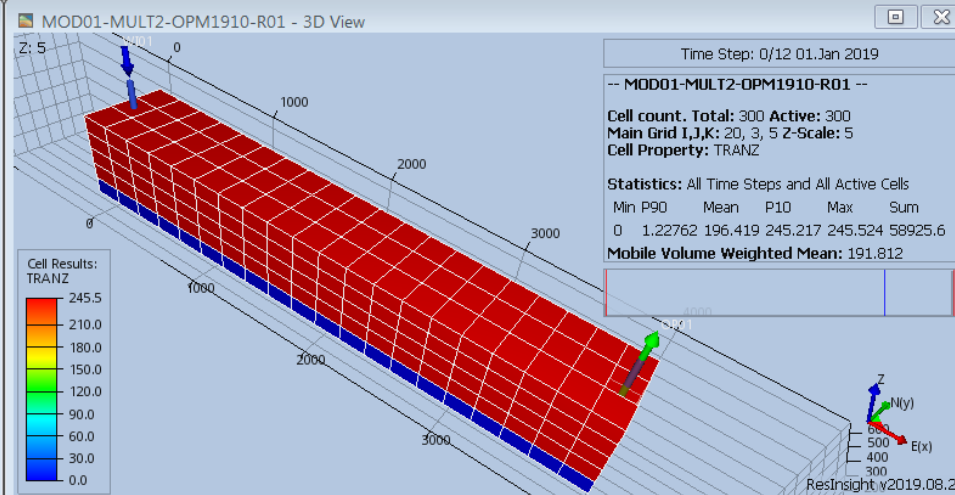
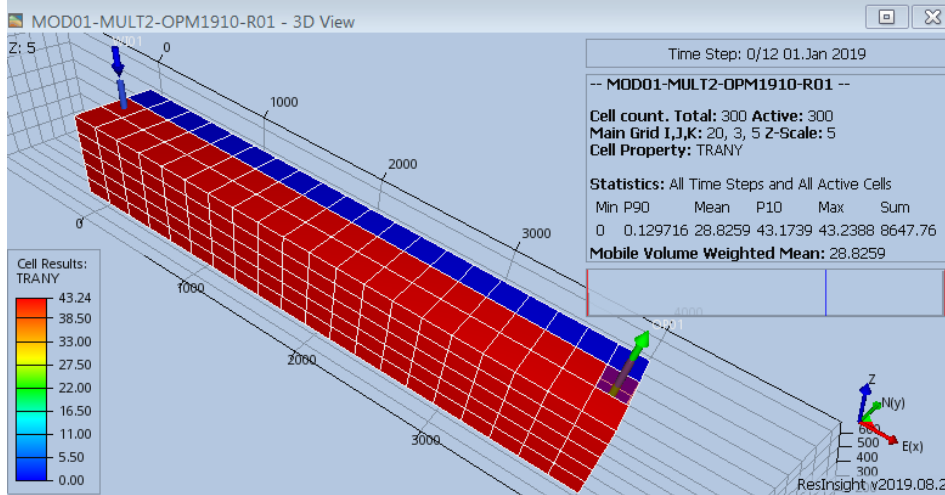
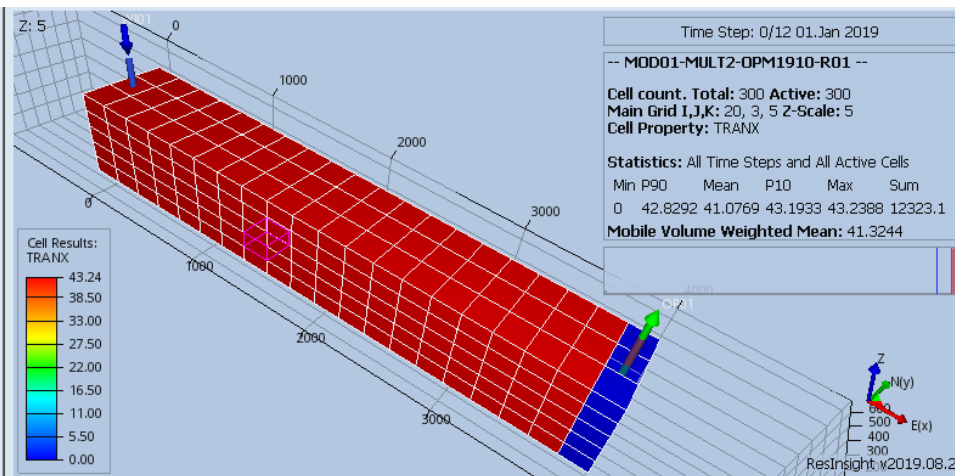
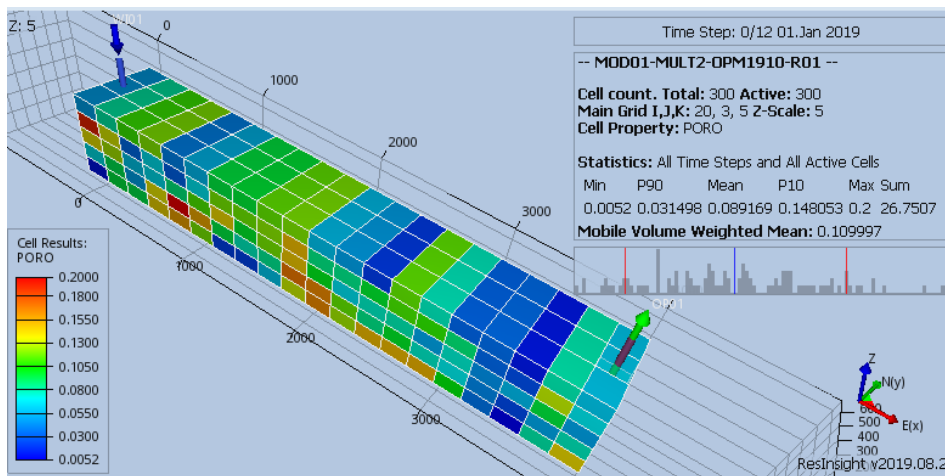


Three Dimensional Cases

E I P C OPM Flow Model Description

- Build 3D model (MULT2) based on the 2D model to check if inconsistencies are a result of working in two dimensions, as oppose to three. Model is 20 x 3 x 5 (x, y, z) with same properties as 2D model.





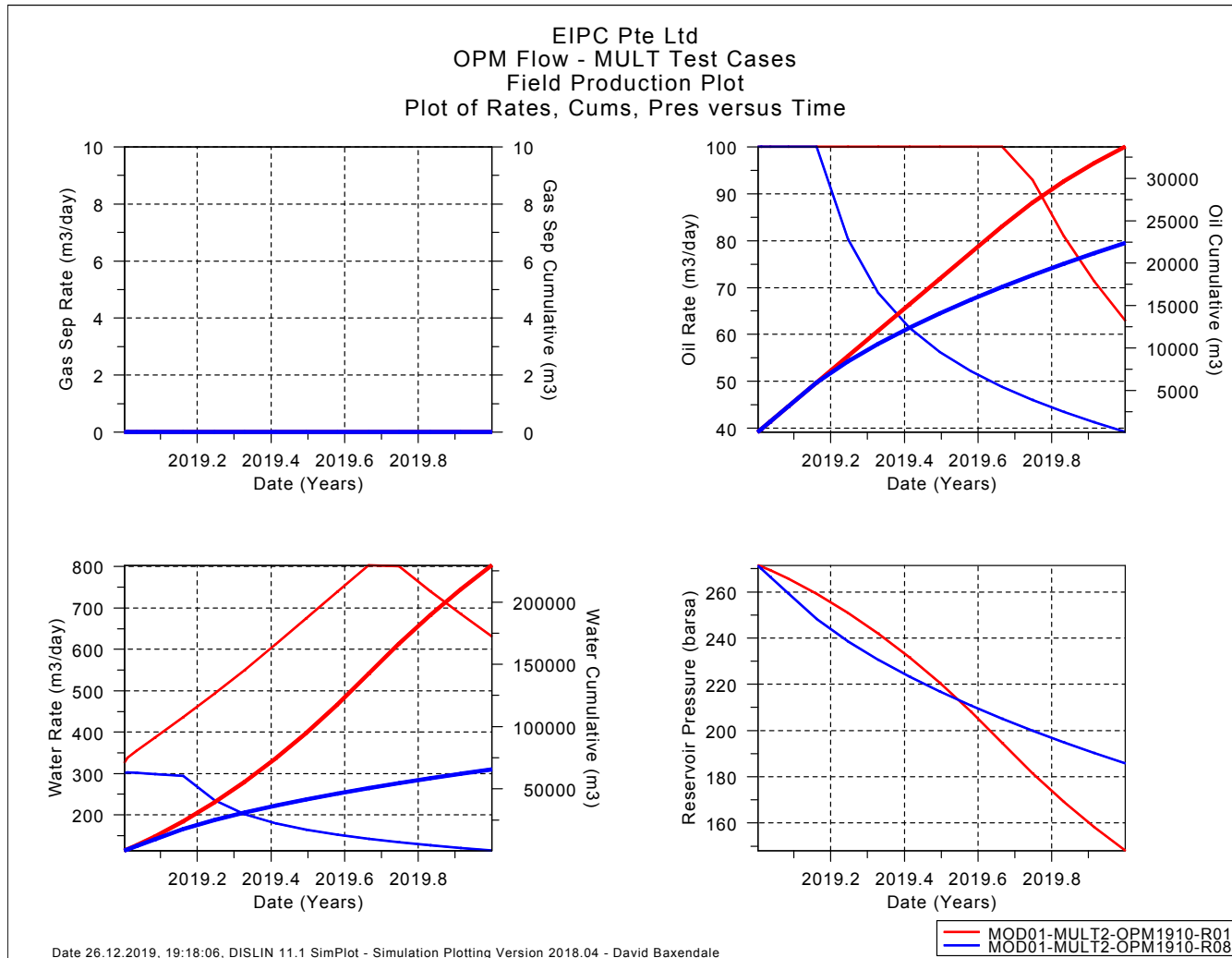
No	Case Name	Objective	Description
1	MULT2~R01	Base	Base Case
8	MULT2~R08	Check if MULTZ is applied cumulatively, or only the last entry in the GRID and EDIT sections combined. Should give same results as Base (R01)	GRID Section (1) Layer 3 MULTZ x 0.0 (2) Layer 3 MULTZ x 0.01 EDIT Section (1) Layer 3 MULTZ x 0.0 (2) Layer 3 MULTZ x 100.0

For multiple MULT keywords, only the last entry is applied in the commercial simulator in both the GRID and Edit sections.

In OPM Flow 2019-10 MULT is Applied Cumulatively in the EDIT Section

OPM Flow Grid Section MULT Results

OPM Flow 2019-10: TRANX, TRANY And TRANZ (3D)

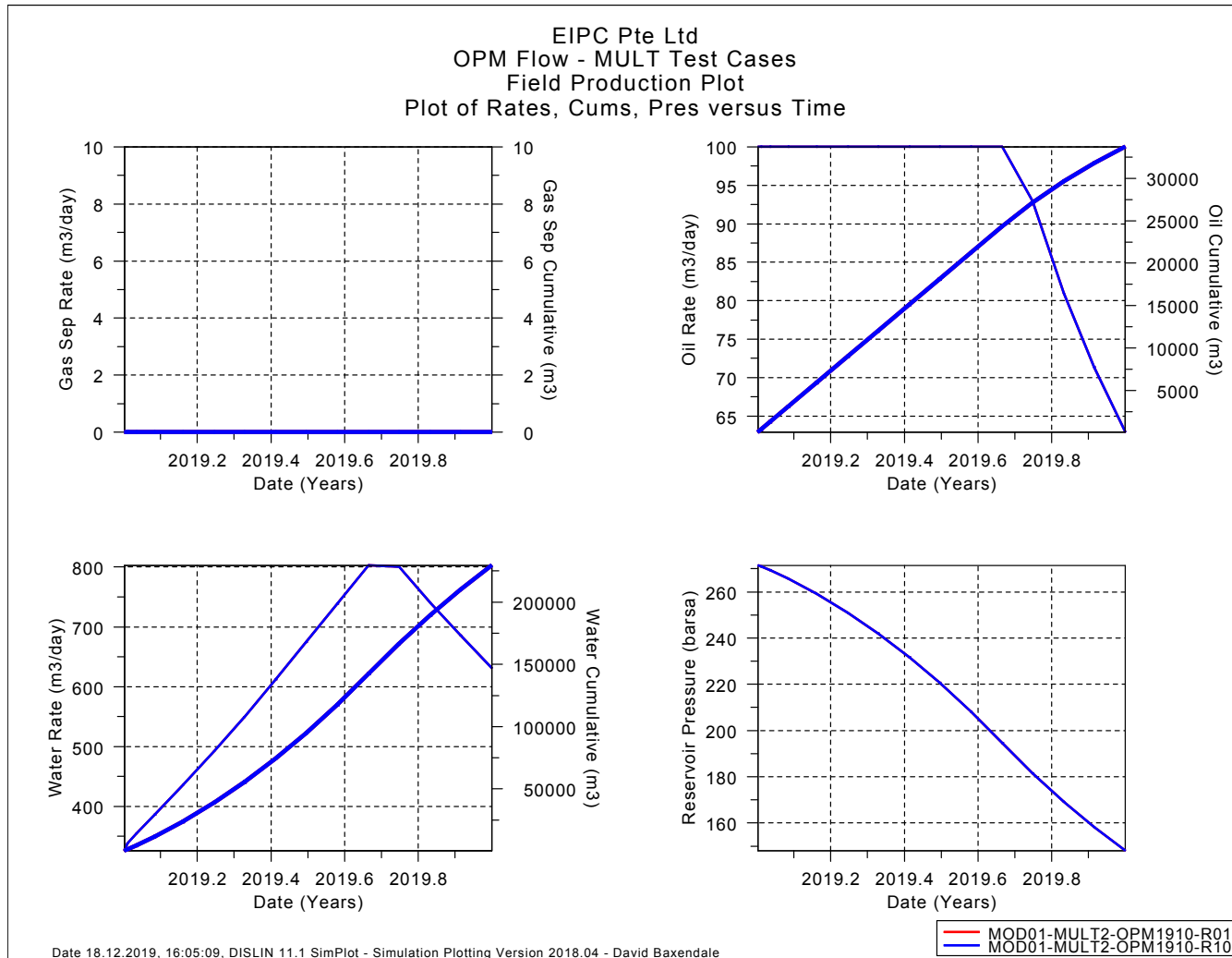


E I P C OPM Flow Grid Section MULT Cases

No	Case Name	Objective	Description
1	MULT2~R01	Base	Base Case
2	MULT2~R10	Check if TRANX, TRANY, TRANZ arrays are applied and used in the EDIT section	GRID Section: (1) Base Permeability Data EDIT (1) Base Case TRANX, TRANY and TRANZ exported from commercial simulator to avoid OPM Flow transmissibility issue.
3	MULT2~R11	Check if TRANX, TRANY, TRANZ arrays are applied and used in the EDIT section	GRID Section: (1) Base Permeability Data (2) Multiply PERMX, PERMY AND PERMZ by 0.5000 (should be over written by TRANX, TRANY and TRANZ in the EDIT section). EDIT Section: (1) Base Case TRANX, TRANY and TRANZ exported from commercial simulator to avoid OPM Flow potential transmissibility issue. SCHEDULE Section (1) WPIMULT times 2 to offset MULTIPLY on PERMX, PERMY AND PERMZ in the GRID Section.

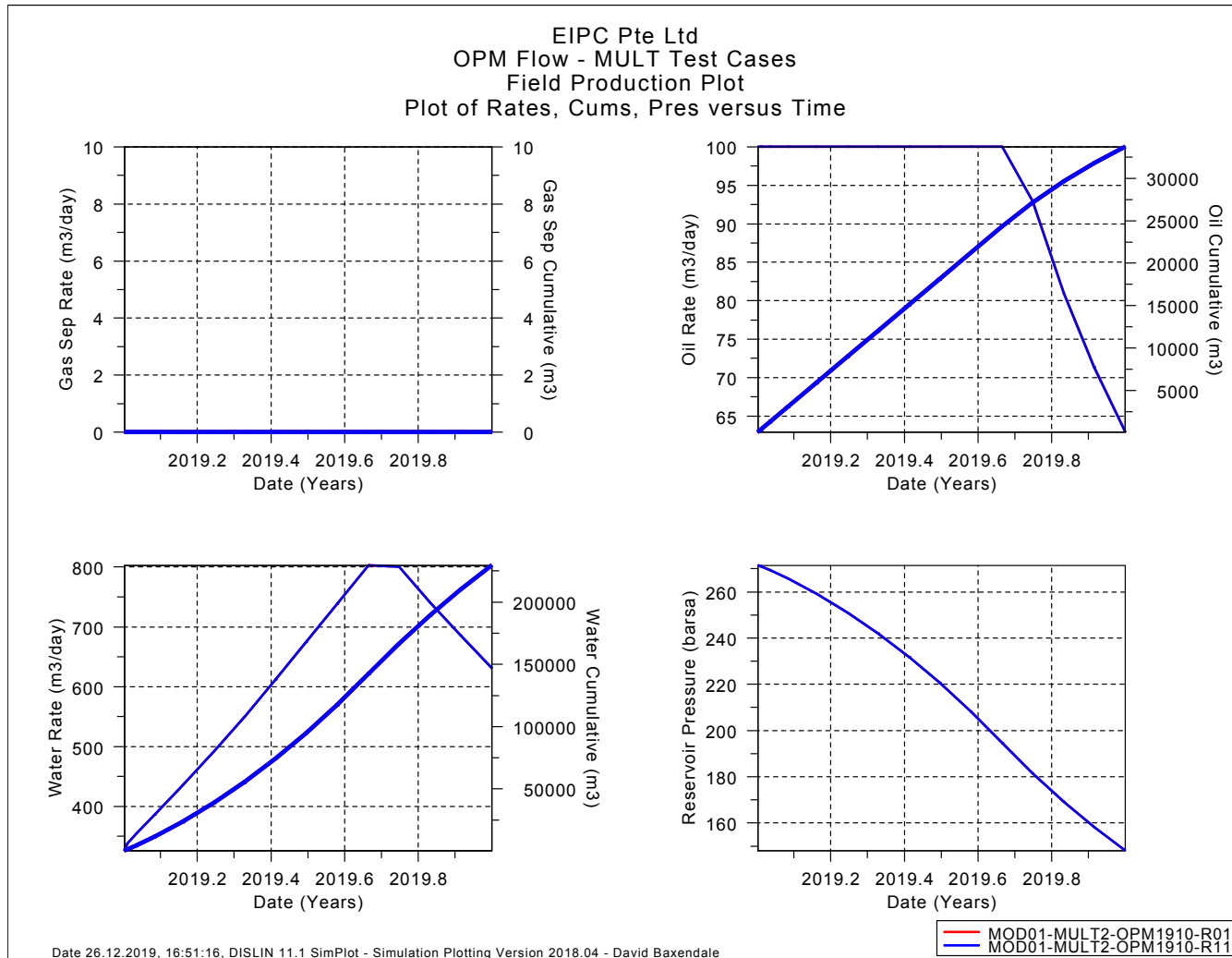
OPM Flow Grid Section MULT Results

OPM Flow 2019-10: TRANX, TRANY And TRANZ (3D)



OPM Flow Grid Section MULT Results

OPM Flow 2019-10: TRANX, TRANY And TRANZ (3D)



End of Presentation